ROUTLEDGE HANDBOOKS



Routledge Handbook of Air Power

Edited by John Andreas Olsen

'*The Routledge Handbook of Air Power* is highly relevant to politicians, diplomats, officers and scholars alike. It is a first-class analysis of how to deliver and apply air power with emphasis on breadth, depth and context, offering unique insight into air power's strengths, limitations and potential as a political instrument. I commend it to you as a "must read".'

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'Air power began to transform the conduct of war in the early twentieth century and it continues to do so. This is an invaluable and authoritative resource guide to all aspects of air power, and its relationship to other aspects of armed force. An excellent set of contributors explores air power's potential as well as limits.'

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'John Andreas Olsen has brought together a group of excellent authors in this volume's first-rate exposition on the state of air power today, its doctrines, roles and force structure. Particularly valuable are the sections on the air power's political, economic, and social impact. No other book approaches it in scope.'

Thomas Keaney, Johns Hopkins School of Advanced International Studies, Washingington D.C., USA

'Desert Storm's success was based on lessons from past air operations; seize control of the air, operate as a single force, see/decide/act with speed. These lessons must be relearned and refreshed with imaginative new concepts. The authors of this Handbook have done both, codified how to fight from the air, now and in the future. An absolute required read for understanding war.'

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Thomas G. Mahnken, Center for Strategic and Budgetary Assessments, Washington D.C., USA



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ROUTLEDGE HANDBOOK OF AIR POWER

The *Routledge Handbook of Air Power* offers a comprehensive overview of the political purposes and military importance of air power.

Despite its increasing significance in international relations, statecraft and war, the phenomenon of air power remains controversial and little understood beyond its tactical and technological prominence. This volume provides a comprehensive survey designed to contribute to a deep and sophisticated understanding of air power. Containing contributions from academics and service personnel, the book comprises five sections:

- Part I Foundation: the essence of air power
- Part II Roles and functions: delivering air power
- Part III Cross-domain integration: applying air power
- Part IV Political–social–economic environment: air power in its strategic context
- Part V Case studies: air power in its national context

Examining a series of themes and factors that contribute to an understanding of the utility and applicability of air power, this Handbook focuses on the essence of air power, identifies its roles and functions, and places air power in its wider strategic and national contexts.

The *Routledge Handbook of Air Power* will be of great interest to students of air power, strategic studies, defence studies, security studies and IR, as well as to military professionals and policy-makers.

John Andreas Olsen is a Colonel in the Royal Norwegian Air Force. He is Visiting Professor at the Swedish Defence University and Non-Resident Senior Fellow at the Mitchell Institute for Aerospace Studies. His latest publications include *Airpower Reborn* (2015) and *Airpower Applied* (2017).



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Edited by
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It is impossible to understand modern warfare and international relations without understanding air power. It is equally impossible to comprehend air power by only looking at targeting, aircraft, missiles and bombs. Air power is a field of study that must be addressed meticulously, laterally and in detail; it is an interdisciplinary field that cannot be fully grasped without an appreciation of the wider political, military, economic and social contexts in which it operates.

The *Routledge Handbook of Air Power* meets these requirements. It provides a comprehensive survey of aerospace power designed to contribute to a deep and sophisticated understanding of air power. First-rate academics and serving air force operators from twelve countries present a series of themes and factors that aggregate into a rounded understanding of air power as an instrument of force for national policy and international security. The authors combine scholarly discipline with air-professional knowledge and recent experience. They emphasise evolving, contextual and operational subjects, and identify a series of interrelated topics relevant to the current debate on defence and security. The book should be of interest to political decision-makers, serving and retired military personnel, and students at both the Bachelor's and Master's degree levels.

I am indebted to the authors who agreed to take part in this project. Their professionalism, team spirit and dedication ensured that this has been a rewarding task. I am especially thankful to those who took part in designing the structure of the book as the project took shape and form in the autumn of 2016: Lieutenant General (ret.) David A. Deptula, Dr Benjamin S. Lambeth, Dr Richard P. Hallion, Dr Phillip S. Meilinger, Air Commodore Dr Frans Osinga, and Dr Alan Stephens. I am obliged to Group Captain James Beldon of the Royal Air Force, Air Vice-Marshal (ret.) Richard A. Mason and Dr H. P. Willmott for consultation throughout the venture. I am also grateful to Routledge for initiating the idea of including air power in its series of handbooks, with special thanks due to Andrew Humphrys and Hannah Ferguson. I also thank the Swedish Defence University and its Section of Air Operations for supporting this and previous air power projects.

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John Andreas Olsen
London

FOREWORD

Just fifteen years after the initial manned, heavier-than-air, powered flight, the Royal Air Force was established as the first national air force – a service separate and distinct from armies and navies. This represented an extraordinary acknowledgement of the potential of air power, and was visionary given the nascent stage of air power at the time. Twenty-two years later air power wielded by the Royal Air Force single-handedly saved England from invasion. Air power tied solely to surface forces to support operations in their domains could not have done that. Separate and distinct air forces exist to master and exploit the advantages of operating in the third dimension of air and space to directly achieve a nation's security objectives.

The *Routledge Handbook of Air Power* yields valuable insights regarding where air power has been, and, more important, provides a foundation to better understand where it might go. From its beginning, the steady drumbeat of technological advance has kept cadence for air power development, maintaining a discernible consistency for over a century – not in its pace, but rather in its continuity. While the speed of air power's technological growth has varied, and the specific directions and forms it has taken along the way have defied prediction, the evolution of aerospace technology has adhered to the key principle that underpinned its foundation. This constant is embodied in the relentless pursuit of advantages provided by harnessing the domains of air and space. Airmen recognise and embrace the ability to rise above the constraints of terrain and to transcend the strictures of the horizontal perspective. They have always refused to think or to operate in less than three dimensions – and with the advent of cyberspace, have planted another flag in that domain. As expansive as the list of twentieth-century advancements in air power may be, its phenomenal progress can be succinctly characterised as resulting from tireless efforts to capitalise on and exploit the third dimension, pushing technology to new limits every step of the way.

Air power is now the indispensable force in the conduct of successful warfare, as well as touching every aspect of modern life. The *Routledge Handbook of Air Power* chronicles critical air power events, concepts, and air-minded leaders who saw past the limitations of their day and recognised the importance of embracing new technologies, new organisational concepts, and new ways of doing business. It examines a series of themes and factors that contribute to a proper understanding of the utility and applicability of air power. This comprehensive survey of air power provides an understanding of the interplay of science, technology, invention, innovation, opportunity, necessity, requirements, politics, economics, national will and industrial practice.

The characteristics of air power – speed, range, versatility, precision, and lethality – yield a strategic perspective associated with its most effective use. This perspective views a specific theatre of interest or the entire globe as an indivisible whole where effects are applied on the basis of their ability to influence. Air power options shape, deter, and dissuade so that we can pursue our fundamental interests while minimising the need for combat operations. When combat is necessary, aerospace capabilities create a variety of strategic, operational, and tactical effects that offer disproportionate advantages relative to surface forces.

Air power has the potential to achieve effects at every level of war both directly and quickly. As a result, it will remain a principal means for achieving strategic outcomes during international disputes and conflicts. Recent advances in technologies applied to weapons, engagement, information, and control systems have enabled order-of-magnitude increases in the effectiveness of aerospace systems. For example, the combination of stealth, stand-off and precision redefined the concept of mass during the 1991 Gulf War Air Campaign. Mass, in the sense of an aggregation of a large number of forces, is no longer required to exert a devastating effect upon a system of forces, infrastructure, government, organisation, or industry. Surface forces will always be an essential part of militaries, but no longer do large numbers of 'boots on the ground' require movement, positioning, and extensive preparation before achieving dominant or controlling effects on an enemy.

The object of presence or massing of force in a region is ultimately influence. The operative element in achieving influence is communicating to friends and adversaries alike that one has the capability and the will to use force to achieve particular effects. If the same effect can be imposed without the continual physical presence or large-scale massing of ground forces, then in some circumstances the constant presence of forces can be replaced by the projection of forces to achieve the same result. In other words, proximity of forces becomes less important than the speed and precision in which force can be applied. Here is where air power is key. Air power is increasing its ability to produce these effects; application of modern aerospace forces in conjunction with nascent control concepts has already demonstrated relevance across the spectrum of conflict.

The evolving security environment requires greater responsiveness (the ability to act in hours rather than weeks or months), long range (the ability to span the globe), effective delivery (the ability to deliver weapons or relief with precision to achieve desired effects), and high leverage (the ability to reduce personnel, support and overall monetary costs). Air power can quickly bring these elements to bear anywhere on the planet, and in a fashion that allows simultaneous application throughout the breadth, depth, and volume of any area of interest. By its nature and by the inherent characteristics of the forces that operate in aerospace, air power has the ability to suppress the conduct of adversary operations in all physical domains – on land, at sea, in the air, and in space. It follows that aerospace forces can and should play an increasingly significant role in shaping and promoting peace and stability, and in providing the operational capabilities needed to dominate an adversary in war.

Today, one hundred years after the birth of the world's first air force, we are witnesses to the impact of air power and its organisation as a separate service. Both were critical elements that thrust the world into the modern era by reducing the constraints of terrain, conquering the tyranny of distance, and routinely shrinking interactions around the globe from months to minutes. Air power continues to propel us into the future in many different ways. As much of a challenge as it is to survey the conceptual distance between 1918 and 2018 in retrospect, consider the view of someone in 1918 looking forward to today. Since our technological push forward shows no signs of slowing down, we must realise that we are in a similar situation today – with another hundred years of unimaginable progress stretched out before us. This is why it

is paramount to understand air power. If we can learn anything from air power's relatively short history, it should be that air power's potential is limited only by our vision and our willingness to advance.

Lieutenant General (ret.) David A. Deptula, USAF



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INTRODUCTION

The new face of war

John Andreas Olsen

This book examines air power: the ability of a nation to assert its will by projecting military power in, through and from the air domain. Air power is the use of air capabilities to influence the behaviour of actors and the course of events.[1] The *Routledge Handbook of Air Power* explores *why* political leaders have come to regard air power as their instrument of choice to deter and coerce recalcitrant regimes, *what* it can and cannot accomplish as a tool of national strategy in the ever-changing and demanding international environment, and *how* air power should be studied to gain an appreciation of its complexity and impact on war and peace. The book seeks to unravel the sinews of a century of air warfare to distinguish the transient from the consequential with a look to the future. Its intent is to advance the strategic meaning of contemporary air power and its ability to contribute to desired outcomes in uncertain conditions, not to promote the aerial weapon as an end in itself.

The *Routledge Handbook of Air Power* provides a cutting-edge, critical, and comprehensive survey of the phenomena of aerospace power, written by an international team of experts and designed to contribute to a proper understanding of air power's strengths, limitations, and potentials relative to other levers of power. In the process, it shows air power's increasing significance to national security, identifies how it has altered the conduct of warfare, and indicates its likely importance in future war.

Air power and the changing character of war

Over the centuries, indeed over millennia, armies barely changed. Infantry and cavalry were the main combat arms, with horses, mules, pack animals, and camels, and in some wars ships and boats, providing transport for troops, supplies, and stores. In the aftermath of the introduction of explosives into Europe in the fourteenth century the slow development of artillery with cannon did away with the catapults and throwers of various descriptions with which armies had equipped themselves over the centuries in terms of the conduct of sieges. It was not until the nineteenth century that real change with regard to armies and the conduct of war manifested itself in three key developments (Willmott 2002).

Prior to these developments the Greeks and the Romans of ancient times would have understood the events at Waterloo, but in the nineteenth century the growth of the powers of the state, the development of railways, and the invention of the internal combustion engine

wrought massive changes. The Industrial Revolution enabled mass production and the Napoleonic Wars, based as they were on armies so large that they had to be divided into separate corps, came to represent a transformation of war in terms of goals, broad participation, scale, accelerated tempo, and the roles that battle and manoeuvre played in the operational repertoire (Olsen and van Creveld 2011: 1). The state became capable of raising millions of men under arms, with railways providing the means of mass movement across thousands of miles. As a result, men and animals were no longer decimated or exhausted by treks across such distances: the Crimean War (1853–1856), with British and French troops moved by rail to ports of embarkation, and then the American Civil War (1861–1865) witnessed battles in which the dimensions of time and space underwent fundamental change. This period also saw the emergence of new means of communication in the form of the telegraph and the telephone, as well as weapons such as rifled gun barrels and rapid-firing guns.

Change with respect to armed forces and war in terms of air power had to await the twentieth century. The first attempts to produce an airship with a hydrogen-powered internal combustion engine date from the first decade of the nineteenth century, but came to little: the mid-century airship, borrowing from the railway, was powered by a steam engine and had a certain power of movement, but this too was very limited.

In 1886 came real change with the invention of the four-stroke gasoline-powered internal combustion engine. The immediate impact manifested itself in the form of the automobile that was to massively change cities, and the routes between cities, by the end of the nineteenth century. This engine, over the next sixty years, was to bring major change in the form of the mechanisation and motorisation of armies. The first heavier-than-air aircraft powered flights, lasting a matter of seconds, took place in 1903 at Kitty Hawk, North Carolina. With proven endurance, future aircraft were assured of a range that lifted them from a position over their own armies to positions over an enemy, whether military or civilian, but at this time they lacked weaponry and effective strike power as well as the means to report and receive signals of varying degrees of importance.

After the first daylight raid on London in 1917, Field Marshal Jan Smuts reported to the War Cabinet:

> The day may not be far off when aerial operations with their devastation of enemy lands and destruction of industrial and populous centres on a vast scale may become the principal operations of war, to which the older forms of military and naval operations may become secondary and subordinate.
>
> *(Quoted in Tedder 1917: 21–22)*

By the time the First World War ended the following year, air power had proven itself useful primarily in observation, reconnaissance, artillery spotting, and battles to control the skies. Early prophets such as H. G. Wells, Giulio Douhet, Hugh Trenchard, Billy Mitchell and others foresaw the aerial weapon having a strategic impact on society, but struggled to find the right words, expressions and terms. Some inspiration was found in the maritime domain, especially in the writings of Alfred Mahan: command of the sea and sea warfare held useful concepts for thinking about air warfare but the relationships between navies and air arms were often uneasy. Besides, the visionaries emphasised the need to break fully with the past to promote the new.

The public fear of strategic bombardment far exceeded any actual destruction at the time, but the impetus for the Royal Air Force's becoming an independent service on 1 April 1918 lay in the lessons of the First World War and the future threat: the need to provide home defence and the waste of duplicated air arms (Mason 1994).

Many feared that the next war would be decided quickly by air attacks against the population with weapons of unprecedented power, but the Second World War in Europe took a very different form. Aerial bombardment in conjunction with operations by ground and naval forces remained the central function of air power and one of the most important contributors to the German victories from 1939 to 1941 and allied victories from 1942 to 1945. While the Axis powers tended to limit their use of air power to support of the ground forces and to air defence, the Allies exploited all aspects of aerial power including strategic bombardment. The expanding role of air power gave the Allies the upper hand, and although air power did not win the war in Europe it represented a critical weakness of the Axis side and the greatest single advantage enjoyed by the Western Allies (Overy 1987; Cox and Gray 2002). The war proved just how important it was to gain and maintain air superiority as soon as possible. The offensive strategic air campaign's major contribution was that it forced Germany to devote what in retrospect seemed an extraordinary level of resources to the defence of the Reich that otherwise could have been turned to offence. Importantly, the old axiom of surface theorists that the defence is the stronger form of war was now being challenged (Meilinger 1995).

Air power dominated events in the Pacific theatre to a greater extent than it did in Europe. The vast size of the battlespace compelled both the United States and Japan to rely extensively on land- and carrier-based aviation to achieve their objectives. In the six months that followed Japan's devastating assault on Pearl Harbor, which quickly secured vital resource zones and a formidable defensive perimeter and temporarily eliminated the US Pacific Fleet, US forces could fight only a valiant rearguard action. Once the United States overcame the shock and surprise, the American drives across the central and south-west Pacific were genuinely joint, even though the air force was not yet an independent service. The bombers softened up Japanese defence positions, the navy commanded the seas and moved amphibious forces ashore, and the ground forces cleared the Japanese from the objectives and brought the local airfields into service. Both General MacArthur and Admiral Nimitz benefited greatly from air power, as it provided a means of first outflanking defences and eventually bringing the Japanese home islands under direct attack. The Pacific air campaign depended on seizing bits of land from which to project three-dimensional power: the power of the airplane and the power of the submarine coupled to the power of ground forces.

Most realised the end of the war was near when B-29 Superfortress bombers based in the Marianas laid waste to Japan's cities in a devastating and controversial firebombing campaign. Several hundred B-29s bombing from about 5,000 feet killed or injured more people and wreaked more damage upon greater Tokyo on 9 March 1945 than did either of the atomic bombs upon their targets. The number of people killed, wounded, and rendered homeless exceeded a million, presaging the horrors of nuclear warfare before the bombs fell on Hiroshima and Nagasaki. On balance, the Second World War marked the ascendency of air power to a level coequal to that of land and sea power and led to the establishment of an independent United States Air Force on 18 September 1947 (Olsen 2010; Overy 1980; Van Creveld 2011; Gray 2012; Stephens 1994). It immediately became the most powerful air force in the world and has remained so ever since. The justification for creation of the separate service was not only America's own wartime experience, but also Great Britain's: British airmen validated the concept of an independent Royal Air Force by their victory in the Battle of Britain. Arguably, Great Britain would have lost the battle had it not established an independent air force in 1918. In the memorable words of Prime Minister Churchill on 20 August 1940: 'Never in the field of human conflict was so much owed by so many to so few.'

The advent of atomic bombs represented a true revolution in political and military affairs, shifting the emphasis away from optimising and perfecting the use of military force toward

avoiding confrontations that could escalate into the destruction of humankind. Air power made significant contributions during the Cold War period, first and foremost in the form of nuclear deterrence and second through operations ranging from the Berlin Airlift to Korea and Vietnam, always under strict political constraints. The latter war was not America's to win and proved the nadir for the United States in terms of international policy and the use of force. The lesson is profound: even the most powerful air power in the world cannot compensate for a fundamentally flawed strategy.

However, the soul-searching that followed in the United States and key European allies led to another revolution in aerospace affairs that manifested itself in Operation Desert Storm – the liberation of Kuwait from Iraqi occupation in 1991. Desert Storm marked the first routine use of precision air attack, reflecting technological developments in weapons and sensors that blended the classic elements of the aerospace revolution (aerodynamic structures, propulsion, and flight controls) with the rapidly proliferating computer revolution. The latter produced sensors of extraordinary fidelity and the analytical tools and understanding that led to the stealth revolution. The twin technological advancements of computers and spaceflight (satellites and the Global Positioning System) enabled precision and unmatched low observability (Hallion 2017: 82).

In Operation Desert Storm, US aircraft armed with precision-guided bombs, operating in tandem with pre-programmed cruise missiles, needed only forty-eight hours to render Iraq's civilian and military leadership all but deaf, dumb, and blind. With few exceptions, President Saddam Hussein and his top commanders in Baghdad were unable to communicate with their security forces, commanders in the field, and the population at large. The Iraqi air defence system was similarly crippled: while many individual control centres with their radar, missile launchers and anti-aircraft guns still functioned, the centralised command and control (C2) system required to coordinate their efforts had ceased to exist and those assets that remained were unable to mount any effective defence.

In the days that followed, the situation steadily worsened for the Iraqi state, society, and military as the air offensive broadened to include attacks on supply, infrastructure, and lines of communication. Coalition aircraft ranging deep into Iraq struck at critical rail and road bridges, oil production, storage facilities, and water distribution centres. The devastation visited upon these installations quickly achieved its intended purpose of degrading the position of the Iraqi military in Kuwait. Essential commodities such as fuel, ammunition, food, and water failed to reach deployed troops in quantities sufficient to maintain their combat capabilities. Direct attacks against the formations and units further reduced their combat effectiveness and caused morale to plummet. By the time the coalition ground forces launched their offensive thirty-eight days after the air campaign commenced, the Iraqi army could scarcely defend itself, much less take meaningful offensive action. Because the air offensive had decided the issue of victory and defeat well before the ground offensive began, the 100 hours of fighting on the ground unfolded without the ebb and flow of alternating fortunes that normally mark major military campaigns. The outcome was the product of overwhelming superiority in every respect; the land campaign simply completed the victory that air power had already won (Olsen 2003).

Since the first Gulf War, Western air power has repeatedly demonstrated an ability to deliver 'outcome-determining results' in campaigns against nation-states. According to Benjamin S. Lambeth:

> The 12 years that spanned the first Persian Gulf War of 1991 and the three weeks of major combat in Operation Iraqi Freedom in 2003 were a triumphal time for American air power. By the end of that eventful period, featuring five successful air-dominated campaigns that also included Operations Deliberate Force, Allied Force, and Enduring Freedom, America's

> air weapon could be fairly said to have matured in its ability to deliver repeatedly the sorts of outcome-determining results that air power's pioneer theoreticians had foreseen generations before.
>
> *(Lambeth 2017: ix)*

During the high-intensity combat phases of both Enduring Freedom and Iraqi Freedom, ground power supported the dominant air scheme of manoeuvre. Air power has also ensured quintessential support to the later stages of counter-insurgency operations in Afghanistan and Iraq, demonstrating an indispensable secondary and supportive role to ground forces. In these conflicts air power provided transportation of soldiers, equipment and supplies, critical intelligence, surveillance, and reconnaissance (ISR), and, most important of all, air supremacy that enabled manoeuvres on the ground. It also provided close air support, interdiction, and other forms of kinetic strikes when needed, but did not play a leading role in these counter-insurgency operations. That said, positioning, navigation and timing (PNT) used together with map data and other information have now become a game-changer in both irregular and regular operations. Whether considered an air power or a space power function, it is perhaps as important as the direct application of force from the air; it is a prerequisite for the functioning of all the other services.[2]

It is fair to conclude that the second aerospace century has seen air power 'come of age'. Air power is now the indispensable force in the conduct of war: without this now-dominant element of combat power there is no national security. Whether acting independently or as a force multiplier in support of diplomacy or surface operations, it is no exaggeration to claim that air power – nuclear and conventional – represents the greatest change in the character of war since the Napoleonic campaigns. For this reason alone it is important to understand the development of aerospace power. It constitutes a 'new face of war'. Prudent use of air power limits risks and is an alternative to large 'boots on the ground' formations; left to the unwise it can destroy civilisation. If nations that exercise air power can succeed in defining the meaning, purpose, and consequences of this political-military arm, air power will have the means necessary to deal effectively with the broadest range of opponents while causing the least possible loss of human life. To the extent that air power develops the right concepts and capabilities, it will reduce both the probability of war and the negative effects of the wars that take place – the ultimate objective of air power (Warden 2017: 363).

To attain this goal, how should policy-makers, military officers, defence consultants, university students, and the general reader go about developing an in-depth, broad-ranging and contextual understanding of air power? Stated differently, how should scholars and practitioners study air power?

The study of air power

Air power is not only about aircraft, weapon systems, and bombing. It is also about training, education, values, rules of engagement, leadership, adaptability, boldness in execution, and a range of other factors, tangible and non-tangible, that influence a military operation. The design of this handbook – what to include, why, and how – embodies a quest to make coherent sense of air power by providing insights and perspectives that are timeless, distinct, and useful. In addition to doctrinal operational aspects, this book accounts for the wider political–military–economic–judicial–ethical–social context in which air power must be viewed. This allows for a full-spectrum approach to multi-domain challenges designed to stimulate an informed, professional debate.

The book chiefly comprises five parts, each consisting of six chapters, as depicted in Figure 1. The first part covers broad developments and experiences, and the *breadth* of the subject at hand; the second and third parts detail operational *depth*; while the fourth and fifth expound on the wider *context* in which air power must be assessed.

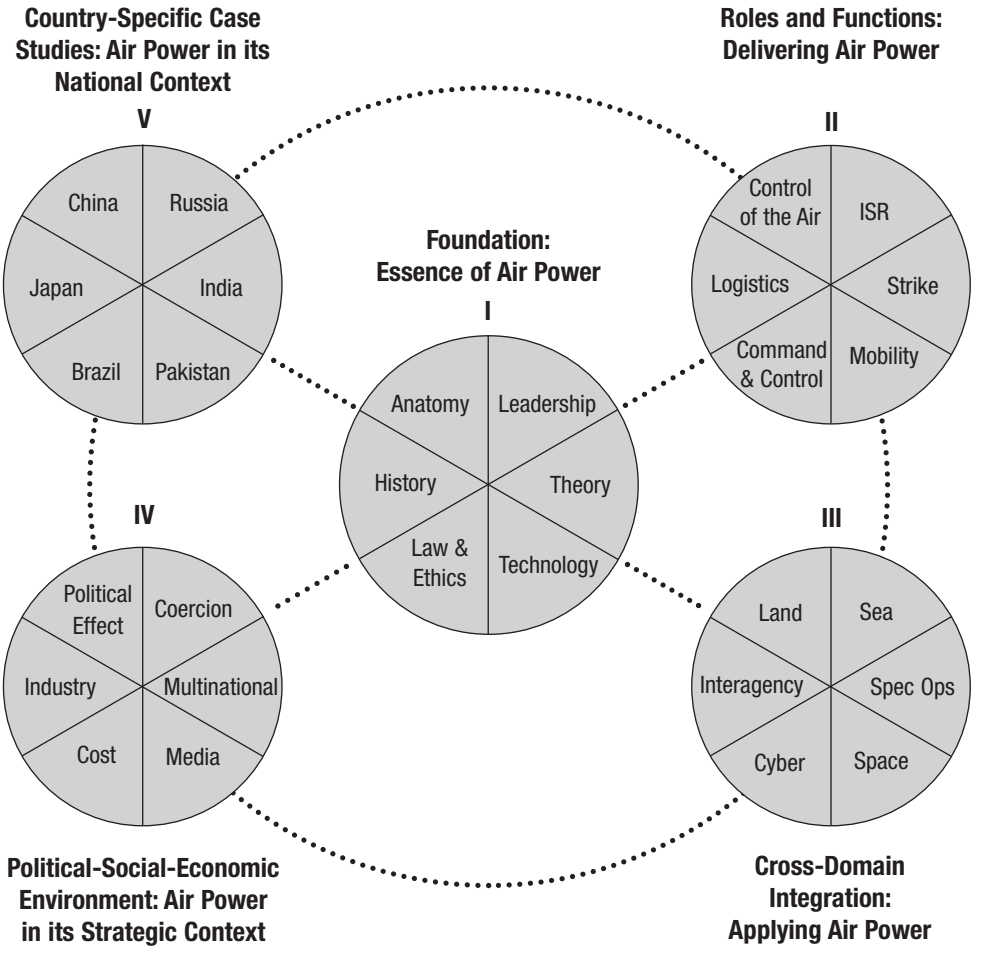


Figure 1 Model of the Book.

To elaborate, Part I addresses the formative factors, seeking to present the *essentials of air power*. It presents the nature, character, and key features of air power, analysing the basics for understanding the profession and its place in war and society. This portion of the book explores the anatomy of air power, examines what modern air capabilities bring to the political table, and assesses its relative strengths and uniqueness compared to other instruments of power. It focuses on high command; how air force leaders can contribute to national policy and strategy rather than merely execute plans. It also deals with the evolution of air power theory from the early pioneers to present-day doctrine – a development of fits and starts. Separate chapters are

dedicated to the impact of science and technology on air warfare and to international law and ethics. Legality and legitimacy are topics that are increasingly important to understand, especially in discretionary and expeditionary warfare. This includes establishing, managing, and archiving a comprehensive audit trail to record actions and decisions for later investigation. Part I ends with a concise history of air power, identifying critical lessons after a century of operations.

With that broad setting in place, Part II focuses on the roles and functions that *deliver air power*. It begins with chapters on the four core, enduring roles. The first is control of the air, *to secure* the ability to conduct operations in the air, land, and maritime domains without effective interference from adversary air power. The second is strike: the ability *to attack* with the intention of damaging, neutralising, or destroying a target; that is, to coerce actual or potential adversaries into changing their behaviour. Third is airborne ISR, *to inform* developing tactical, operational, and strategic understanding. ISR offers timely and relevant situational awareness to optimise decisions at all levels of war. Fourth is air mobility, *to move* personnel, equipment, or forces using airborne platforms to create strategic effects and to enable operational and tactical manoeuvre and sustainment. The one hundred-year history of air power validates the value of airlift as a means of crisis response for both humanitarian relief and military presence. Part II also has a chapter on C2: the crucial enabler *to lead* an air campaign; that is, to direct assigned forces along the principle of centralised command and adaptive execution. Part II closes with a chapter on logistics, that is, principles and philosophies to *support* movement and maintenance of air forces. In sum, this part offers the 'bread and butter' for mastering air power.

Part III looks into the cross-domain environment to impart an understanding of how to *apply air power*: that is, instantiate the collaboration, coordination, and ultimately integration of air power into joint, multinational, and interagency environments. The military instrument is divided by geographical focus into three main parts: land, sea, and air, with space and cyber requiring more status, attention, understanding and funding. Importantly, air power is applied within a multi-domain context to create precise effects; the objective must be to ensure best practice rather than parochial self-interest. Although air power can at times create decisive effects 'on its own', air capabilities are almost always more effective when combined or integrated with other instruments of power in a comprehensive action framework to attain optimal synergy for the specific situation at hand. Part III begins with chapters on air–land integration and air–sea integration, the latter including aircraft-carrier-enabled power projection. A separate chapter is dedicated to integration with Special Forces, mainly because this is different from integration with regular divisions, brigades, and battalions. Part III then moves on to the growing importance of integrating air power into the space and cyber domains. It ends with a chapter on the role that air power has played and should play in interagency operations.

Having dealt with the operational aspects of air power, the fourth part of the book comprises chapters on its wider strategic context. Part IV offers insight into a selection of themes to help readers comprehend the *international context of air power*. It elaborates on the external factors that influence employment of air power, with the overall objective of developing a deep and sophisticated understanding of the consequences. It follows the advice of Professor Colin S. Gray, 'that they cannot air power know who only know of air power' (Gray 2012: x), by taking a close look at the political imperative of combat air power, the art of coercion and the nuclear dimension, the experiences and lessons from recent multinational operations, the ever-more important role of media and public perception, the cost of combat air power, and the interdependent relationship between industry and air power. These chapters offer a framework for situating air power in society writ large; these themes link air power to

the 'external' elements to complement the 'internal' operational dynamics explored previously. In total, Part IV encompasses the importance of people, platforms, partnerships, politicians, and public sensitivity to aerial warfare.

The fifth and final part offers *national perspectives*, covering the status and prospects of air power in a selection of non-Western countries. National air power doctrine cannot be understood apart from the intellectual, cultural, historical, and political contexts in which it evolved. National concerns inevitably result from the ever-dynamic realities of local, regional, and global insecurity. To reach beyond the Anglo-American perspective that inevitably dominates the book, Part V examines the development of air power in China, Russia, India, Pakistan, Brazil and Japan, exploring how these nations think about aerospace power and how they integrate it with other military and non-military instruments. It does so by analysing security policy documents, military reforms, force structures, investments, educational systems, and military doctrine and by discussing both short- and long-term challenges. These case studies supplement the traditional military perspective with examinations of the ideological, economic, and cultural factors that give the respective air forces their distinctive characters. It demonstrates that both Russia and China, although not on par with leading Western nations, are modernising and improving their air capability and should under no circumstances be underestimated.

Summary

The *Routledge Handbook of Air Power* is intended to improve knowledge of and insight into the phenomena of aerospace power. It does so by covering a range of interdependent themes and interpretations rather than by advocating one specific approach. The thirty authors, individually and collectively, examine strengths, limitations, constraints, expectations and conditions for the successful employment of air power in response to national security problems. The book is designed so that readers can select specific topics of interest, but in the hope that they seek an appreciation of the 'whole of air power before its components' because it is with that kind of interdisciplinary reading that the true understanding starts to emerge.

Notes

1 These are the definitions of air power from the Royal Australian Air Force and the Royal Air Force, respectively (see Royal Australian Air Force 2003; Ministry of Defence 2013).

2 I would like to thank Peter Engelmann for offering this observation.

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PART I

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The essence of air power



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1
AIR POWER ANATOMY

Benjamin S. Lambeth

Armed conflict on land and at sea has been a part of the human condition almost since time immemorial, with the notion of sea power having finally entered the lexicon of warfare in 1890 via the seminal book *The Influence of Sea Power Upon History* by the American naval historian Captain Alfred Thayer Mahan (1890). In contrast, combat operations in the third dimension have been a far more recent phenomenon, reflecting a fundamentally new form of force employment that arose only after the start of the twentieth century with the first use of military aircraft in the First World War from 1914 to 1918.

From those earliest beginnings, however, the ensuing emergence and refinement of the analogous notion of air power were not long in coming, with its casual mention first heard as early as 1918 and with its formal introduction into the vocabulary of warfare first recorded in 1925 in the pioneering treatise by the US Army Air Service's Brigadier General William 'Billy' Mitchell titled *Winged Defense: The Development and Possibilities of Modern Air Power – Economic and Military* (Mitchell 1925). By the 1930s, the respected American reporter Hanson Baldwin was routinely alluding to 'air power' in his *New York Times* articles on military matters, and the aviation pioneer Alexander de Seversky, in the early aftermath of Japan's surprise attack on Pearl Harbor on 7 December 1941, further formalised it in 1942 in his advocacy volume *Victory through Air Power* (de Seversky 1942). By the time Congress established the United States Air Force as an independent service five years later in 1947, the now-familiar construct of air power had finally been ratified in the public's mind and was in the vernacular of warfare to stay (Boyne 1997).

The chapters that follow will offer a thorough canvass of the idea and reality of air power, including its history, its provisions for command and control, its associated doctrine and concepts of operations, its technological dimensions, its wartime roles and missions, its diverse operating modes and strategic potential, and its manifestation in the armed services of the world's leading non-Western countries. This introductory chapter, for its part, offers a foundation-laying perspective on the overall *essence* of air power, with a principal focus on its background and early evolution, on the nature and significance of the later developments that have so greatly improved its capabilities since the mid-1970s, and on its singular and enduring distinguishing characteristics that have made it such an effective and often outcome-determining tool of modern warfare.

Background and early evolution

The first use of the airplane as an instrument of war occurred during the Battle of Tripoli in 1911 when an Italian army pilot, Captain Carlo Piazza, overflew Turkish lines in Libya to conduct the world's first aerial reconnaissance mission. A week later, another Italian army pilot dropped the first bomb ever delivered in anger from the air – on a Turkish troop concentration positioned just outside the Libyan capital. The following year, Great Britain's Royal Flying Corps was established as a precursor to what would soon thereafter become the world's first independent air arm, the since-renowned and redoubtable Royal Air Force. Not long thereafter, the still-embryonic flying machines of that early era saw their first sustained combat use in the First World War, in what the late historian Lee Kennett years later would aptly call 'the first air war' (Kennett 1991).

In the early aftermath of the First World War, the progenitors of air doctrine maintained that the airplane embodied such advantages over all other weapon types as to be able to destroy all assets of any value on the Earth's surface while itself remaining comparatively protected from an effective response from the ground. Those platforms and munitions, however, were at best primitive when compared to today's capabilities, and they offered but the faintest hint of what air power would eventually become a century later as a truly decisive means of warfare.

As for the first concepts of operations for aerial force employment, serious theorising about the uses of air power began with the pioneering work of an Italian artillery officer, General Giulio Douhet, who wrote the first published exposition on the subject entitled *The Command of the Air* in 1921 (Douhet 1942 [1921]). In that path-breaking volume, Douhet argued that civilian morale would be shattered by aerial bombardment and that the main targets of air warfare should accordingly be not the enemy's fielded forces but rather his cities. In Douhet's view, if an enemy's cities could be repeatedly struck from the air, something that land and naval forces were incapable of accomplishing, enemy populations would eventually become demoralised and would pressure their leaders to capitulate (Meilinger 1997).

It bears stressing here that Douhet was driven to that ultimately unfounded and erroneous conclusion because the rudimentary aerial munitions and aiming devices of his time were so inaccurate that they were incapable of effectively doing much else *but* cause large-scale harm to civilians. Largely for that reason, the indiscriminate attacks on enemy populations, in what today would be rightly ruled out as an unpardonable infliction of unwarranted harm on innocent civilians, became the actual overarching *goal* of allied bombing strategy, and it remained so both in Europe and in the Pacific throughout the Second World War (MacIsaac 1976).

For most of the West's ensuing Cold War against Soviet communism from the late 1940s through the 1980s, 'strategic' air power tended to be associated exclusively with long-range bombers and nuclear weapons and was generally regarded as an instrument of deterrence whose sole reason for existence was never to be used. Everything else short of 'strategic' air power, so narrowly defined and understood, was relegated to the subordinate category of 'tactical' or 'theatre' air power, whose only presumed purpose was to support US and allied ground forces in combined-arms conventional *land* warfare. Virtually no consideration was given in US and allied defence planning throughout most of the Cold War years to the potential ability of conventional air power to achieve combat effects that might, in and of themselves, determine the ultimate course and outcome of a campaign. To be sure, Western observers marvelled at Israel's bold use of its fighter aircraft during the opening hours of the Six-Day War in June 1967 to destroy Egypt's and Syria's air forces on the ground by surprise, thereby ensuring that the remainder of Israel's pre-emptive campaign would play itself out unmolested by enemy air action (Yonay 1993). By and large, however, despite that remarkable

performance by Israel's air force in what was clearly an outcome-determining role, 'strategic' air power throughout most of the Cold War was thought of almost entirely in nuclear terms, with the rest of American and allied combat aviation having been consigned to little more than a supporting role in a traditional combined-arms approach to warfare in which infantry and armour were taken to constitute the cutting edge of the alliance's non-nuclear power.

The capability and potential of conventional air power did not improve much throughout most of America's long combat involvement in Vietnam. Especially during that war's first three years, beginning in August 1965, the use of American air power was hampered by significant shortcomings in equipment and aircrew proficiency. Although the eventual US defeat in Vietnam was mainly the result of a bankrupt strategy and scant leadership seriousness of purpose, shortcomings in the nation's air posture also played a non-trivial role in accounting for it. Until the intensive American bombing campaign in support of Operation Linebacker II in December 1972 finally overcame North Vietnam's heavily echeloned air defences, enemy surface-to-air missiles and anti-aircraft artillery posed an ever-present threat to US air operations. Early night and all-weather air combat missions were also rendered extremely challenging as a result of technology limitations. The later and more effective American air operations in 1972, in contrast, exploited newly emergent technologies, such as laser-guided bombs and improved means of electronic warfare, that would eventually form the basis for air power's subsequent gains in capability (Thompson 2000).

In the end, American air assets by 1972 were substantially improved over those that had been available between 1965 and 1968. As a result, American aircrews finally learned how to operate in the sort of heavy air defence environment that they might encounter in a future conventional war against the Soviet Union and Warsaw Pact in Central Europe. That experience, in turn, eventually put the United States and, later, its North Atlantic Treaty Organization (NATO) allies on a course to perfect their capabilities in both the air superiority and ground-attack mission areas throughout the eighteen years that separated Vietnam and the first Persian Gulf War against Iraq in 1991 (Lambeth 2000).

Virtually all of those innovations in air warfare capability were inspired by American airmen armed with a 'never-again' mindset from their sobering experiences in Southeast Asia between 1965 and 1973 (Kitfield 1995). Those airmen later rose to senior leadership positions in the US Air Force and US Navy, determined to correct the many shortcomings that had been unmasked during the course of the Vietnam War. Perhaps more than any other single causal factor, the legacy of Vietnam was the principal instigator behind air power's final coming of age during the ensuing decade and a half that preceded Operation Desert Storm. The resulting innovations that were set in motion during those years put the American air services and, eventually, NATO's air arms as well on a path towards gaining a winning combination of cutting-edge equipment, improved aircrew prowess and smarter ways of fighting. In that respect, America's failure in Vietnam was a defining experience for air power's subsequent maturation throughout the remainder of the twentieth century.

Air power's post-Vietnam transformation

By any measure, the role of US and allied air power in shaping the course and outcome of the 1991 Persian Gulf War reflected a major breakthrough in the effectiveness of the air weapon after a promising start in the Second World War and more than three years of costly misuse in the overly gradualist American bombing effort against North Vietnam from 1965 to 1968. During its epochal use against Saddam Hussein's Iraq, coalition air power was the *only* significant contributor to combat operations against the Iraqi army for thirty-eight straight days

until a four-day air-enabled allied land offensive was finally unleashed at the very end to complete the job against by then badly degraded Iraqi ground troops (Keaney and Cohen 1995).

After it was over, the Desert Storm experience confirmed that in the years after Vietnam, American air power had undergone a non-linear improvement in its ability to contribute to the outcome of joint campaigns at the operational and strategic levels, thanks to a convergence of low observability to enemy radar in the stealthy F-117, the newly acquired ability of combat aircraft to attack fixed targets consistently with high accuracy from relatively safe stand-off distances using laser-guided munitions, and the expanded battlespace awareness that had been made possible by recent innovations in air- and space-based platforms for providing accurate and timely intelligence, surveillance and reconnaissance (ISR).

The first decade after Vietnam also saw a surge of long-overdue attention in all American air services towards the unglamorous but essential needs of resource management and operational support. After all, satisfactory combat results require not just adequate weapons stocks and aircrew proficiency, but also an adequate sortie-generation capability. It soon dawned on airmen that the mere doubling of a combat aircraft force's sortie rate could nearly double the force's overall productivity, all other things being equal. More sorties per aircraft per day promised substantially increased leverage if those sorties were more uniformly combat effective.

Towards that end, designers devoted major efforts to make the latest generation of fighters less dependent on an elaborate logistics infrastructure by reducing the number of parts, increasing the accessibility of critical components, using line-replaceable avionics modules, and providing on-board systems that reduced the need for constant ground servicing. As a result of such efforts, besides increased concentration of fire, the new platforms promised to offer more sustained force application as a result of improved reliability and maintainability. The generation of fighters represented by the US Air Force's F-15 and F-16 and by the US Navy's and Marine Corps' F/A-18 offered far better in-commission rates than their predecessors, thanks to the increased durability of their avionics and the greater ease of repair permitted by exchanging line-replaceable modular units. Much of that heightened reliability resulted from the accompanying shift from an electromechanical era to a microelectronics era. Because it incorporated technology from the later generation, the F-16, for example, was able to fly upward of 65 per cent more sorties within a given period than could the F-4 of the previous generation, and it required only some twenty maintenance man-hours per flying hour, compared to forty-one for the F-4.

This enhanced maintainability and reliability was a truly novel design feature in modern aircraft development, and it contributed significantly to the confidence of commanders that their high-technology equipment would perform as expected when and as asked. In previous years, the reliability of an overall weapon system, defined as the mean time between failure of various essential on-board subsystems, was often shorter than the average duration of a combat sortie. That meant that a certain percentage of scheduled aircraft would never reach their assigned targets because something critical to the mission, such as the radar, would fail en route, forcing mission planners to build a margin of additional aircraft into a strike package simply to ensure that enough aircraft would make it to target to get the job done. With the reliability and maintainability improvements designed into the latest generation of fighters, in contrast, combat aircraft were typically likely to land after a mission in what is called Code One condition, namely, with all their systems in proper working order and the aircraft ready to launch again upon being refuelled and reloaded with weapons, with no repair actions needed.

As a result of these and other mutually reinforcing improvements, American air power during the decade after Vietnam finally acquired the capabilities needed to fulfil the long-standing promise of its pioneers of being able to set the conditions for winning in joint warfare. Yet it did so not through the classic imposition of brute force, as had been the case throughout most of air power's history, but rather through the *functional* effects now achievable by targeting an enemy's greatest vulnerabilities and taking away his capacity for collective action (Deptula 2001). The combination of real-time surveillance and precision target-attack capability that was applied to such telling effect by allied air power against Iraq's fielded ground forces in particular heralded a new relationship between air- and surface-delivered firepower, in which friendly ground forces did the fixing and friendly air power, now the predominant manoeuvre element, did most of the actual killing of enemy troops rather than the other way around (Lambeth 2014).

As attested by its remarkably effective combat performance in Desert Storm, air power was transformed over the preceding two decades to a point where it had finally become truly strategic in its character and potential effects. That was not the case before the advent of stealth, highly accurate target-attack capability and substantially improved battlefield information availability. Earlier air offensives had been of limited effectiveness at the operational and strategic levels because they simply took too many aircraft and involved too high a loss rate while achieving too few meaningful results. By the time of the 1991 Gulf War, however, air power had matured to a point where it could now make its presence felt quickly and could impose effects on an enemy from the outset of fighting that could have a determining influence on the subsequent course and outcome of a campaign. It was able to do so, to be sure, not by winning the war all by itself, but rather by enabling largely unopposed friendly ground manoeuvres, and thereby establishing and maintaining the needed conditions for achieving a joint force commander's objectives.

Perhaps first and foremost as a result of this transformation, US and allied commanders no longer had a need to amass forces as had been the case even in the recent past. Such advances as low observability to enemy radars and the ability to destroy or neutralise both fixed and moving targets with a single munition had finally obviated the need for the sort of cumbersome formations of strike and support aircraft that had typically been required in Vietnam. The large force packages that the US Air Force and US Navy routinely employed during their air war over North Vietnam offered the only way at the time for ensuring that enough aircraft would reach their assigned targets to deliver the number of bombs needed to achieve the desired result. By the time of Operation Desert Storm, in contrast, improved battlespace awareness, heightened aircraft survivability and serviceability, and increased weapon accuracy had rendered possible the *effects* of massing without actually having to mass. Thanks to that breakthrough, air power was now able to produce desired combat effects that had previously been unattainable. The only question now remaining was *when* those effects would be registered, not *whether*.

A new pattern of combat performance

When American and allied air power played such a central role in driving Iraq's occupying forces out of Kuwait in early 1991, many doubters tended to dismiss that remarkable performance as a one-of-a-kind force employment anomaly. It was, the doubters said, the clear and open desert environment, or the unusual vulnerability of Iraq's armoured formations to precision air attacks, or any number of other unique geographic and operational circumstances that somehow made the first Persian Gulf War an exception to the general rule that it takes 'boots on the ground' in large numbers, and ultimately in intensive head-to-head land combat, to defeat well-endowed enemy ground forces in high-technology warfare.

To many, that line of argument seemed reasonable enough when air power's almost singular contribution to the defeat of Saddam Hussein's fielded forces had been such an unprecedented historical achievement. During the dozen years that followed in the aftermath of Desert Storm, however, the world again saw American and allied air power prevail in broadly comparable fashion in four widely dissimilar circumstances, starting with NATO's two air-centric wars over the Balkans in Operations Deliberate Force in 1995 and Allied Force in 1999 and followed soon thereafter by Operation Enduring Freedom against al-Qaeda and the Taliban in Afghanistan in late 2001 and by the subsequent three-week major combat phase of Operation Iraqi Freedom in March and April 2003 that finally brought an end to Saddam Hussein's regime (Lambeth 2017).

What accounted for this unprecedented run of banner performance by modern air power? For one thing, almost every American and allied combat aircraft now possessed the ability to deliver precision-guided munitions. For another, the advent of stealth, as had first been demonstrated on a significant scale by the F-117 during the first Gulf War, was further advanced by the subsequent introduction of the US Air Force's second-generation B-2 stealth bomber that entered operational service in 1993. Finally, the advent of the satellite-aided GBU-31 Joint Direct Attack Munition gave mission commanders the ability to conduct accurate target attacks with near impunity, now around the clock and in any weather, against an opponent's core concentrations of power, whether they entailed fixed infrastructure assets or fielded forces.

In the three major wars after Desert Storm that saw American and allied combat involvement, the dominant features of the ensuing operations were persistence of pressure on the enemy and rapidity of execution, thanks to the improved data fusion that had been enabled by linking the inputs of various air- and space-based sensor platforms around the clock. Greater communications connectivity and substantially increased available bandwidth allowed constant surveillance of enemy activity and contributed significantly to shortening the sensor-to-shooter data cycle time. Throughout each campaign, persistent ISR and an ever-expanding use of precision munitions gave the United States and its coalition partners the ability to deny the enemy a sanctuary around the clock, in any weather, and not just as an exception but now as the rule.

Granted, in none of those instances, except for NATO's air war for Kosovo in 1999, did allied air power produce the ultimate outcome all by itself. However, in each case, successful aerial combat and support operations were the principal enablers of all else that ensued in producing the sought-after results at such a relatively low cost in friendly and non-combatant enemy lives lost. In light of those collective achievements, what was demonstrated by transformed air power between 1991 and 2003 was *not* a succession of anomalies, but rather the bow wave of a fundamentally new American and allied approach to force employment in which the air weapon had consistently turned in a radically improved performance compared to what it had previously delivered. Indeed, that newly emergent pattern had become so pronounced and persistent by 2003 as to suggest that modern air power had finally become the tool of first choice by combatant commanders, at least with respect to defeating large enemy force concentrations in high-intensity warfare. More important, they reflected an ongoing paradigm shift in combat style that promised to be of greater historical import than was the introduction of the tank at the beginning of the twentieth century.

Since then, mastering the sorts of lower intensity counter-insurgency challenges that have dominated more recent headlines around the world has highlighted modern air power's continued limitations as well as its strengths. Although today's means of air warfare have thoroughly transformed the ability of their possessors to excel in conventional warfare, those

same tools have yet to show comparable potential in irregular warfare. That has been so largely because irregular opponents like the current forces of the Islamic State in Iraq and Syria, given their asymmetric composition and tactics, including an intentional commingling of their combatants with innocent civilians, are less susceptible than conventional opponents to air power as currently configured, all the more so when national leaders have studiously insisted on prioritising non-combatant immunity over the often conflicting demands of prompt and assured mission achievement. Conversely, however, it is also true that the recent rise of irregular warfare as the pre-eminent concern of the United States and NATO today has been largely a result of opponents' forced response to air power's clear effectiveness in conventional warfare, a fact that attests to modern air power's unprecedented leverage at the same time as it spotlights the continuing challenges that air power faces.

Furthermore, although allied combat aircraft in these irregular engagements have often appeared less decisive in their effectiveness than in previous efforts against more traditionally configured opponents, air power has nonetheless remained both indispensable and central to the continuing war effort through its mostly non-kinetic but still key enabling contributions by way of armed overwatch, on-call close air support, inter- and intra-theatre mobility, medical evacuation and ISR. To mention just one especially revealing example of this continued relevance, the constant overhead presence of allied aircraft armed with precision weapons has made it infeasible for insurgents to concentrate their troop formations, thereby limiting the threat they might present to defending host-nation and coalition forces. Such a presence has been especially helpful in Afghanistan since the end of major combat there, where NATO forces over time have evolved a strategy entailing numerous small units scattered throughout the countryside in isolated outposts. Without the availability of omnipresent air power to provide resupply, ISR and on-call strike support as needed, those NATO outposts would be non-viable.

The operational face of air power today

In all, current and emerging air employment options now offer theatre commanders the promise of engaging and neutralising an enemy's military forces from stand-off ranges with virtual impunity, thereby reducing the threat to friendly troops who might otherwise have to engage undegraded enemy forces directly and risk sustaining high casualties. They also offer the potential for achieving strategic effects from the earliest moments of a campaign through their ability to attack an enemy's vulnerabilities with both shock and simultaneity. That transformation in capability, most recently dramatised by the air contribution to the three-week major combat phase of Operation Iraqi Freedom in early 2003, is the essence of modern air power's having come of age since the late 1970s (Lambeth 2013b).

For the United States, as the world's leading wielder and practitioner of air power, the most important features of this transformed capability acquired over time since Vietnam include:

- intercontinental-range bombers and fighter aircraft with operational persistence;
- a tanker force that can enable and sustain global strike operations;
- sustainable global mobility provided by an abundance of long-range airlifters;
- naval aircraft carrier strike groups capable of operating as a massed force;
- an increasingly digitised and interlinked force;
- unsurpassed ISR and a common operating picture for all;
- air operations centres worldwide as weapons systems in themselves; and
- operator competence and adaptability second to none in the world.

These modern air power equities, in turn, have given their possessors some new and unique capabilities, which now include:

- freedom *from* attack and freedom *to* attack for all friendly force elements;
- situation awareness dominance in all combat arenas;
- independence from shore basing for theatre strike;
- unobserved target approach and attack through stealth;
- consistently accurate target attacks day or night and in any weather;
- the ability to maintain constant pressure on an enemy;
- the ability to perform time-sensitive targeting routinely; and
- the ability to avoid unintended harm to non-combatants *almost* routinely.

Some of these recent attributes of modern air power, most notably operator competence and adaptability second to none in the world, are shared by many of America's closest allies. But the global reach, awareness dominance and sustainability attributes, along with air operations centres worldwide as weapons systems in their own right, are uniquely American contributions to the global air power equation.

Air power properly understood

Against the backdrop etched out above, we must note three important bounding rules to clarify what is really meant when we speak about air power. To begin with, air power does not refer simply to combat aircraft or to the combined hardware assets of an air arm, even though these are typically the predominant images of air power held by both laymen and professionals alike. Rather, in its totality, air power is a complex amalgam of equipment and less tangible but equally important enabling ingredients bearing on its overall effectiveness, such as employment doctrine, concepts of operations, training and tactics, leadership quality, adaptability, operator proficiency, boldness in execution and practical combat experience. These and related 'soft' factors vary enormously among air arms around the world operating superficially similar kinds, and often even identical types, of equipment. They also largely account for why some air forces are simply better and more combat effective than others. Yet all too often they are given short shrift in what typically passes for 'air capability' analysis. Only through their combined effects can one ultim - ately determine the extent to which raw hardware will succeed in producing desired combat outcomes. As always, the leverage of an air arm will continue to depend heavily on a complex blend of equipment and operator prowess, with weakness in either of these two categories likely to engender debilitating shortcomings in the effectiveness of the air posture as a whole.

Second, air power – like *any* form of military power – is inseparable from battlespace information and intelligence. True enough, as a result of the dramatic growth in the lethality of modern air power in recent years, it has become both correct and fashionable to speak increasingly not of the number of sorties required per target killed, but rather of the number of individual target attacks that can now be conducted during a single combat sortie. Yet that said, air power involves more than merely attacking and destroying enemy targets. It also involves knowing *what* to hit and *where* to find it.

Towards that end, advances in air- and space-based ISR capabilities lie at the heart of the recent transformation in modern air power's overall combat effectiveness. It is now almost a cliché to say that air power can kill anything it can see, identify and engage. To note a persistent shortfall in air power's leverage, however, it can still kill *only* what it can see, identify and engage. Air power and actionable real-time intelligence are thus opposite sides of the same coin. If the

latter is unavailing in circumstances in which having it is essential for mission success, the former is likely to be unavailing also. For that reason, accurate, timely and comprehensive information about an enemy and his military assets is not just a crucial enabler for allowing air power to produce pivotal results; it is also an indispensable *precondition* for ensuring such results. In this regard, it will be in substantial part through continued improvements in air- and space-based ISR capabilities that the US Air Force's long-sought ability to find, fix, track, target, engage and assess any target of interest on the Earth's surface will eventually become an established reality rather than merely a catchy vision statement offering great promise.

Third and last, air power, properly understood, knows no colour of uniform. It entails not just the aircraft, munitions and other assets maintained by a nation's formally designated air force, but an astute harnessing of *all* the diverse equities fielded by the nation's various armed services that exploit the medium of air and space to visit combat effects on enemy targets. Recognition and acceptance of the fact that air warfare is an activity in which all combatants that operate in the vertical dimension have important roles to play is an essential precondition for a full appreciation of air power's evolved role in modern warfare.

Unique and enduring features

For all its distinctive attributes summarised above, air power has by no means become a tool offering an answer to every conceivable security challenge that might arise. On the contrary, the spectrum of possible circumstances that could test a joint force commander is so diverse that one can never say for sure that any single force element will always predominate. On the contrary, although air power as it has evolved since the mid-1970s has now made possible the application of new concepts of operations, ultimate success in major theatre wars will, as before, continue to require the involvement of all force elements in an appropriately balanced and integrated fashion.

That said, however, today's air and space capabilities are now configured to allow commanders to conduct their operations against enemy forces more quickly and efficiently than ever before. Thanks to precision, stealth and expanded information availability, airmen are now able to apply air power as first envisioned by its early advocates, yet not in a way in which those advocates could even remotely have foreseen and recognised. True enough, *all* force elements – ground and maritime as well as air – have gained the opportunity in principle to seek decisive combat effects by making the most of new technologies now at their disposal. What is singular and unique about air power, however, is that it has lately pulled well ahead of competing surface forces in its *relative* ability to do this, thanks not only to its recently gained advantages in stealth, all-weather precision and information dominance, but also to its long-abiding signature characteristics of speed, reach, ubiquity and flexibility.

Furthermore, air power in its broadest sense, to include its critical ISR, space and cyberspace components, has fundamentally altered the way a coalition might best fight any major wars in the near-term future through its ability to fulfil functions traditionally performed at greater cost by surface forces. Thanks to these new capabilities, allied air power now offers the promise of being the swing factor in an ever-widening variety of situations. Indeed, as we have seen in virtually all of the US and NATO combat involvements worldwide throughout the twenty-first century so far, the predominant pattern of overall joint force employment suggests that the principal role of land power in major combat may now be increasingly to *secure* a win rather than to achieve it.

In enabling this progressive reversal of roles between air and land forces since the mid-1970s, the first, and by far most important, pay-off of air power's transformed capability has entailed

increasing the situational awareness of friendly forces while denying it to the enemy. The various air- and space-based ISR capabilities now available to the United States and its allies offer greatly improved knowledge of a battlespace situation. Such an information advantage entails a major breakthrough in targeting capability and one that, in conjunction with high-accuracy attack systems, has made for a uniquely powerful force multiplier.

Indeed, the broad area of sensor fusion is perhaps more pivotal than any other single area of technology enhancement in the realm of air power, because it is the *sine qua non* for extracting the fullest value from the new options for achieving desired combat effects that modern air power developments have made available to joint force commanders. Thanks to the much-improved awareness picture it now promises, this synergistic fusion of information and precision attack capability will strengthen the hands of warfighters up and down the chain of command, from the highest level to individual shooters working within tactical confines.

A second pay-off area worth emphasising is the broadened ability of air power to do things it could not do before, as well as to accomplish more with less for a joint force commander. On the first count, it has shown the ability of such a commander to maintain air dominance over the heart of an enemy's territory, enforce no-fly and no-drive zones, and engage enemy armies effectively from relatively safe stand-off ranges. On the second count, increased information directability has enabled reduced mission-conduct cycle time, yet another force multiplier which creates a larger apparent force from smaller numbers by permitting a higher operations tempo.

A third major pay-off afforded by recent air power improvements is situation control from the outset of combat, such that the first blow can now decide the subsequent course and outcome of a war. Air power now permits the attainment of strategic goals through simultaneity rather than through the more classic sequence of methodical plodding from tactical through operational-level to strategic goals by means of gradual attrition at an exorbitant cost in lives, forces and national treasure expended. This is quite different from what Giulio Douhet and those air warfare theorists who first followed him envisaged (MacIsaac 1986). It also goes well beyond anything that the iconic Prussian military strategist Carl von Clausewitz might have imagined (Clausewitz 1976 [1832]). Air power now has the ability to cause the early disruption of an enemy's war-making potential. Yet its main objectives are no longer just the familiar ones of leadership, infrastructure and economic potential that are key to any nation's political and societal organisation and coherence, but also those assets that make up an enemy's fielded forces and capacity for organised combat action. In light of recent developments in the realm of cybernetic warfare, the initial attack can now even be surreptitious – for example, by means of an air-delivered digital strike into an enemy's computer systems to pave the way for fire and steel to follow.

Finally, the transformation of modern air power in recent years has enabled the maintenance of constant pressure on an enemy from a safe distance, increased kills per sortie, selective targeting with near-zero unintended damage, substantially reduced reaction time, and, at least potentially, the complete shutdown of an enemy's ability to control his forces. These and other pay-offs in no way add up to all-purpose substitutes for ground forces. However, they can now permit joint force commanders to rely on air power to conduct deep battle for the greater extent of a joint campaign, foreshadowing an end to any need for friendly armies to plan on conducting early close-manoeuvre ground combat as a standard practice.

Conclusion

To conclude this stage-setting overview, the most careful advocates of air power in today's strategy debates are the first to concede that air power can be decisive in many but not all conflict situations and that in some cases, it will play only a supporting role to other combat

arms (Lambeth 2013a). However, they are also quick to add something else close but with an important difference, namely, that air power can now generally create the requisite conditions for achieving desired combat outcomes by making the endgame of any major conflict relatively effortless for all other force components. Today, thanks to the offerings of mature conventional air power as it has evolved since the mid-1970s, American and NATO commanders have the ability to locate, attack and destroy enemy ground forces in large numbers without having to engage in direct fire engagements by halting them and rendering them ineffective from stand-off ranges while denying them the ability to inflict casualties on friendly ground troops through return direct fire. In realising and duly assimilating that signal breakthrough, they have grasped the true meaning of air power's final coming of age since Vietnam.

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2

AIR POWER AND HIGH COMMAND

Alan Stephens

For the past one hundred years the senior commanders of advanced air forces clearly have been doing something right. During most of the twentieth century and for all of the twenty-first century, Western air power has enjoyed a sustained level of supremacy within a particular combat domain arguably the equal of any in history. Furthermore, the extent of that supremacy has continually increased. Domination in the air was hard won in the First and Second World Wars, but since 1950 it has progressively been achieved faster and more comprehensively in Korea, Vietnam, Iraq (twice), the former Republic of Yugoslavia (twice), Afghanistan, Libya, and Iraq–Syria. The contrast with the West's experience in surface warfare in the past seventy years is so striking that it cannot pass unremarked. With the exception of the 1991 Gulf War, since 1945, Western land forces have been singularly unsuccessful in achieving their military objectives, let alone anything vaguely resembling supremacy. The point here is less about armies and more about air power's remarkable record of achievement.

To continue setting the context for this study, elaboration of the terms 'advanced' and 'Western' is necessary since, like most broad categorisations, they are subject to exceptions. Nevertheless, they remain valid and instructive.

Many nations and interest groups have been able to assemble effective land forces, but few have been able to construct sustainable, first-rate air forces. Most lack the essential components, namely: a comprehensive and high-quality education system, a strong industrial and research and development base, a sound economy (air power is expensive), and visionary leadership. Consequently, in the main, advanced air power has largely been the province of the political–ideological–economic bloc known as 'the West'.

In particular, the drivers of this achievement have been the United Kingdom until the 1960s, and the United States until today. Every contemporary advanced air power has benefitted at some stage from the professional, intellectual, and technological leadership of either or both of the Royal Air Force (RAF) and the United States Air Force (USAF) and their predecessors.

As mentioned above, there are exceptions. For example, there have been world-class 'non-Western' air services, such as those of the Japanese Army and Navy in the 1930s and 1940s; however, a central factor in that achievement was Japan's early access to British technology, training, and ideas. More recently, other Asian nations, including Singapore, South Korea, and Taiwan, have developed strong air power models; again, however, all have been greatly assisted

by their affiliation with advanced Western air forces such as the USAF, the RAF, the Royal Australian Air Force, the Israeli Air Force, and France's Armée de l'air.

There are also the cases of Russia and China, neither of which is categorised as Western but each of which is today regarded as an advanced air power. Both, however, have their limitations.

The Red Air Force was highly effective during the Second World War but it never developed a genuine strategic dimension, serving instead primarily as an adjunct to the Soviet army. Subsequently, its doctrine, training, and operational practices were notoriously rigid and controlled (like Soviet society itself), constraints that among other things inhibited the development of the most advanced combat procedures (Kainikara 2007). The adverse consequences of that model have been exposed in the dismal performance in war of numerous client states. Despite operating modern aircraft and weapon systems, the air forces of Egypt, Syria, and Iraq, which were lavishly equipped, trained, and indoctrinated by the Soviets/Russians, have been routinely outclassed – indeed, humiliated – in their clashes with British, American, French, and Israeli air forces from the late 1940s onwards. No less damning was the reported alarm of senior Russian commanders when they witnessed the manifest doctrinal, operational, and technological superiority of Western air forces, particularly those of the US, during Operation Desert Storm in 1991 (Villahermosa 2016). As the importance of contemporary air combat capabilities such as the real-time exploitation of information, sensor fusion, networking, and decentralised authority continues to grow, question marks must remain with regard to the Russian air force's competitiveness.

As to China, the People's Liberation Army Air Force fought with a degree of individual and organisational proficiency in the classic air-to-air campaign between MiG-15 and F-86 jets overhead the Yalu River in Korea in the early 1950s, and is at present in the process of a potentially revolutionary modernisation programme. Thus far, however, its operations and ideas – that is, the achievements or otherwise of its senior leadership – have had minimal impact on the development of global air power.

With that context in mind, this chapter examines the successful model of high command purposefully constructed by air power's most important first-generation Western leaders: Marshal of the Royal Air Force Hugh Trenchard; Brigadier General William Mitchell; and General H. H. Arnold. The model established by those great high commanders rests on four key components: organisation, intellect (strategy), politics, and inspiration (leadership). The chapter then examines the model's subsequent application, and identifies the challenges facing today's high commanders.

Trenchard – purpose and vision

In the one hundred years of systematic aerial warfare, only a handful of countries have been able to develop effective, balanced, and sustainable air power. Most have lacked the essential combination of technical, financial, and human resources. That combination was first translated into organisational form by Hugh Trenchard, chief of staff of the world's first air force, the Royal Air Force.

Trenchard was a strong personality, an excellent organiser, and a skilful political operator, but it was his vision and intellect that above all else made him a towering figure in British and global air power in the period between the First and Second World Wars. His inability to express himself fluently has occasionally been taken as an indication of a mediocre mind, and suggestions have been made that his claims to intellectual distinction rested largely on the literary skills of his aide-de-camp, the Cambridge-educated man of letters Maurice Baring.

Nothing could be further from the truth. As Trenchard's biographer wrote, 'in the scores of official papers which stand out like milestones in the development of [British air power], the strain of prophecy … is Trenchard's' (Boyle 1962: 146). In the words of Trenchard himself, 'An air force can't be built on dreams [but] it can't live without them either, and mine will be realised sooner than you think' (ibid.).

British air power developed squarely from the base of Trenchard's vision and professional mastery. Under his leadership the essential building blocks were put in place or consolidated: a central flying school to set and maintain standards; research and development establishments to build the technological edge; a cadet college at Cranwell to produce the future leaders; a staff college at Andover to give those leaders the finishing touches; and an apprentice scheme to train the mechanics. Implicit in Trenchard's model were two external components: a strong national economy and a progressive, broadly based education system, because advanced air power is expensive and requires a skilled workforce. Nothing has changed since then. The Trenchard model has been emulated by effective air forces ever since, and without it no high commander, regardless of his personal attributes, is likely to succeed.

Trenchard complemented his organisational achievements with a forceful and persistent contribution to the defence debate in both the military and political domains. His concept for the employment of air power was uncompromisingly aggressive. In part, that approach was related to Trenchard's determination to preserve the RAF as a separate service, for it was offensive action, expressed through the relatively untested but psychologically compelling notion of strategic bombing, that underpinned the RAF's claim to equal and independent status with the older services (Webster and Frankland 1961: 54). There was, however, much more to his position than mere parochialism. His directive of 1916 titled 'Future Policy in the Air', written when Trenchard was a general and the Royal Flying Corps was a corps of the British Army, remains to this day the classic expression of the intrinsically offensive nature of air power (Trenchard 1990).

Trenchard's belief in an unremitting offensive initially did not extend to the notion of strategic bombing, but instead applied only to the use of tactical air power over the battlefield. The job of arguing the case for the bomber was left to others, such as the South African soldier-statesman Jan Smuts, the influential newspaper commentator Brigadier P. R. C. Groves, and Captain B. H. Liddell Hart, all of whom promoted the idea of making war-winning strategic strikes from the air against an enemy's munitions industry, submarine force, and moral and political heart and brain.

That early hesitation does not, however, detract from Trenchard's status as the pre-eminent voice in British air power strategy. Soon a convert to the notion of strategic bombing, he became its most effective proponent, adapting whatever he needed from the work of others, adding his own forceful ideas and unique experience, and then providing the political and institutional leadership necessary to turn beliefs firstly into policy and then into force structure. It was Trenchard who gave the idea of strategic bombing form and official status.

In addition to formalising the airman's belief in the offence, Trenchard was the driving force behind the novel concept of 'substitution', known also as 'air control' and the 'air method'. The proposition was simple: in many circumstances, air forces could be substituted for land or naval forces, and do the job effectively at far less cost in terms of casualties and cash. With the support of Winston Churchill as the Minister for War and Air, Trenchard applied the strategy in British territories in the Middle East and on the Northwest Frontier throughout the 1920s, using the RAF instead of the army to control vast, remote areas. Basically, errant communities were given a warning, sometimes by a note dropped from the air. If they remained refractory, the RAF would conduct bombing attacks, usually against high-value targets such as crops or herds of

animals, often at pre-warned times. Attacks could be sustained if necessary, in effect blockading a village (Portal 1959).

Substitution was not always successful, particularly when rugged terrain and/or nomadic peoples made targets difficult to find and attack. However, when geography and demography were favourable, the concept could be highly effective. Iraq, for example, proved an ideal location for the innovative application of air power in 1921 (just as it did seventy years later in the First Gulf War), when five RAF squadrons without any army units in support were successfully substituted for thirty-three Imperial battalions, reducing the annual cost of the garrison from £20,000,000 to less than £2,000,000 (Aircraft 1928).

Part of the appeal of substitution for airmen was the fact that the concept best suited forces that could rapidly be deployed and change roles, and that it placed few friendly lives at risk. In other words, the concept applied far more to the employment of air power than it did to either sea or land power.

Not surprisingly, the strategy was intensely disliked by the British Army and, to a lesser extent, the Navy, and the substitution debate was perhaps the most contentious issue in British defence circles in the late 1920s and early 1930s. Trenchard and his supporters remained undeterred, as they sought to introduce the practice as widely as possible (Slessor 1956: 45–75). Similarities can be seen between Trenchard's early innovative application of air power and the West's equally successful substitution of air for massed armies in the West's campaigns in the former republic of Yugoslavia in 1995 and 1999, and in Iraq, Afghanistan, Libya, and Syria since 2008.

In addition to his masterful contribution to organisation and strategy, Trenchard sought to secure his legacy by mentoring a cadre of exceptional younger officers. Few senior officers can claim to have groomed future leaders the equal of Charles Portal, John Slessor, and Arthur Tedder (Boyle 1962). Trenchard's influence also extended to the US, where he was admired by William Mitchell and Henry Arnold, among others.

Trenchard continued to play an active role in the defence debate following his retirement from the RAF in 1930. He was politically influential, remaining on good terms with numerous national leaders, not least Winston Churchill, and widely respected. In other words, he assumed the role of a de facto high commander for air power.

Mitchell – courage and inspiration

The notion that one of a high commander's primary responsibilities is to give his cause a public and political voice was taken to the extreme by the American brigadier general William 'Billy' Mitchell. Passionate and outspoken in his beliefs, particularly regarding the independence of air forces, Mitchell had an over-riding faith in the inevitable dominance of air power through offensive action. A key factor in that belief was his perception of the continually increasing technical superiority of aircraft over other machines of war.

The son of a wealthy US senator, Mitchell joined the US Army in 1898 after graduating from college. Despite being a member of the Army, he was soon predicting that future conflicts would be decided in the air. A member of the Signal Corps (which initially controlled Army aviation), Mitchell took private flying lessons and quickly became one of the leaders of American military aeronautics. In 1916 he was appointed chief of the air service of the US First Army.

Following the US's late entry into the First World War, Mitchell arrived on the Western Front in France in April 1917 and immediately began to make an impact with his inspirational leadership. He formed professional relationships with Trenchard and other senior allied air

commanders, studied strategies and technologies, inspected facilities, and flew on operations. In September 1918 he led some 1500 allied aircraft in the successful air campaign at the Battle of Saint-Mihiel. By the end of the war he had become America's pre-eminent airman, commanding all US air combat units in France.

But Mitchell had alienated many senior officials with his outspoken advocacy of air power, and for the next eight years his career was defined by his highly publicised fight with the Army and Navy. Never one to take a backward step, Mitchell frequently exceeded the bounds of military discipline; indeed, it seems he may have been deliberately insubordinate in his efforts to gain publicity for his cause. As well as infuriating many senior officers, he irritated civilian officials, with the then-assistant secretary of the Navy and future president Franklin D. Roosevelt denouncing Mitchell's ideas as pernicious. Be that as it may, as the Second World War was to demonstrate, a case can be made that many generals and admirals remained wilfully ignorant of technological progress and were simply not interested in listening to Mitchell's reasoning.

Mitchell's style may have been confrontational, but in the circumstances it was justifiable. The establishment's obdurate mindset meant that attempts to work within the system were pointless, so Mitchell decided to bypass it. Almost single-handed, he gave American air power a vision and a public voice. Two events defined his idiosyncratic but powerful model of high command: first, the *Ostfriesland* bombing demonstrations in mid-1921, and second, his court-martial in 1925.

The remarkable development of aircraft, weapons, and tactics during the First World War had convinced Mitchell that capital ships could be sunk from the air. If he was right, this would represent a dramatic shift in the nature of warfighting, and would among other things imply that the defence of the continental US might be best achieved by strengthening the air service at the expense of the Navy.

In late 1920, the US Navy's leaders tried to block further debate on the 'aircraft versus ships' controversy by conducting a trial in which Navy aircraft 'bombed' an old battleship. Always intended to 'prove' that aircraft could not sink ships, the trial was a farce – indeed, fraudulent – because the Navy aircraft dropped inert weapons (Correll 2008). Nevertheless, the Navy issued a statement claiming that the trial had 'pointed to the improbability' of a modern warship being either destroyed or put out of action by aerial bombing.

Boosted by public support, Mitchell managed to circumvent the air power deniers and gained official approval to conduct his own trials. But still the Navy went to extreme lengths to obscure rather than reveal the truth, setting rules of engagement that imposed unrealistic limitations on aircraft numbers, bomb loads, and the intensity of attacks, with the intention of minimising the possibility that any ships might be damaged.

The trials commenced off the Norfolk, Virginia, coast in June 1921, with bomber aircraft from Mitchell's First Provisional Air Brigade authorised to attack a number of stationary surplus warships. Large numbers of officials and news reporters were present to observe the results. A dramatic climax was reached on 21 July when Mitchell's crews sank the captured German dreadnought *Ostfriesland* with 2,000-pound bombs, stunning senior Navy officials.

This was a moment of the first order in the history of combat. *Ostfriesland* had been built to be 'near-unsinkable', and had in fact survived severe punishment from British warships during the battle of Jutland in mid-1916. Now, contrary to most expert (naval) opinion, she had been destroyed from the air. From then on, reasonable men had to regard surface ships operating without air cover as being at risk; furthermore, they also had to regard aerial bombing as a warfighting capability of immense potential. The problem for Mitchell, however, was that he was not dealing with reasonable men, and within official circles the trials were largely ignored.

While the government and the Navy continued to dissemble, Mitchell turned his attention to the intellectual dimension of air power. In 1922 he visited Europe, where, among other things, he held frequent discussions with Giulio Douhet. Not long afterwards extracts from Douhet's *The Command of the Air* began to appear at US Army planning and education centres. In 1925 Mitchell published *Winged Defense*, a book about the economic and military possibilities of air power that remains a basis for doctrine today (Mitchell 1925).

Despite the momentous implications of the sinking of the *Ostfriesland*, vested interests continued to frustrate Mitchell; consequently, his public comments became increasingly inflammatory. He finally went too far in September 1925 when, following a series of Navy and Army flying accidents, he publicly accused the two service's leaders of a degree of incompetence in their management of national defence tantamount to treason. A month later charges leading to his court martial were issued on the order of President Calvin Coolidge, who called Mitchell a 'God-damned disturbing liar' (Clodfelter 1997: 103).

Mitchell's trial attracted considerable interest. Despite strong public and press support he was found guilty, not because of his claims on behalf of air power, which clearly had been vindicated, but because of insubordination. He was suspended from active duty for five years. A month later, in February 1926, Mitchell resigned from the Army. From then until his death ten years later he continued to promote air power through lecturing, writing, and lobbying.

Mitchell's deliberate courting of controversy sometimes offended as much as it pleased. Still, as the eminent publisher George Putnam wrote in his preface to *Winged Defense*, 'Prophets … aren't always highly regarded at home'. Franklin D. Roosevelt was one early critic who changed his opinion, promoting Mitchell posthumously to major general in 1942; presumably the realities of being president during a world war had given Roosevelt a better understanding of Mitchell's fearless advocacy of air power twenty years previously.

Mitchell's legacy has been profound. At a time when the future of independent air power was not merely under siege from armies and navies but subject to mendacious opposition, his leadership as typified by the *Ostfriesland* trials and his court martial epitomised courage in high command.

Mitchell's model of leadership may not have general applicability; on the contrary, in many settings it may be counterproductive. But certain circumstances call for certain behaviour. Situations arise in which the conventional metrics of conduct become secondary: when circumstances are so unusual (and in this instance unfair) that a commander's first duty is to expose the truth. Billy Mitchell's contribution to air power and high command may have been different, but the passing of time has shown it to have been necessary, inspirational, and enduring.

Arnold – an air power master class

If Trenchard was air power's prototype high commander and Mitchell its necessary populist champion, then Henry Harley 'Hap' Arnold conducted its first master class.

A reluctant graduate into the US Army's infantry (he had wanted cavalry) from West Point in 1907 assigned to the US Army's infantry (he had wanted cavalry), Arnold undertook flight training at the Wright brothers' school in 1911. For the next two decades his experience was eclectic. One of the US's top-rated military aviators, he set numerous flight records and won prestigious awards. He also excelled in appointments associated with operations, engineering, management, doctrine, research and development, and logistics. Despite periodic setbacks caused by his criticism of the Army's indifferent aviation policy, Arnold's obvious intellect and strength of character invariably saw him surmount difficult times. Moral support during those

episodes often came from George C. Marshall, whom Arnold had met when both were lowly lieutenants and who became a lifelong friend and mentor.

An ally of Billy Mitchell, Arnold tempered his early radicalism – at one stage he, too, was threatened with disciplinary action because of his advocacy of air power – and learned to work within the political and military establishments. His professional excellence was complemented by a farsighted contribution to strategic thinking that included writing influential articles and books, and mentoring advanced technologies such as intercontinental bombers, jet propulsion, radar, and atomic weapons. He rose rapidly through the ranks and in 1938 was appointed chief of the US Army Air Corps.

Arnold's leadership of the US Army Air Forces (USAAF) during the Second World War was magisterial. Under his guidance the service grew one-hundred-fold into the world's best air force and the most devastating military weapon in history. Arnold was knowledgeable, intelligent, politically astute, and strategic in his thinking. Considerate and popular in his professional relationships, Arnold was nevertheless capable of making hard decisions and did not hesitate to dismiss underperforming friends. He could persuade presidents, politicians, and generals; plan grand strategy; direct campaigns; organise and manage the USAAF's extraordinary growth; guide industrial activity and research and development; and inspire loyalty (Daso 2000). Furthermore, he never forgot that the single most important factor in any undertaking is good people, mentoring men who were to become leading names in military history, such as Carl Spaatz, George Kenney, Jimmy Doolittle, Ira Eaker, Haywood Hansell, and Curtis LeMay.

Arnold's final contribution to our understanding of what it means to be a high commander took two separate forms. The first was the establishment at his direction in 1945 of Project RAND, which subsequently grew into the RAND Corporation, arguably the world's most influential think tank for air and space power research for the past seventy years. The second was an article he wrote that same year titled 'Air Power and the Future' (Arnold 1945). Masterful in its vision, clarity of thought, and grasp of key issues, the paper remains a blueprint for advanced air power today.

The paper comprised three main sections: a definition of the characteristics of air power; an analysis of the lessons from the Second World War; and a proposed structure for the post-war American air force. Arnold started with an observation that remains central to airmen and high command. Wars, he reasoned, were no longer the sole province of fighting forces, but instead touched entire nations. Air power had made it possible to bypass all lines of defence to deliver devastating blows at economic, industrial, governmental, and population centres within hours rather than the weeks or months required by surface forces. Because of air power, surface forces now had to be sufficiently mobile and/or dispersed to avoid detection and destruction from the air. Accordingly, control of the air had become the first essential for offence as well as defence. Arnold acknowledged that an advanced air force would not alone be sufficient to protect a nation, but without that now-dominant element of combat power there could be no national security.

Arnold identified two major lessons from the Second World War, each of which emerged from a failure of German leadership. The Nazis had underestimated the power, technological resources, and determination of the RAF during the Battle of Britain; and they had neither understood nor adopted the strategic uses of air power. If American and allied air forces were to avoid similar mistakes in the future, their leaders would have to display 'imagination [and] boldness' (Arnold 1945).

In a seminal passage, Arnold argued that an air force is always verging on obsolescence, and that in times of peace its size and replacement rate will always be inadequate to meet the

demands of war. That led to a fundamental proposition. National security would be endangered, he wrote, by an air force whose doctrine was tied 'solely to the equipment and processes of the moment'. It is essential, Arnold concluded, for an air force to 'keep its doctrine ahead of its equipment and its vision far into the future'. Experience in war has shown this to be an enduring dictum for the high command of air power.

High command in the twenty-first century

For seventy years now, the West's airmen have delivered a national security capability whose dominance arguably has been unequalled in any domain. By definition, every great commander has been an outstanding leader with a deep knowledge of his (thus far there have been no great female air commanders) profession, encompassing operations, logistics, personnel management, organisation, training, technology, and research and development. However, even more important than their mastery of those foundations of advanced air power has been their commitment to innovative, even daring, strategic thinking, and their courage in not shirking the political battles that inevitably attend high public office.

The careers of Trenchard, Mitchell, and Arnold spanned some four decades. Throughout that lengthy period each of them had to deal with the determined ignorance – indeed, in many instances, the wilful obstructionism – of Army and Navy counterparts who refused to comprehend the implications of air power's ever-increasing importance as the West's single greatest military comparative advantage. Regrettably, that attitude is still prevalent, most noticeably in the development of operational strategies.

If we trace the West's combat experiences from 1950 to 2017 – that is, from the Korean War through to Vietnam, Iraq (twice), the former Republic of Yugoslavia (twice), Afghanistan, Libya, and Iraq/Syria – we find that, broadly speaking, the West dominates in the air and struggles on the ground. Yet in every one of those wars, Western campaign planning started with a land-centric bias. Even worse, in all but the Korean War that bias was shaped by an uncritical, almost faith-based belief in the cult of counter-insurgency warfare, defined by self-referential slogans such as 'fight amongst the people', 'seize and hold ground', 'win hearts and minds', 'the three-block war', and so on (Bacevich 2010: 196–205). This approach exposed a mindset that was inexcusably dismissive of the values of the countries Western forces invaded. What was their history? What did their religious beliefs imply? What did their thousands of years of distinctive social mores indicate? How had previous invasions fared? How did they regard the West? And so on. The fact is that it is very difficult to 'fight amongst the people' when most of those people do not want you there.

At this juncture two crucial points must be made. First, despite repeated failure for more than sixty years and through nine campaigns, the West's high commanders persisted with a flawed military strategy. They were abetted in this abrogation of duty by politicians who were either guilty of the same strategic hubris or did not know enough about modern warfighting to do anything. It is also fair to question the inability or unwillingness of numerous air power high commanders to influence the public debate during this period.

Second, when in the recent past a handful of air power strategists in the United States did develop alternative strategies, their work was not merely criticised, but censored. Reminiscent of the institutional obstructionism faced by Trenchard and Mitchell, this perverse attitude towards intellectual discourse warrants elaboration, through the examples of the 'Rapid Halt' and 'Effects-Based Operations' (EBO).

A general model for theatre-level (land-centric) warfare involves three stages: first, halt the enemy's advance; second, build up one's own forces; and third, launch a counter-offensive. The

model is favoured by armies, whose innate slowness to deploy and reinforce makes stage two critical if they are to play a pre-eminent role in stage three. During the 1990s, strategists from the USAF proposed a variation to the concept, with which they planned to leverage the US's greatest military comparative advantage by substituting air power for land power. Many Third World armies fight very well close up, where they can use their massed numbers and disregard for casualties to advantage: the point is to deny them that opportunity. Consequently, the phases of the USAF's 'Rapid Halt' concept were: first, halt the enemy army's advance (with air power); second, punish the enemy rapidly (with air power); and third, having seized the initiative, choose what to do next from any one of a number of options, such as impose sanctions, attack the enemy leadership, build up one's own forces, seek a diplomatic end-state, do nothing, and so on.

As General Arnold had noted half a century previously, military forces can only be as good as their ideas. By any measure the Rapid Halt represented innovative, high-quality thinking and warranted an open and full debate. Regrettably, when the USAF chief of staff presented the idea to the Joint Staff, it was rejected outright by the Army. In what to a disinterested observer seems to have been an extraordinarily narrow-minded action, the (Army) then-chairman of the Joint Chiefs of Staff, General Henry Shelton, ordered all references to the concept to be 'excised' from joint documents (Grossman 2001).

It is noteworthy that only several years after General Shelton censored the term 'Rapid Halt' from the military lexicon, US air strike crews executed a de facto application of the concept during a stunning victory they won against two divisions of Saddam Hussein's elite Republican Guard. In late March 2003 those divisions were deployed eighty kilometres south of Baghdad with instructions to stop the advance of allied forces. Instead, the Guards were themselves 'halted' by a concentrated and precise aerial bombing offensive that ignored a seemingly impenetrable sandstorm to inflict heavy losses.

Perhaps if the notion of the Rapid Halt had been fully debated it would have been exposed as conceptually and operationally deficient; alternatively, perhaps it would have been revealed as an important addition to strategic thinking. But any conclusion one might reach regarding the Halt Phase (or any other concept) is not the point. In the interests of identifying the best possible strategies, ideas should be encouraged and their merits or drawbacks fully examined. Censorship can only stifle initiative and inhibit progress, and its enforcement represents the antithesis of high command.

Precisely the same kind of regressive mindset was exposed when the notion of 'Effects-Based Operations' was promoted by air power strategists during the First Gulf War in 1991. Prompted by quantum improvements in information systems and weapons, which in combination enabled highly accurate targeting, EBO campaign planning focused on desired effects (outcomes) using a minimum of force, rather than on traditional force-on-force 'targeting for destruction' operations, which may or may not represent a desired outcome (Deptula 2001). EBO thinking was at the heart of the extraordinarily successful air campaign that dominated the First Gulf War (noting that its logic is not confined to any single form of combat power).

Yet apparently because of EBO's air power origins, the concept was resisted, then censored, rather than debated, by opponents in the land forces. The nadir was reached in 2008 when, in an article published in *Joint Force Quarterly*, the then-commander of the US Joint Forces Command (USJFCOM), Marine general James N. Mattis, ordered that 'effective immediately, USJFCOM will no longer use, sponsor, or export the terms and concepts related to EBO' (Mattis 2008). Seemingly determined to prove his immunity to contemporary thinking, Mattis went on to endorse Carl von Clausewitz's nineteenth-century model of warfare, derived from such archaic concepts as mass (as in very large numbers), taking and holding ground as an end

in itself, force-on-force, close engagement, and attrition. It was a view of strategy and warfighting that seemed to owe more to the First World War than to the twenty-first century.

It is to the credit of *Joint Force Quarterly* that its next edition published a critique of General Mattis's article written by two middle-ranking USAF officers (Carpenter and Andrews 2009). And it is to the credit of the US military establishment in general that the debate on EBO did not go away, unlike USJFCOM, which was disestablished in August 2011. Indeed, for the past decade, the efficacy or otherwise of EBO has been a perennial topic at academies and in professional journals, which is as it should be. Strategic thinking should be informed by best interest, not self-interest.

Still, it is easier to cling to the past than to prepare for the future. Presenting the prestigious Robert O'Neill War Studies lecture in Canberra in May 2016, the prominent American Army soldier-scholar Lieutenant General H. R. McMaster somehow managed to attribute the failure of his service's counter-insurgency strategy in Afghanistan and the Middle East between 2001 and 2015 to 'air power doctrine from the 1920s and 1930s' (McMaster 2016). General McMaster did not elaborate on his bizarre assertion, but his curious logic did at least serve the purpose of reminding us that the contest of ideas is unceasing.

Conclusion

For most of the history of warfare, soldiers have dominated the higher command of defence forces. Closing with the enemy and occupying his territory almost invariably have been necessary conditions for achieving military objectives; consequently, strategic thinking has properly concentrated on armies. However, during the past seven decades, it has become evident that war is now concerned more with acceptable political outcomes than with seizing and holding ground, and that concepts of warfighting derived from a Clausewitzian devotion to mass, force-on-force engagements, and attrition are obsolescent. It has also become evident that air power has continually expanded its ability to influence – indeed control – events in all domains.

Since 1914, airmen have had to fight a constant war of ideas to ensure that their distinctive capabilities have been understood. Periodic lapses in the necessary intellectual effort almost invariably have been accompanied by increased ignorance of and, therefore, resistance to those ideas.

It is self-evident that a high commander must possess professional mastery in operations, planning, organisation, technical development, research, logistics, personnel management, and so on. That skill set does not, however, satisfy the definition of a true high commander. The great challenge for great leaders lies within the contest of ideas, because it is that contest that shapes the strategies, concepts of operations, and force structures that in turn determine how we can fight and win.

As the world enters the era of a Fourth Industrial Revolution, that challenge has assumed even greater importance. The shift from analog to digital technology that started in the late 1950s and that gained momentum in the 1970s has now reached lift-off speed because of innovations such as computers, the Internet, robotics, 3D printing, and artificial intelligence. Like its predecessors, the Fourth Industrial Revolution is likely to create dramatic social change, in this instance by hollowing out workforces by up to 80 per cent as people increasingly are replaced by robotics (Fox and O'Connor 2015).

Because air power is an intensely technological business, its practitioners should be well placed to prosper in this new environment. Air forces have always sought to substitute machines for manpower, a methodology that will become even more relevant as the latest

industrial revolution enhances the already formidable capabilities of remotely controlled and increasingly autonomous weapon systems.

It is not yet clear whether these revolutionary developments will change the way that Western nations develop strategy and conduct wars. What is clear, however, is that in this dynamic and uncertain environment, the single most important responsibility of air power's high commanders will be to honour the legacy of their great predecessors, Trenchard, Mitchell, and Arnold, by informing the strategic debate with courage and vision.

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3
AIR POWER THEORY

Phillip S. Meilinger

Before the aircraft was even invented, farsighted thinkers and writers speculated about flight and how the air would become a medium of war. Ancient cultures conjured winged gods and goddesses tossing thunderbolts, and Renaissance sages imagined flying ships that rained death from the skies. By the end of the eighteenth century, balloons were capturing the imagination, and a little more than a century later technology had advanced to the stage of heavier-than-air flight. Despite the doomsayers, some early airmen, such as Orville Wright in America and Clément Ader in France, opined that the new invention would be used only for peaceful purposes and, indeed, would help to eliminate war. The airplane and the destruction it could deliver would make war so horrifying that nations would be deterred from using such methods (Howard 1987: 416; Ader 2003: 3). This idea soon proved to be an illusion.

By the beginning of the twenty-first century, air power had begun to dominate war on land and sea. Unfortunately, air theorists seldom synchronised their ideas with the technology they espoused. Between the First and Second World Wars they spun ideas that were years ahead of the abilities of aircraft and weapons of the time. Post-Second World War, military leaders virtually abandoned the field of air power thinking to civilian academics who devised theories of nuclear war and deterrence. The Vietnam War was a watershed that led to a renaissance in air power theory. In today's world, preoccupied with terrorist threats and collapsing nations, air and space technology has leapt forward into pre-eminence, but the methods and doctrines needed to employ it successfully against these threats have lagged behind the technology.

The early years

The Wrights first flew in 1903 and barely a decade later aircraft were used as weapons in the First World War. That war smashed empires, spawned dictatorships, caused the deaths of millions, and had a profound effect on the conduct of war. The heavy loss of life convinced military leaders that tactics and strategy had to be altered, so radical solutions received greater consideration than they would ordinarily have. This demand for alternatives gave airmen a receptive audience. Moreover, original thinkers such as J. F. C. Fuller and B. H. Liddell Hart – both of whom were British Army officers during the war – imagined a new theory of war centring on air power, reinforcing the airmen's credibility. Fuller stated: 'As the aeroplane is the most mobile weapon we possess, it is destined to become the dominant offensive arm of the

future' (Fuller 1935: 209). Liddell Hart was more effusive: 'Aircraft enable us *to jump over* the army which shields the enemy government, industry, and people, and *so strike direct and immediately at the seat of the opposing will and policy*' (Liddell Hart 1925: 37; emphasis in original). Nonetheless, the path to a coherent theory of air power was steep and rocky, partly because air warfare differs fundamentally from surface warfare.

The Italian general and air theorist Giulio Douhet noted as early as 1909 that air power was an intrinsically strategic weapon in ways that traditional surface forces were not: the centres of gravity or vital centres of an enemy country were, in theory, always within range of aircraft. Those centres consisted of the industrial, political, economic and population loci that made a country function (Douhet 1942: 15, 27–28). Airmen have often hailed this ability to operate routinely with strategic effects; however, the specific ways in which to employ air power strategically differed significantly.

An opponent's vital centres had long been the ultimate goal of armed forces, but because they were generally well behind the frontier and heavily defended it was difficult to reach them. War therefore became a contest between armies: the losers in battle exposed their country's interior to the victor. Often, actual destruction or even occupation proved unnecessary: with the interior exposed and vulnerable, the loser sued for peace. Military theorists over the centuries therefore equated the enemy army with the main centre of gravity, because when the army collapsed, so did resistance. The First World War demonstrated that such attritional contests had become too bloody to serve as rational instruments of policy.

Air power offered a potential solution while also introducing a new set of problems. If the enemy army was no longer the main target, then what was? Airmen now had to become familiar with the specific workings of a nation. Knowing that a country depended on its railroads, steel mills, electrical power grid, factories and other specific assets was interesting, but not all of these targets could be struck, so which were the most important? Selecting targets thus became the essence of air strategy. Yet simply because something could be targeted did not mean it was valuable, and a valuable asset was not necessarily targetable. Thus, when perceptive air planners noted that intangible factors such as religion, nationalism, tradition and culture also played crucial parts in holding a country together during war, the problem became daunting, and over time has become even more complex.

Douhet identified the population as the prime target for air attack. He viewed civilians as prone to panic, and the limited experience garnered from the First World War seemed to support that contention. The bombing strikes in Italy, though sporadic, caused widespread absenteeism and evacuation from the cities. Relatively limited in number and scale though these strikes were, they had disproportionately large psychological effects. To Douhet, the implications were obvious: he was convinced that dropping bombs on a country's major cities would cause such disruption and devastation that revolt and subsequent surrender were inevitable.

> A complete breakdown of the social structure cannot but take place in a country subjected to this kind of merciless pounding from the air. The time would soon come when, to put an end to horror and suffering, the people themselves, driven by the instinct of self-preservation, would rise up and demand an end to the war – this before their army and navy had time to mobilize at all!
>
> *(Douhet 1942: 58)*

A pragmatist, Douhet rejected arguments that attacks on civilians were immoral. To him, war itself was inhuman, and in the war just experienced there were no innocents. Offering a paradox common among other air theorists such as Wright and Ader, he maintained that air

warfare would be so horrible it would be humanizing. Certainly many thousands would die, but many millions died in the old form of war. A short, violent and decisive conflict dominated by air power was much preferable to another world war that might drag on for years and wipe out an entire generation (Douhet 1942: 9–10, 61, 181).

By contrast, Douhet's American and British counterparts saw in air power the hope of winning wars by destroying things rather than people. Air doctrine in both Britain and the United States during the interwar years focused on an enemy nation's industrial infrastructure, not its population. According to this economic view of war, the modern state depended on mass production of military goods: ships, aircraft, tanks, trucks, artillery, ammunition, uniforms and all the rest. Moreover, most airmen took an even broader view, arguing that essential resources such as electric power, steel, coal, chemicals and oil were also military targets and actually of greater importance because they constituted the building blocks for other types of manufactured military goods needed to sustain a war effort. The key was to disrupt these economic and industrial processes (Biddle 2002).

In America the Air Corps Tactical School (ACTS) further refined this concept. Hal George, Ken Walker, Don Wilson and others devised a theory that sought out industrial bottlenecks – those factories or functions integral to the effective operation of the entire system. Their theory, termed the 'industrial web', envisioned a country as an integrated and mutually supporting system, but at the same time viewed this web as inherently fragile: if the right bottleneck target were struck the entire edifice would come crashing down (Sherman 1926: 218; Wilson 1971: 19–25; Hansell 1972: 6–49). It was this doctrine – unsupported by combat experience – that the Army Air Forces carried into the Second World War.

The Royal Air Force (RAF), led by Air Chief Marshal Hugh Trenchard for the decade after World War I, took a slightly different approach. Trenchard had witnessed the extreme reactions of the population and their political leaders to the German air attacks on Britain in 1917 and 1918; indeed, these raids by German Zeppelins and Gotha bombers had prompted the formation of the RAF. He argued, as did Douhet, that the psychological effects of bombing outweighed its physical effects (Boyle 1962: 577–578). However, Trenchard did not believe that attacking the people directly was the way to produce that psychological trauma.

> I emphatically do not advocate indiscriminate bombardment, and I think that air action will be far less indiscriminate and far less brutal and will obtain its end with far fewer casualties than either naval blockade, a naval bombardment, or sieges, or when military formations are hurled against the enemies' strongest points protected by barbed wire and covered by mass artillery and machine guns.
>
> *(Trenchard 1928)*

Instead, Trenchard advocated something similar to the Tactical School's idea: a country's industrial infrastructure was the appropriate target. He reasoned that the disruption of the normal life of the people – the loss of jobs, wages, services, transportation and goods – would be so debilitating that the people would demand peace. In short, whereas the Americans wished to bomb industry to destroy capability, Trenchard sought to bomb industry so as to fracture the national will (Meilinger 1996).

Another RAF officer, Wing Commander John Slessor, was a World War I combat pilot who later commanded an army cooperation squadron from 1925 to 1928. Afterwards, he worked on Trenchard's personal staff, and in 1931 was assigned to the faculty of the British Army Staff College. This broad background, combined with a first-rate mind, made Slessor one of the most original air thinkers prior to the Second World War.

Slessor's seminal book *Air Power and Armies* was based on his lectures at the Staff College and posits a war in which the British Army has been deployed to the Continent. Slessor argued that the enemy army's lines of supply and communication were the key targets. Significantly, he did not think only in tactical terms on this matter; rather, he maintained that the enemy's entire transportation system must be disrupted and neutralised. If this were accomplished, not only would the army be unable to offer effective resistance, but the entire country would be paralysed. This paralysation – also effected by destruction of the enemy's command and control network – would in turn have a decisive effect on not only the enemy's capability, but also its will (Slessor 1936: 97, 111, 122–147). In essence, Slessor was advocating a strategic- or operational-level air interdiction campaign. During the Second World War, RAF leaders, notably Air Chief Marshal Arthur Tedder, pushed strongly for just such an air campaign against Germany in 1944. This 'transportation plan' was successful in ensuring the success of the Normandy landings by severely restricting the flow of German reinforcements to the lodgement area. In addition, the wholesale destruction of the German rail and bridge systems in Western Europe had devastating effects on Germany's entire war effort (Tedder 1948: 106–115).

Others took an unusual approach to strategic air targeting. Although General Billy Mitchell would by the late 1920s fluctuate between a strategy akin to that of Douhet and one closer to that of the ACTS, his writings immediately after the First World War were different. In his first book, Mitchell called for the use of air power to destroy the military forces of the enemy. In other words, he saw victory occurring in the time-honoured method of the decisive counterforce battle (Mitchell 1921: 15). Only now, aircraft could accomplish such destruction in a quicker and more efficient fashion. Mitchell saw fleets as even more vulnerable than armies, and his bombing tests of 1921 and 1923 in which aircraft sank several battleships reinforced this belief: 'Neither armies nor navies can exist unless the air is controlled over them' (Mitchell 1925: XV).

Such an idea – in essence, the use of air power in a tactical role that would have strategic effects – had existed since the early days of flight. Trenchard, for example, believed during the First World War that the primary mission of air power should be to help ground forces achieve their objectives (Boyle 1962: 183–188). He would later change his opinion. In Italy, Douhet's ideas on strategic bombing would give way to those of Amedeo Mecozzi, who favoured tactical air power, pushing for a force structure composed of fighters, attack aircraft and medium bombers (Corum 1997: 159–162). A similar belief prevailed in France, which also focused on tactical air power between the World Wars (Cain 2002).

In Germany, a traditional land power, this notion took root with tenacity. After the war, German combat officers who had fought on the Western Front studied the lessons of the war and determined that mobility had been lost and must now be regained for future success. Under the direction of General Hans von Seeckt, the German military embraced this notion, and so was born what would later be termed *blitzkrieg* – lightning war. Ground forces would be mechanised and motorised, and tanks would play a major role in the offensive. The Luftwaffe would concentrate on the development of fighters and medium bombers for the express purpose of aiding this rapid ground assault (Corum 1992: 144–169).

In Russia this same intellectual journey took place with the same results (Hardesty 1982). In short, France, Germany and Russia did not develop a true strategic bomber during the Second World War; instead, they focused on tactical air power to support the ground forces.

Japan was unique. It had both a strong army and a powerful navy but did not establish a separate, independent air force. Instead, it built air arms for both services: the mission of the Army Air Service was to support ground troops and that of the Imperial Japanese Naval Air Service was to scout and to support and protect the fleet. Both contingents consisted largely of fighters, attack aircraft and medium bombers (Evans and Peattie 1997: 332–340).

Post-war nuclear theory

One would expect that the massive and decisive use of air power in the Second World War would have spawned an outburst of new ideas in the years following 1945; surprisingly, that did not occur. The atomic strikes on Japan had both a catalysing and a numbing effect on military leaders worldwide. The new weapon appeared to revolutionise warfare in ways that made prior experience obsolete. The atomic and then nuclear ages redefined war. As a consequence, a different group of theorists emerged who attempted to explain the use of military force in this new age.

Alexander P. de Seversky, a Russian fighter pilot and ace during the First World War, had immigrated to the United States. Having lost a leg in combat, he turned to engineering. He built an air refuelling device in the early 1920s and eventually founded his own aircraft company. His designs were years ahead of their time, and his P-35 was the ancestor of the famed P-47 Thunderbolt. He also became a prolific spokesman and advocate for air power. His technical acumen and combat experience made him an authoritative commentator on air-centred issues (Libbey 2013).

During the Second World War he stressed the importance of strategic bombing and in his popular work *Victory through Air Power* he detailed how Allied bombers would bring Germany and Japan to their knees. (The book was a best seller and was even turned into an animated movie by Walt Disney.) After the war, de Seversky toured war-torn Europe and Japan and was awestruck by the devastation unleashed by bombing – especially by the atomic bombs. He therefore wrote about the need for an atomic-capable air force to deter the Soviets or, if necessary, defeat them (Libbey 2013: 22–41).

De Seversky was an important transitional figure between the air theorists of the interwar years, mostly uniformed airmen, and those of the atomic/nuclear era, most of whom were civilians. After de Seversky, who enjoyed using his Air Corps Reserve rank of major throughout his life, a new breed of civilian academics – Bernard Brodie, Herman Kahn and Thomas Schelling, for example – with little or no experience in war emerged to define and articulate theories of nuclear war. Since there was virtually no experience with this type of war, these academics were seemingly as capable of devising a theory of nuclear war as were uniformed professionals. The ideas they proposed – balance of terror, mutual assured destruction, strategic sufficiency and the like – were elegant, reasoned and served the West well throughout the Cold War era. Significantly, these ideas were largely theoretical and based on logic, not experience (Mueller 1997: 290–305; Ball and Richelson 1986). In this sense they were not unlike the interwar ideas of airmen, which were also largely devoid of concrete examples and instead relied on theory and on the development of weapons and technologies that would exist sometime in the future. At the same time, the very thought of nuclear war was so horrible that theorists hoped that the mere existence of such weapons would deter war.

Regrettably, military airmen too easily abandoned the intellectual field to the civilians. At the same time, the military accepted the premise that future wars would involve nuclear weapons. As a result, few airmen gave serious thought to the use of conventional air power at the strategic level.

The impact of the Vietnam War

The Vietnam War had many negative effects on the United States and its military services. One positive aspect, however, was the growing realisation that nuclear war theory was an interesting intellectual exercise, but hardly likely to be implemented – if only because the superpowers

were so well prepared to wage such a catastrophic form of war. At the same time, Vietnam demonstrated that tactical air power might not be a war-winning weapon. Although US Air Force, Navy and Marine Corps aircraft dropped enormous bomb tonnage on North Vietnam, the vast majority of the objects struck were interdiction targets (Thompson 2000: 307). The policy of Gradual Escalation, devised by civilian advisors to President Lyndon Johnson in Washington, called for an air campaign that offered Hanoi both carrots and sticks: carrots in the form of an easing of air attacks on North Vietnam, as well as other diplomatic and economic inducements, and sticks in the form of increased bombing if the North Vietnamese were not accommodating. It was a disastrous strategy that produced no useful results, but did cause heavy casualties to airmen attempting to implement it as well as to civilians on the ground (van Staavaren 2002).

Thus, while ideas about air power had become polarised between those who thought only of nuclear holocaust and those who prepared to fight the tactical air battle, world conditions indicated that neither extreme offered decisive results. The vast middle ground between those two poles had to be recaptured. The renaissance of strategic conventional air power thought began with Colonel John Boyd.

As a fighter pilot during the Korean War, Boyd was intrigued by the success of the F-86 in air combat with the MiG-15 (an eight-to-one superiority) (Werrell 2005: 221). Upon reflection, he decided that the F-86's advantage was due largely to its hydraulically operated flight controls that allowed it to transition from one aerial manoeuvre to another more rapidly than the MiG. After further thought, Boyd began to see the implications of this theory in a broader context. The key to victory was to act more quickly, both mentally and physically, than the opponent. He expressed this concept in a cyclical process he termed the OODA loop (observe–orient–decide–act). As soon as one side acted, it observed the consequences and the loop began anew.

Boyd identified the orient phase as the most important portion of the loop. He speculated that the increasing complexities of the modern world necessitated an ability to take seemingly isolated facts and ideas from different disciplines and events, deconstruct them into their essential components, and then reassemble them in new and unusual ways. He termed this process 'destruction and creation' (Osinga 2015: 51–52). This process dominated the orient phase of his OODA Loop. The goal was to think and operate more quickly than the enemy so that the adversary always reacted either too late or inappropriately.

Even more significant, Boyd later hypothesised that this continuously repeating cycle was at play not only in an aerial dogfight, but also at the higher levels of war. In tracing the history of war Boyd saw victory consistently going to the side that could think most creatively – orienting itself – and then act quickly on the resulting insight. Because of the emphasis on the orientation phase of the loop, in practical terms Boyd called for a strategy directed against the mind of the enemy leadership. Although a pilot, his theories encompassed far more than a blueprint for air operations: to Boyd, this process governed all of warfare (Osinga 2015: 91–92).

Another airman who has thought deeply about strategic air power, and who also focused on enemy leadership as the key, was Colonel John Warden. Like Boyd a fighter pilot and combat veteran, Warden began a serious study of air warfare while a student at the National War College in 1986 (Warden 1989). His subsequent assignment in the Pentagon placed him in an ideal location when Saddam Hussein invaded Kuwait in the summer of 1990. Putting his theories into practice, Warden designed an air campaign calling for strategic attacks against Iraq's centres of gravity.

Warden asserted that war is a combination of physical and psychological factors, but because the psychological facet is difficult to measure or even identify the air strategist must focus on

the physical manifestations of the enemy. The device he used to illustrate his concept was a target consisting of five concentric rings, with leadership as the bull's-eye – the most important centre of gravity while also the most fragile – and armed forces as the outermost ring – the least important but also the most hardened (Olsen 2007).

Warden likened his Five Rings model to the human body. The innermost ring, the enemy leadership, equated to the human brain. Just as the brain was the most important organ of the body – it controlled all movement while also receiving all inputs and was thus irreplaceable – so too enemy leadership was the key to enemy resistance. If the leadership could be killed or captured, then the entire country – the enemy body – would be incapacitated.

Warden went on to argue that the other rings – organic essentials (raw materials and power), infrastructure (industry and transportation), the population and fielded forces – were distractions best avoided. These target systems should be attacked only as necessary to expose the leadership ring to offensive action. Warden concluded that this type of 'inside-out' warfare has always been the most effective in theory, but only the invention of air power made it routinely possible. In his view, the strategic nature of air power, combined with new technology, produced the type of rapid and relatively bloodless victories military leaders had sought for centuries. In short, air power could lead to strategic paralysis (Olsen 2007).

Thus, whereas John Boyd sought to disrupt the *process* of the enemy's leadership, John Warden focused instead on hitting the *form* of that leadership (Olsen 2007). For both men the 1991 Gulf War represented the realisation of such an air strategy. Air strikes against the Iraqi communications network, road and rail systems, and electrical power grid made it extremely difficult for Saddam Hussein to control his military forces, and also induced enormous confusion and uncertainty in his decision-making process. His OODA Loop was expanded and slowed, while Saddam himself was effectively cut off from his forces. (The coalition also flew numerous missions to locate and kill Saddam himself, but he remained well hidden.)

In effect, the theories of Boyd and Warden helped to enable a strategy that resulted in near-paralysis of the Iraqi regime. This air strategy came to be termed 'effects-based operations': the realisation that destruction was not always necessary to determine the success of an air strike. Rather, if the goal, for example, were to shut off the electricity in a certain sector of Baghdad for a short period of time, then it was not necessary to destroy an entire power plant, but simply to damage key elements that could be easily repaired, although not for several hours. This created the desired *effect* – shutting off the electricity for a specified period of time – which is what really counted (Deptula 2001).

Just as experience during the Gulf War of 1991 tended to support the theories of Boyd and Warden, it also revived an old theory of air power employment. Robert Pape was a civilian academic who taught at the School of Advanced Airpower Studies. In his seminal work, *Bombing to Win*, Pape reviewed strategic air campaigns in the Second World War, Korea and Vietnam, studied the works of Douhet, Mitchell and other classic air thinkers, and then examined the results of the Gulf War. He argued that it was not the relatively small number of air sorties directed against strategic targets in and around Baghdad that determined the outcome of the war; rather, the massive use of air power directly against the Iraqi forces and their supply lines proved decisive. Approximately 80,000 Iraqis deserted their posts and another 80,000 or so surrendered virtually without a fight as a result of six weeks of pounding from the air. To Pape, the Iraqi army was rendered 'combat ineffective' before the Coalition ground assault even began at the end of February.

Pape was revisiting the early ideas of both Billy Mitchell and Hugh Trenchard: the primary role of air power was to complement the ground forces in the defeat of the enemy's forces. In short, the route to victory was the same as it had been for centuries: the defeat of the enemy

army. Only now, air power had advanced to the stage where it could destroy an army faster, more easily and at less risk than could another army (Pape 1996: 240–253).

The aftermath of Desert Storm and the revolution in war

The decades following the first Gulf War have strengthened the dominance of air power in modern war – at least the way it is practised by the United States and its major allies. Military successes, large and small, have included removal of drug king Manuel Noriega from power in Panama, Desert Storm (albeit temporary), Bosnia, Kosovo, Libya, and the early victories in Afghanistan and Iraq post-9/11.

Military planners must focus on successes as well as failures to determine a way ahead that maximises the chances of achieving political success while minimising the cost in blood and gold. If a terrorist or unconventional enemy pursues war with asymmetric strategies and weapons, then nations must counter them with their own asymmetric advantages.

The increasing use of precision-guided munitions has allowed air power to mitigate the problems of collateral damage and the large intrusive footprint (large numbers of conventional ground troops) that have plagued American interventions in the post-Second World War era. Because of its range, precision, lethality, flexibility and security – air forces have suffered remarkably few casualties since the Vietnam War – air power limits risk.

As an example, at the beginning of the Iraq operation in 2003, thirteen Iraqi divisions were positioned in the north to defend against a possible invasion from Turkey. Besides the Kurds, there were US special operations forces (SOF) teams in the north – fewer than 600 men – plus the 173rd Airborne Brigade that was air-dropped into Bashur. Of note, this brigade arrived with almost none of its equipment, which had been pre-positioned in Turkey before it became apparent that operations from that front would be denied. Nonetheless, on 30 March 2003 these forces destroyed the Iraqi 4th infantry division, followed by the 21st division on 31 March, and the 81st and 38th divisions on 2 April. The entire northern front collapsed on 10 April with the 5th Iraqi Corps surrendering and Kirkuk falling (Andres 2006: 412). In the words of one observer:

> In short, against all prewar expectations, SOF operations in northern Iraq were fantastically successful. Despite numerous logistical and political obstacles, a small SOF group working with unskilled indigenous allies and highly constrained airpower defeated a significant portion of Iraq's army. Moreover, it did so without suffering a single American death.
>
> *(Andres 2006: 412)*

This is remarkable, and comparable with the Afghanistan situation where SOF troops, teamed with the indigenous Northern Alliance and backed by ubiquitous intelligence, surveillance and reconnaissance (ISR) assets and Coalition air power, produced a rapid and stunning victory – before conventional US ground troops even arrived in theatre. Also of importance, the Northern Alliance, even with the smattering of SOF troops present, was always outnumbered by the Taliban; at Mazar-e-Sharif, for example, 5,000 Taliban in defensive positions confronted 2,000 Northern Alliance troops (Andres, Wills and Griffith 2006: 149). But of course the Northern Alliance had air power behind it, with targets called in and directed by SOF. Air power was the great equaliser.

Indigenous troops were essential to both of these operations, as they had been in the Balkans when Croats and Kosovars benefitted from North Atlantic Treaty Organization (NATO) air power. Of importance, these indigenous forces were not considered of high quality prior to

hostilities. The Kosovars and the Northern Alliance, for example, were deficient in quantity, quality, training and weapons; they had proven largely unsuccessful in fighting the Serbs or the Taliban previously. Yet, when stiffened with SOF and air power, they achieved enormous success (Lambeth 2001: 221–227, 242–243). In Libya, it was air power teamed with local opposition ground forces which brought down Muammar Gaddafi – with no casualties to NATO forces (Mueller 2015).

In sum, the world in this second decade of the twenty-first century involves peer competitors that must remain deterred. A major conventional war – or worse, one using nuclear weapons – must always remain a concern for political and military leaders. It is probable that a key reason nuclear weapons have not been employed since 1945 is that so many nations have them and state their intention of using them if directly attacked. Nonetheless, it is also true that the majority of conflicts that will see US or Western involvement are the types of punitive or United Nations-sanctioned protection missions witnessed over the past four decades. Recent events point towards a new paradigm involving air power (including robust ISR assets), special forces, and indigenous ground troops in the types of wars now endemic.

Key observations

When reviewing air theory over the past century, both as imagined and as conducted, four themes become most prominent. First, air power has been recognised as an inherently strategic weapon in ways that surface forces are not. At the same time, it can also operate effectively at all three levels of war simultaneously from the outset of war.

Second, air power has always been viewed as a powerful offensive weapon. Although defence may be the strongest form of war on land, such is not the case with air power because of its ability to strike quickly, virtually anywhere, and often with little or no warning.

Third, air theorists have continually stressed the importance of achieving air superiority as rapidly as possible. Some argue this is essential only in the operational area, while others insist on gaining command of the air at the theatre level. Gaining air superiority allows both the freedom *to* attack and the freedom *from* attack. Joint force operations as conducted by the United States and its allies have come to depend on this air superiority – and usually air supremacy.

Finally, targeting still remains crucial, but ingenuity and trenchant analysis to determine the correct targets when fighting a terrorist organisation such as so-called Islamic State in Iraq and Syria (ISIS). Old templates traditionally used against conventional opponents must now be modified.

The task of the air strategist is to make sense of the various conflicting theories and concepts noted above and translate them into a workable plan. This begins with asking three fundamental questions: what is the goal; how much is it worth to achieve that goal; and what is it worth to the enemy to prevent you from achieving it. After addressing these basic questions, air strategists must devise a campaign plan to achieve the political goals set by the nation's civilian leaders. This involves transforming broad goals into specific military objectives, identifying the target sets that must be affected (not necessarily destroyed) to attain those objectives, and then combining the results into a coordinated operations order that can be implemented by the military forces involved.

What cannot be overemphasised is that there must be a clear linkage between the targets chosen and the objectives sought. For example, what specifically do planners expect to gain by bombing the power grid? If their overall objective is to force the enemy to halt an invasion of a neighbouring country, then how, exactly, will striking the power grid – or a munitions factory,

or armoured divisions, or intelligence headquarters – contribute towards achieving that objective? In other words, just because a target is destroyed or neutralised does not mean it was important or that the campaign has come any closer to attaining its goals. The intellectual process of linking ends and means is a crucial, yet too often overlooked, requirement for the air strategist.

Determining the key target or group of targets within a country requires careful and accurate measurement of the effects of air attacks. This analysis is essential to ensure the results are what were expected, so that adjustments can be made for future operations. This is not a minor consideration. Air warfare ordinarily requires a detailed understanding of an adversary's entire economic and political systems. Prior to the Second World War this was a fundamentally different type of military intelligence than that required during previous eras. As a result, new bureaucracies arose, composed of economists, industrialists and engineers, whose main function was to study the makeup and vulnerabilities of an enemy state. Today, these intelligence agencies have become key elements of the military, and their products are vital to the formulation of a viable air campaign plan (Ehlers 2009).

Perhaps the greatest caveat for the air strategist to bear in mind is that few wars are simple. Just as nations go to war for a complex array of varied, often conflicting, reasons, so too they choose to make peace based on a calculus that is seldom easily identifiable. And that is perhaps the most valuable lesson for any military strategist: beware the theorist who offers a model of war that purports to give a simple and universally applicable answer to the numbing complexities of war. There is seldom one answer; moreover, answers usually vary from one country to the next and from one situation to the next.

Conclusion

In summary, it has become apparent over the course of the past six decades that air power is playing an increasingly important role in warfare. Surface force commanders realise that their operations are extremely difficult, if not impossible, without the extensive employment of air power. Airmen have often claimed that the basic methods and strategies of war-making have changed because of their new weapon. Without denying the dominance of air power on the battlefield, they also argued for its pre-eminence at the strategic level, basing this contention upon various targeting philosophies. The question as to which strategic targets should have priority in an air campaign has proven surprisingly thorny, and the answer is not self-evident. As a result, a variety of air theories have sprung up, each encompassing much internal logic, as well as an increasing volume of operational experience and evidence to support it.

Nonetheless, it is time to move beyond overly prescriptive interpretations of air power's use in war. It has become an aphorism that flexibility is the key to air power. That is just as true in the theoretical sense as in the operational. Needed are airmen well grounded in all aspects of air warfare, including the theoretical. Only then will we be able to select the concept for employing air power best suited to the situation at hand. Flexibility is also the key to air strategy.

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4

SCIENCE, TECHNOLOGY AND AIR WARFARE

Richard P. Hallion

Military aviation involves the interplay of science, technology, invention, innovation, opportunity, necessity, requirements, politics, economics, national will and industrial practice. The extant state of science and technology, the political–military–economic environment, and even social and cultural patterns shape the 'market' push-and-pull factors. Emulation (following the example of others), innovation (building upon previous experience) and invention (creating from the outset) constitute ways to describe aspects of the aviation design process. These latter aspects, interrelating with the former push-and-pull factors, shape acquisition needs, consequent design and resulting capabilities.

Though each case was strongly individual, and not all of these factors played equal roles, out of this environment came the tethered observation balloon at the end of the eighteenth century, the motorised steerable airship late in the nineteenth century, the military airplane at the beginning of the twentieth century, the all-metal monoplane revolution prior to the end of the First World War, the reactive propulsion revolution – the rocket and turbojet – at the end of the 1930s, the high-speed aerodynamic revolution culminating in transonic and supersonic military aircraft, the introduction of precision weapons in the 1940s, the systems and sensor revolution beginning in the 1950s, ballistic missiles and orbital spaceflight later in that decade, the fan-jet revolution of the 1960s (both the high-bypass turbofan enabling the first wide-body military transports, and the afterburning turbofan for fighter and strike aircraft), the electronic flight and engine control revolution of the 1970s–1980s, composite flight structures over that same period, low-observable 'stealth' aircraft and weapons, sensor-fusion and distributed information architectures, and, most recently, the widespread employment and proliferation of so-called 'drone' systems.

Military balloons and airships

In 1783, French paper-makers Jacques and Joseph Montgolfier built the first hot-air balloons based upon their observations of burning embers rising. Their first human-carrying balloon followed on 21 November 1783. Simultaneously, French scientist J. A. C. Charles was investigating hydrogen as a lifting gas and on 1 December 1783 he flew with a passenger, afterwards reaching a height of over 10,000 feet. The French government established the world's first military aviation unit in April 1794 (Dégardin and Valladier 1995: 77–78, 450–453).

Hydrogen-filled balloons thereafter served in various conflicts, even as late as the Second World War.

The inability to steer balloons led to the first piloted airship, built and flown by Henri Giffard in 1852. Charles Reynard and Arthur Krebs followed with the 165-foot *La France* of 1884, the first military blimp (Lissarrague 1982: 50–57). In 1900, German count Ferdinand von Zeppelin flew the first of his large rigid-framed 'Zeppelin' dirigibles, the 450-foot LZ-1. Like the balloon and the airplane, the rigid-structured dirigible represented a 'dual use' civil–military technology (Robinson 1973a: 9–39). Airships were fraught with danger and set-backs, and the airplane soon supplanted them. Zeppelin hangars and bases became targets for the first strategic air raids in military history (Castle 2011: 13–75). Its vulnerability to interceptors armed with machine guns firing incendiary bullets ensured that, by 1918, the Zeppelin represented the past, not the future, of military aviation (Robinson 1980: 324–353).

The military airplane through the era of piston power

In 1892, the French war ministry issued Clément Ader the world's first research and development contract for a heavier-than-air flying machine. The result was the steam-powered *Avion III*, which did little but hop; officials cancelled it in January 1898 (Facon 1986: 77–79). In 1898, the US Army awarded Smithsonian Institution Secretary Samuel Langley a contract for a heavier-than-air 'Aerodrome'. It crashed twice in late 1903, even as the Wrights were readying their Flyer for its epochal 17 December 1903 flight (Crouch 1981: 255–292; Crouch 1989: 270).

Though not engineers, the Wrights knew practical mathematics and industrial arts, and possessed a studious mindset reflected in their methodical research (Crouch 1989: 270; Jakab 1990: 115–152). In 1908, they demonstrated their Flyer to military authorities at Fort Myer, Virginia, and also took another Flyer overseas. Europe's aviators quickly adapted Wright control concepts, but rightly rejected their marginally stable design. By 1911 France stood foremost as the world's dominant aviation nation. That year, Italy took the airplane and airship to war in Tripoli. By August 1914, Europe's militaries possessed roughly 1,162 aircraft. Between then and the Armistice in November 1918, they produced a further 205,308 aircraft and 235,535 engines (Hallion 2003: 230–323; Hallion 2014: 77, 87–88).

As early as the battles of Tannenberg and the Marne in August–September 1914, the airplane demonstrated its value as a reconnaissance platform. Other missions rapidly evolved and by war's end, airplanes were fighting for air superiority so that other aircraft could conduct reconnaissance, control artillery fire, bomb targets, torpedo ships and depth-charge submarines. The first aircraft and seaplane carriers had already appeared, launching raids against shore targets. Long-range multiengine bombers routinely raided enemy homelands.

If the airplane had come of age as a military weapon, so too had aviation science and technology. In 1914, the airplane had been little more than a wood, wire and cloth powered ultralight, flying at about seventy-five miles per hour (mph) on as little as fifty horsepower (hp). By 1918, new all-metal monoplanes had engines of at least 185 hp, and flew at 140 mph. In 1919, American and British aviators completed three flights across the North Atlantic, by a seaplane, a converted bomber and an airship.

By war's end, crude empiricism and craft-and-shop practice had given way to nascent aeronautical engineering – the merger of mechanical engineering with fluid dynamics and applied mathematics. Nations established governmental research centres such as America's National Advisory Committee for Aeronautics (NACA, predecessor of today's National Aeronautics and Space Administration (NASA)), Britain's Royal Aircraft Establishment (RAE) and

Soviet Russia's Central Aero-Hydrodynamic Research Institute (TSAGI). Ground and flight testing became rigorous, professional activities. Kite-like wooden aircraft gave way to ones with welded steel tube fuselage structures and robust flight structures.

Göttingen University's Ludwig Prandtl and his students transformed global aerodynamic research and aerofoil design practice after the First World War (Hirschel 2004: 172–186; Eckert 2006: 42–79, 177–194). When coupled with duralumin construction – a byproduct of German interest in lightweight airships – the stage was set for a revolution in flight. Incorporating these, German designers reinvented the airplane, replacing the externally braced thin-wing, open-cockpit, wood, wire and cloth designs with new all-metal streamlined enclosed cabin cantilever monoplanes. By mid-1918, German aeronautical science, engineering, research, education and design practice stood *sans pareil*, emulated afterwards in the world's other aviation nations (Hallion 2017: 5–33).

Over the 1920s, several global developments led to fast, reliable and highly efficient 'modern' airplanes. These included increasingly powerful and reliable liquid-cooled and air-cooled engines; controllable-pitch propellers; drag-reducing cowlings; all-metal monocoque fuselages; 'multicellular' wing structures; lift-enhancing wing flaps, leading-edge slots and slats; turbulence-reducing wing-root fillets; and locating engines in nacelles projecting well ahead of a wing's leading edge (Spenser 2008: 217–227).

By 1934, the United States had emerged as the global leader in streamlined, all-metal air transport design. New designs such as the Boeing 247, the more commercially successful Douglas DC-2, and the Pacific-spanning Martin M-130 flying boat signalled this transformation, reinforced in 1935, when the Boeing Model 299 (prototype for the B-17), Consolidated PBY Catalina and the Douglas DC-3 completed their first flights. With these, America's aeronautical industry took the global lead in the design of long- and medium-range bombers, airliners and seaplanes (Crouch 2003: 316–339).

The technical base that had supported design of these aircraft constituted a 'dual use' industrial base for both civil and military purposes (Bilstein 1996: 21–48). Boeing and Douglas, for example, mixed technology between airliners and bombers: the Douglas DC-2 led to the B-18 and the DC-3 to the B-23; Boeing's XB-15 furnished the wing for its Model 314 flying boat, and its B-17 furnished the wing and tail surfaces for its Model 307 airliner. Later its post-Second World War B-50 furnished the wing and tail surfaces for its Model 377 airliner as well (Miller and Sawers 1970: 54–66; Loftin 1985: 88–95).

For all its advances, America lagged in the design of fully cantilever low-wing monoplane fighters with retractable landing gears and low-frontal area inline piston engines having good power-to-engine weight ratios. In part, this was because America lacked the immanency of threat that increasingly dominated Europe's militaries and forced fighter (and bomber) development. Thus, through the mid-1930s its streamlined new Boeing, Douglas and Lockheed airliners out-performed open-cockpit, externally braced, fixed-landing-gear Army and Navy-Marine fighters such as Boeing's P-12 and F4B-4, even matching their successors, the Boeing P-26 and Grumman F2F.

Exemplifying foreign fighter superiority were five outstanding all-metal or mixed metal-and-wood streamlined cantilever monoplane aircraft with retractable landing gears: the Soviet Polikarpov I-16, the German Messerschmitt Bf 109; the British Hawker Hurricane and Vickers-Supermarine Spitfire; and the Japanese Mitsubishi A6M2 Type 0. Two of these – the Bf 109 and I-16 – flew against each other in the Spanish Civil War (1936–1939) and all flew in the Second World War (1939–1945) with great distinction.

American fighter inferiority lasted into the Second World War. Army Air Forces (USAAF) and Navy-Marine Corps (USN-USMC) pilots flying the Bell P-39, Curtiss P-40 and

Grumman F4F survived by a combination of resolute courage, wits, discipline, and better training and tactics (for example, the Navy's 'Thach weave'). The world-class fighters with which they destroyed the Axis air arms only gradually entered service: the Lockheed P-38, Republic P-47, Vought F4U, Grumman F6F and the Anglo-American North American P-51 (Wagner 1983: 260–286, 384–393).

The onset of the 'jet age'

By 1944 the era of the high-performance piston-powered airplane was inexorably drawing to a close. Piston engines had evolved to the point where for every pound of engine weight an engine could produce approximately one hp. The most powerful engines produced approximately 2,000 hp, and employed complex gear-driven or turbine-driven engine superchargers to maintain good performance at high altitude. But overcoming the high drag rise associated with aircraft flying faster than approximately Mach 0.70 demanded even more powerful engines, of at least 3,000 hp, perhaps with 'turbo-compounding', whereby the turbine not only drove an air compressor, but was itself also geared to the propeller drive shaft. Engine reliability now declined sharply, because such engines could not be adequately cooled and were too complex as well (Spenser 2008: 201–230; Connors 2010: 145–157).

As flight speeds rose beyond Mach 0.70, propeller efficiency decreased, and aircraft suffered marked reductions in stability and controllability from 'compressibility': transonic airflow and shockwave formation inducing buffeting and changes in control response. In each of the advanced aeronautical nations, pilots perished as a result of aircraft going out of control and/or breaking up at high speeds, threatening to limit future fighter, bomber and transport flight speeds to the high subsonic region (Becker 1980: 3–68; Loftin 1985: 112–120).

Fortunately, a new form of reaction propulsion – the turbojet engine – was under development, thanks to inventors in Britain and Germany. While British research, by test pilot and engineer Frank Whittle, had begun earlier, it was the Germans who in August 1939 flew the first jet airplane thanks to the vigorous partnership of physicist Hans von Ohain with speed-obsessed aircraft manufacturer Ernst Heinkel. Whittle's engine took to the air in May 1941, and served as the basis for America's first turbojet (by General Electric), which flew for the first time in October 1942. These three turbojet flights launched a turbojet revolution that took flight beyond 500 mph (Schlaifer and Heron 1950: 321–508).

The first jet fighters and bombers – the German Messerschmitt 262 and Arado 234 and the British Gloster Meteor – entered service in 1944. The American P-80 followed in 1945. Germany's jets made no difference to the outcome of the war, for they were too few in number, inadequately supported; lacked fuel to fly, and were swarmed by more numerous Allied propeller-driven fighters. Had they appeared two years earlier, they would have forced a temporary suspension of the Allied daylight strategic bombing effort until Allied jets entered combat (Pavelec 2007: 91–109). (Given that the Roosevelt administration began the Manhattan Project with Nazi Germany explicitly in mind, this might have ensured Germany, not Japan, first experienced the horror of atomic warfare.)

As well as the airplanes themselves, systems technology advanced markedly. Instrument displays were first added to enable a pilot to fly more safely. By the end of the First World War, the first crude 'human factors' research had resulted in organised instrument clusters and dial layouts facilitating quick instrument scans. Aviation medicine emerged as a specialised discipline, rapidly expanding to meet the challenges of flight at high altitudes and at high accelerations. The danger of blind flight led to precision radio-navigation and gyroscopically stabilised instruments. Gyro-controlled autopilots, experimented with before the First World

War, became standard by the end of the 1930s. The advent of radar and beam-location improved safety and led to precision radio- and radar-guided bombing. Instruments went from adjuncts of flight safety to essential components of integrated systems (Robinson 1973b: 108–198; Spenser 2008: 142–200).

The airplane was now in the earliest stages of evolving into a 'weapon system'. Aircraft such as Boeing's 'Very Long Range' (VLR) B-29 Superfortress blended new 'avionic' architectures into their bombing, defensive fire control, navigation and communication systems. So, too, did advanced night fighters such as the American P-61 and the German Heinkel He 219. Airborne weapons technology advanced as well. The bombsight underwent progressive refinement, including gyro-stabilisation. The precision weapon era opened in 1943 with introduction of the homing torpedo and the anti-shipping missile, followed in 1944 by introduction of the cruise missile and ballistic missile, the former reflecting the progress in jet propulsion and the latter advances made in liquid-fuel rocketry. By war's end the Axis and Allied powers alike were embarked on a race to develop and place into service the first surface-to-air and air-to-air missiles (McFarland 1995: 68–88; Johnson 2002: 10–57; Black 2013: 183–196).

Refining the military airplane through the Vietnam era

The second half of the twentieth century witnessed the continuous evolution, refinement and increasing power of gas turbines: small-diameter high-efficiency axial-compression jet engines replaced large-diameter low-efficiency centrifugal-compression ones; axial turbojets with afterburners enabled the first supersonic jet fighters; geared-turbine turbo-propeller engines permitted development of fuel-efficient airliners and transports; and geared turboshaft engines enabled development of more powerful, higher payload and faster helicopters, the low-bypass-ratio fanjet used on early jet airliners, the high-bypass-ratio fanjet that made possible high-capacity civil and military air transports, and the afterburning turbofan for high-performance military aircraft (Kinney 2016: 73–179).

Sifting Nazi Germany's scientific and technological establishment revealed an approximately ten-year advance over the Allies in high-speed aerodynamics, exemplified by Adolf Busemann's 1935 discovery of the benefits of wing sweep for high-speed drag reduction, rediscovered independently in 1944 by NACA aerodynamicist Robert T. Jones (Hallion 2010a: 5–20). German sweptwing research broadly influenced American, European and Soviet design practice, including (most significantly) the American F-86 Sabre and B-47 Stratojet, the Soviet MiG-15 and the Saab J-29 Tunnen (Smelt 1946: 899–934; Kármán 1963: 133; Steiner 1979: 145–148; Meier 2006: 16–36). German advances in cruise missiles and ballistic rocketry likewise highlighted Allied technical shortfalls, even if the actual military effect of these weapons was relatively minimal. These and other developments – particularly in sensors, instrumentation, test facilities and various other weapons – reflected the increasing alliance between the military, industrial and scientific communities, which grew ever more significant over the Cold War (Kranzberg 1969: 123–170; Bright 1978: 11–75; Leslie 1993: 14–132).

The greatest immediate challenge after 1945 was piloted supersonic flight, accomplished on 14 October 1947 when the Air Force's air-launched rocket-propelled Bell XS-1 (later X-1) research airplane attained Mach 1.06, approximately 700 mph. A sweptwing Navy-sponsored research airplane, the D-558-2, became the world's first Mach 2 airplane in November 1953. The opening of the sonic frontier, coupled with improved gas turbine engines, resulted in the rapid introduction of high-transonic and supersonic combat aircraft. The challenges of the bipolar nuclear arms race accelerated bomber and interceptor development, and that of surface-to-air missiles (SAMs) and air-to-air missiles (Saltzman and Ayers 1995: 6–13; Hallion 2010b: 223–257).

From the invention of the airplane through 1946, the normative airplane had been a straight-wing propeller-driven design; from 1947 onwards, it was a sweptwing turbojet-driven one (Hallion 2010a: 4). For transonic and supersonic aircraft, shock-induced airflow changes forced relocation of the horizontal stabiliser from its traditional middle or high level to a low level aligned roughly with the bottom of the fuselage. As well, the decline in longitudinal (pitch) control effectiveness led to introduction of the adjustable horizontal stabiliser (first proven on the Bell XS-1), which very quickly changed into an all-moving 'stabilator' combining the functions of the fixed-stabiliser and moveable elevator into a single pivoted surface. (A variation was the 'rolling tail', an all-moving tail that could pivot differentially, combining the functions of elevators and ailerons.) Bombers and transports had their jet engines buried in their wing roots or, in American practice, in engine pods under the wing for long- and medium-range jet bombers, tankers, transports and airliners, and (later) off the sides of the aft fuselage for medium- to short-range airliners, regional jets, business jets and some military designs (Saltzman and Ayers 1995: 9–10, fig. 3; Loftin 1985: 355–478).

The need to reduce drag rise at transonic and supersonic speeds dramatically changed the ratio of fuselage length to wingspan: whereas aircraft previously generally had wingspans that greatly exceeded their fuselage length, now the reverse was true. NACA research aerodynamicist Richard Whitcomb advanced the area rule concept which emphasised minimising drag-inducing discontinuities in the progressive growth and reduction in the cross-sectional areas of an aircraft measured along the length of its fuselage. Previously advanced by Junkers engineer Otto Frenzl, area ruling was first applied to the Convair F-102 Delta Dart, saving what had been a failed design and enabling it to exceed the speed of sound, which previously it could not. Popularly dubbed 'Coke bottle' and 'wasp-waisted' design, area ruling became one of the distinctive markers of supersonic aircraft design (Hansen 1987: 327–335; Hirschel 2004: 185; Kinney 2010: 97–108).

Wing aspect ratio – the ratio of span to chord (the distance from leading to trailing edge, measured parallel to the line of flight) – was reduced as well. Thickness/chord ratios reduced from approximately 15 per cent for wartime propeller-driven fighters to 10 per cent for transonic designs and even less for supersonic ones. These came at a price: sharply sweeping wings, increasing fuselage fineness ratio, and reducing the wing's aspect ratio reduced longitudinal (pitch), lateral (roll) and directional (yaw) stability. Aircraft such as the Douglas X-3, the North American F-100 Super Sabre and the Lockheed F-104 Starfighter manifested dangerous 'inertial coupling' (combined roll–yaw–pitch dynamic instability) forcing development of stability augmentation technology. As well, designers markedly increased tail surface area, added ventral fins for directional stability, and many eventually adopted twin vertical fins planforms (Saltzman and Ayers 1995: 10–12).

The increased dynamic air loadings of transonic and supersonic flight endangered pilot escape and forced changes to flight control systems. No longer could pilots simply leap out of an airplane. German, British, Swedish, American, Russian and French firms developed cartridge-propelled ejection seats. These imposed very high and sometimes injurious initial physical loads on the pilot; in response the Martin-Baker company pioneered rocket-boosted seats that not only enabled ejection at zero altitude and zero forward airspeed but also reduced the acceleration load on the pilot. Specialised escape capsules and encapsulated seats were also built (for example, for the F-111 and the B-58), but never enjoyed the success or acceptance of the conventional ejection seat with leg and arm restraints (Engle 1963: 71–82; Robinson 1973b: 231–243; Ryan 2015: 56–58).

From the earliest days of aviation, pilots had added dampers and devices to enhance their control over aircraft, whether motion-limiting bungee cords and bob-weights attached to

control sticks, or trim tabs added to control surfaces to enhance control response. Now, in the transonic-supersonic era, pilots could no longer physically exert sufficient force to overcome the air loads acting on control surfaces, particularly in the dense lower atmosphere. In this environment, flight controls evolved from simple 'pilot-stick-cable-control surface' systems to 'pilot-stick-damper-control surface' systems, then 'pilot-stick-boosted-control surface' systems, and finally systems whereby the pilot had essentially a completely artificial feel over what was a fully redundant boosted and stability-augmented flight control system. In 1983 an F-15 fighter with such a system returned safely to base – admittedly to the amazement of witnesses – following a mid-air collision during a training exercise that had removed almost all of the plane's right wing.

The Vietnam War illustrated for both the United States and Soviet Union the need for more balanced aircraft designs able to meet the challenges of war-fighting across the spectrum of conflict from low to high. Such post-Vietnam aircraft as the F-15 and Soviet MiG-29 exemplified the result, taking advantage of new flight control architectures and higher thrust-to-weight-ratio engines to achieve previously unattainable levels of energy-driven manoeuvrability and flight safety (Huenecke 1987: 207, chart 9-14).

Further, the war revealed deficiencies in existing air-to-air missiles, accelerating post-war development of more reliable and operationally flexible munitions such as the later AIM-7 Sparrow and AIM-9 Sidewinder families, variants of which proved decisive in later combat over the Bekaa Valley and the Falklands, and in the Gulf War of 1991. It stimulated development of the AIM-120 AMRAAM (Advanced Medium-Range Air-to-Air Missile), deployed in the 1990s and used to great effect in later Gulf and Balkan fighting. Deficiencies in air-to-surface munitions such as the AGM-12 Bullpup and AGM-62 Walleye resulted in much improved weapons, notably the AGM-65 Maverick (and the much later AGM-114 Hellfire), enabling pilots to destroy high-value targets from greater distances and with greater prospect of success. Accompanying this achievement was development of advanced imaging and target designation systems and sensors, vital enablers for the weapons themselves, thus accelerating development of the laser-guided bomb (LGB), the 'signature' precision air-to-surface weapon of the modern era (Mets 1987: 43–93).

Perhaps most significantly, the Vietnam experience with inadequate aircraft and weapons drove a shift away from envisioning testing as primarily a method for ensuring contractor compliance towards more realistic operationally focused test and evaluation of weapons and aircraft, including systems integration and human factors issues, to ensure the aircraft or weapon under test met war-fighting needs. In May 1972, even before the Vietnam War ended, the Air Force revised its test practices to draw a sharp distinction between developmental test and evaluation (DT&E, basic engineering airworthiness testing) and operational test and evaluation (OT&E, operational testing addressing tactics, techniques and procedures; reliability and maintainability issues; and combat-focused operational suitability under realistic test conditions). Subsequently, Secretary of Defense Caspar Weinberger established a Director of Test and Evaluation in the Office of the Under Secretary of Defense (Acquisition and Technology) in the Pentagon to ensure the appropriateness and effectiveness of testing DoD-wide (Hall and Griffin 1976: 160–168; McKinney and McWilliams 1976: 128–137; Adolph and Hallion 1998: 16–45).

The challenge of defeating increasingly sophisticated integrated air defences blending radar-cued SAMs and conventional anti-aircraft artillery (AAA) led to development of both 'soft kill' electronic countermeasures (ECM) and 'hard-kill' anti-radiation missiles such as the AGM-45 Shrike, AGM-78 Standard ARM and AGM-88 HARM (High-speed Anti-Radiation Missile) (Browne and Thurbon 1998: 30–36). In addition, it catalysed the first efforts to examine the

foundational underpinnings of radar itself via radar scatter analysis and careful shaping and materials selection, leading in the mid-1970s to the 'stealth' or 'low-observable' revolution (Kaminski 1997: 299–309; Aronstein and Piccirillo 1997: 2–29; Browne and Thurbon 1998: 224–231).

The military airplane after Vietnam

The 1970s brought the introduction of lighter, stronger, more rigid composite structural materials permitting non-standard design. Whereas previously designers had to accommodate their concepts to the limitations of metal structures, they could now use the greater rigidity of composites to create radically forward-sweptwing (FSW) or pure flying wings without incurring the severe weight penalty associated with traditional structures, as well as very-high-aspect-ratio long-loiter remotely piloted vehicles.

The decade also brought the emergence of practical computer-based fly-by-wire (FBW) flight control technology. The drivers for FBW were not only improved flight control efficiency, and the prospect of using it to artificially induce stability even over inherently unstable designs that could never have flown without it, but also aircrew survivability. During the Vietnam War, many aircraft – particularly the Air Force F-105 and Navy F-8 Crusader – had been lost to hydraulic leaks that had resulted in control surfaces going 'hard-over', forcing an immediate ejection, sometimes at very high airspeeds that crippled or even killed the escaping aircrew (and certainly prevented them from seeking to evade and escape). FBW promised to enable the pilot to retain much greater control over the aircraft in the event of control system damage. Intensive laboratory research coupled with aggressive flight testing led to the first significant FBW testbeds, followed by incorporation of FBW into inherently unstable designs such as the General Dynamics (now Lockheed-Martin) F-16, the Lockheed XST stealth demonstrator and the Grumman X-29 FSW. Today, FBW technology has already made the traditional transfer from the military to the civilian sector, and from testbeds and military aircraft to civil airliners (Tomayko 1997: 163–185; Tomayko 2000: 125–135; Piccirillo 2010: 630–723).

The steady advance of Moore's Law drove new analytical and predictive tools and methodologies such as computational fluid dynamics (CFD), computer-aided design (CAD) and computer-aided manufacturing (CAM), and computational structural analysis (Ceruzzi 1989: 114–148; Anderson 2010: 427–458; Aronstein 2010: 461–567). The miniaturisation of avionics and sensors enabled distributed internetted control architectures and sensor capabilities. Integrated with other aerospace advances including FBW, composite structures and precision weapons development, this enabled creation of the F-117 stealth fighter, its electro-optical sensor package, and its principal weapon, the GBU-27 LGB. Introduced into the Air Force's combat forces in 1983, the F-117 was the signature attack aircraft employed in the Gulf War of 1991 (Aronstein and Piccirillo 1997: 133–162).

By the mid-1990s, the many varied threads of aerospace and avionics advance had led to an emergent era of drone warfare. Drone aircraft experimentation dated to the First World War, and by the Second World War had given rise to target drones used for routine training. In the Second World War, large explosive-filled attack drones converted from war-weary B-17, PB4Y-1 and Ju 88 bombers were placed in limited operational service by the United States and Germany. In Korea, the Navy tested carrier-launched bomb-carrying F6F-5K drones by attacking North Korean bridges. In all these cases, the drones were command guided into their targets by accompanying aircraft (Fahrney 1982: 21–26; Werrell 1985: 8–40; Hallion 1986: 193–194). In the 1960s, modified Ryan BQM-34 target drones were used over North Vietnam

for reconnaissance and signals intelligence. Over that same decade, the Navy deployed an operational torpedo-carrying antisubmarine warfare (ASW) helicopter drone on various destroyers and surface craft, taking it out of service in 1971 (Momyer 1978: 233; Newcome 2004: 83–87).

After Vietnam, the Air Force undertook armed BQM-34 weapon trials at the Utah Test and Training Range (UTTR), until, in 1978, Carter-era economic stringencies forced the Air Force to retire its Lockheed DC-130 launch airplanes (Wagner and Sloan 1992: 95–108). Over that same period, NASA made significant advances in developing specialised research drones, including Hyper III, a helicopter-launched hypersonic re-entry vehicle model; a converted Piper PA-30 light twin-engine utility aircraft; a B-52-launched 3/8 scale F-15 spin research glider; and the Rockwell HiMAT (for Highly Maneuverable Aircraft Technology), a B-52-launched afterburning jet-propelled remotely piloted research vehicle. All these were piloted remotely from ground stations with an actual cockpit display, stick or wheel control, and a rated test pilot in command (Hallion 1984: 210–216).

Israel pioneered small propeller-driven intelligence drones, using them to such effect in the 1980s above Lebanon that US Defense Secretary Caspar Weinberger directed the Pentagon's Joint Chiefs of Staff to implement drone research and development programmes. While the Army's Aquila programme proved too complex, the Navy and Marines enjoyed greater success, placing some small drones in service with ground units and on battleships for reconnaissance and gunfire control, and using them with notable success in the Gulf War: Iraqi troops fearing naval bombardment even tried to surrender to one. In that war, the Air Force used modified target drones as emulators of manned aircraft to trigger a response from Iraqi air defence radar sites, which could then be destroyed by roving anti-SAM AGM-88 HARM-shooters (Hallion 1992: 311–312).

Today, the widespread use of drones such as the General Atomics Predator and Reaper and the Northrop-Grumman Global Hawk to counter terrorists and their organisations has obscured that their roots significantly pre-date 11 September 2001. Nevertheless, these benefitted from further advances in small engine power and reliability, composite structures and sensors; the availability of suitable weapons such as the Hellfire; space-based (Global Positioning System) navigation; and satellite communications permitting pilots and weapons officers sitting in Nevada to control drones in-theatre – observing, identifying and targeting terrorists and their organisations. The advent of stealthy drones (pursued as long as four decades ago) and drones of greater payload, sophistication and weapons-dispensing capability indicates that the drone revolution, as conducted to date, is genuine and has staying power (Whittle 2011: 3–32).

The continued refinement of avionics, the advance of computational power (at present on the verge of nano-computing), and the reduction in the size and weight of sensors have now led to the first fully netted 'sensor fused' aircraft: the Lockheed F-22 and Lockheed F-35 (Bevilaqua 2009: 1825–1836; Mullen 2012: 12–50).

Conclusion

Rather than being constrained by the old mission-specific distinctions dating to the First World War – reconnaissance, bombing and fighting, for example – the future airplane (whether with an on-board or remote pilot) will be a multi-mission information-acquiring-sharing-and-using system itself. It will function as a sensing, processing and shooting platform drawing upon other systems and architectures across multiple domains, operating in concert with other sensing, processing and shooting platforms, netted both to traditional command and control nodes and intelligence sources (surface, atmospheric and space), and non-traditional post-9/11 sources as well, and functioning in at least semi-autonomous mode. It will dispense a variety of weapons,

including, perhaps, directed energy and long-range rocket-boosted and/or scramjet-powered hypersonic cruise missiles (Hallion 2010c: 7–30).

Already, since shortly after 9/11, the joining of the multiple revolutions that have occurred over the last century in aerospace were readily apparent in what is now an almost mundane example: the US Air Force special operations weapons controller on horseback in Afghanistan, using laptop targeting and communication systems to assist the Northern Alliance against the Taliban. Modern technology enabled him to call in close air support from loitering B-52 bombers that themselves employed space-based navigation, weather, communications and warning systems, and that, in response to his request and targeting input, dispensed satellite-controlled guided munitions. Altogether, this blending of the air–space–cyberspace environment, effected through technological and scientific symbiosis and reflecting the advantages of circumstantial exploitation, tactical insight and operational need, will characterise the continuation of the military aerospace revolution as it progresses further into the twenty-first century.

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5

AIR POWER, INTERNATIONAL LAW AND ETHICS

Jeffrey Biller

The last two centuries have seen rapid technological and doctrinal advances in the application of air power, forcing a constant re-evaluation of legal and ethical principles in the air domain. The first great re-evaluation occurred during the Second World War, when air power came into its own as a dominant strategic force in warfare. However, strategic bombing against targets other than fielded military forces raised serious ethical and legal concerns. The ability at high altitudes to distinguish civilians from combatants, and then deliver a munition with enough precision to adequately prevent civilian casualties, became, and has remained, the primary ethical and legal challenge in the use of air power.

Although no specific treaties govern the use of air power, a significant body of rules based on general international humanitarian law (IHL) constrains the use of air power in armed conflicts (HPCR 2013). The application of IHL to air power can be broken down into two primary categories. The first consists of those rules specific to the air domain and includes such issues as airspace control and regulation, aircraft sovereignty, and specially protected aircraft. The second consists of those rules governing air-to-ground targeting. For the legal advisor to an air campaign, the second category comprises the vast majority of IHL issues and, therefore, will be the focus of this chapter.

The discussion of air-to-ground targeting has two parts. The first part presents a systematic analysis of the IHL targeting rules, broadly categorised by the general principles of distinction, military necessity, proportionality, and humanity. The second part examines some of the most prominent legal and ethical questions confronting current uses of air power, specifically the application of air power against strategic targets such as Islamic State in Iraq and Syria (ISIS) oil facilities in Iraq and Syria, targeting objects surrounded by human shields, the utilisation of remotely operated aircraft, and autonomous aerial weapon systems.

Air-to-ground targeting under international law

Given air power's potential to deliver devastating effects on both military forces and the civilian population, a lack of understanding regarding targeting limits may result in both strategic failure and an increase in civilian suffering. International lawyers, policy-makers, operators, and others with influence over the air-to-ground targeting process must understand targeting law's guiding principles as well as positive laws. However, the debate should also display a sensitivity

to IHL's underlying balance between the effective conduct of military operations on the one side, and on the other side the humanitarian mandate to protect civilians from war's tragic consequences and combatants from unnecessary harm.

As with international law generally, IHL takes the form of either treaty law for states party to a particular treaty or customary international law (CIL) binding on all states. CIL emerges over time through a combination of state practice and *opinio juris*, which is a state's belief that it is engaging in, or refraining from, an action out of legal obligation (Henckaerts 2005). This chapter covers those IHL targeting rules that are considered customary in nature and that apply during armed conflicts.

The 1977 Additional Protocol I (AP I) to the Geneva Conventions includes the majority of contemporary targeting law. Most states (the United States and Israel being notably absent) are party to the instrument and are therefore bound directly by its terms. However, most non-party states consider nearly all of the treaty's targeting provisions as CIL (Matheson 1987). The AP I references in this chapter replicate accepted rules of CIL and therefore apply to all states.

As a matter of law, IHL applies during an 'armed conflict', defined as 'a resort to armed force between states or protracted armed violence between governmental authorities and organized armed groups within a state' (*Prosecutor* v. *Tadić* 1995: 70). Absent an armed conflict, international human rights law and domestic law govern the targeting of individuals or objects (Milanović 2011: 95). The IHL targeting laws apply to both international armed conflict (IAC) – conflict between two or more states, and non-international armed conflict (NIAC) – conflict between a state and an organised armed group. NIACs also include armed conflicts between multiple organised armed groups. Finally, although AP I does not encompass all aspects of air warfare, Article 49(3) demonstrates that it expressly applies to 'attacks from … the air against objectives on land'. This section proceeds by analysing four general principles – distinction, military necessity, proportionality, and humanity – and the positive rules that extend from each.

The principle of distinction

The principle of distinction is the cornerstone of targeting law. Originally promulgated in the 1868 St Petersburg Declaration and expanded upon in the 1899 and 1907 Hague Regulations, it was codified in Article 48 of AP I, which states:

> In order to ensure respect for and protection of the civilian population and civilian objects, the Parties to the conflict shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives and accordingly shall direct their operations only against military objectives.

The International Court of Justice has referred to distinction as one of two 'cardinal' principles of IHL (Advisory Opinion 1996: 78), along with preventing unnecessary suffering by combatants. The commentary to the Additional Protocols refers to distinction as the 'foundation on which the codification of the laws and customs of war rests' (Sandoz, Swinarski and Zimmermann 1987: 1863).

Several specific IHL rules flow from the general principle of distinction, and cover the targeting of both personnel and objects. For the targeting laws to apply in an armed conflict, however, the action must constitute an 'attack', which AP I Article 49(1) defines as an act of 'violence against the adversary, whether in offence or defence'. Perhaps the primary positive rule regarding distinction is the AP I prohibition against attacks on civilians contained in Article 51(2): '[t]he civilian population as such, as well as individual civilians, shall not be the object of

attack. Acts or threats of violence the primary purpose of which is to spread terror among the civilian population are prohibited.' AP I Article 50(1) defines a civilian as 'any person who does not belong to one of the categories of persons referred to in Article 4A(1), (2), (3) and (6) of the [1949] Third [Geneva] Convention and in Article 43 of this Protocol'. Stated more generally, a civilian is anyone not part of the 'armed forces'.

A component of modern armed conflicts, particularly counter-insurgencies, is the increased difficulty of determining who belongs to the 'armed forces'. According to the Geneva Conventions, armed forces essentially consist of two groups: traditional combatants and members of organised armed groups. Included under the umbrella of combatants are three types of individuals (GC I 1949: Art. 13). The first and most traditional are members of the regular military. Second are members of militias or volunteer corps that 'belong to' a party to the conflict. These groups qualify when they:

- wear a fixed distinctive sign recognisable at a distance;
- carry their arms openly;
- abide by the laws of war; and
- operate under responsible command.

The third group is the rarely seen category of members of a *levée en masse*, who consist of:

> Inhabitants of a non-occupied territory, who on the approach of the enemy spontaneously take up arms to resist the invading forces, without having had time to form themselves into regular armed units, provided they carry arms openly and respect the laws and customs of war.
>
> *(GC I 1949: Art. 13(6))*

As combatants, all of these categories are subject to attack based solely on their status, unless they are *hors de combat* or in a specially protected category, such as medical and religious personnel (*Prosecutor* v. *Kordić and Čerkez* 2004: 51).

The second group encompassed by the definition of 'armed forces' is organised armed groups (OAGs). Significantly greater debate surrounds the circumstances when members of an OAG may be targeted. OAGs are groups with sufficient structure to engage in military activities as a unit, and who actively engage in hostilities (Melzer 2009: 32). The debate as to who in an OAG may be targeted revolves around the requirement for targetable members to have a 'continuous combat function' within the group. This requirement means those not having such a function within the OAG are considered civilians who enjoy protection from attack.

Several controversial issues exist regarding the principle of distinction. The first issue relates to civilians who 'directly participate in hostilities (DPH)'. Civilians who DPH lose their protection from attack 'for such time' as they participate in hostilities (AP I 1977: Art. 51(3)), raising the 'revolving door' question of those civilians who only periodically take up arms. The question is whether they should be targetable in the interim period between attacks. The International Committee of the Red Cross (ICRC) Interpretive Guidance states they should not be targetable during this period (Melzer 2009: 47). However, this places enemy military forces in the obviously difficult position of having the civilians determine when and where they may be subject to attack.

Finally, the use of so-called 'signature strikes', or those attacks directed at persons 'who bear certain signatures, or defining characteristics associated with terrorist activity, but whose identities aren't known' (Klaidman 2012: 41). The problem is particularly difficult in conflict

zones such as Afghanistan, where civilians with no connection to the conflict often meet 'signature' criteria, such as openly carrying military-grade light weaponry. Although this list of controversial topics is not exhaustive, it demonstrates the difficulties of distinction on the modern battlefield.

The principle of military necessity

In addition to not targeting civilians, the principle of military necessity further restricts targets to those objects considered to be military objectives. Article 52(2) of AP I defines military objectives as 'objects which by their nature, location, purpose, or use, make an effective contribution to military action and whose total or partial destruction, capture or neutralisation, in the circumstances ruling at the time, offers a definite military advantage'. Thus, military objectives have two cumulative criteria:

- an 'effective contribution' to the adversary's military action; and
- a 'definite military advantage' gained through attack.

Often, particularly in asymmetric warfare, a party to the conflict will use a traditionally civilian object for a military purpose, for example placing anti-aircraft artillery within an otherwise civilian structure. AP I states that objects 'normally dedicated to civilian purposes, such as a place of worship, a house or other dwelling, or a school' should carry a presumption that they remain civilian objects when questions arise as to whether they are being used for military purposes and are thus subject to targeting, until solid evidence indicates otherwise (Art. 52(3)). However, if evidence indicates a definite military use, the military objective criterion applies during the period of military use. If possible, distinct civilian components of a target must be considered independently.

Regarding air-to-air targets and distinction, military aircraft are military objects by their nature and subject to attack, unless in current use as medical aircraft (HPCR 2013: 32). Non-military aircraft, except civilian airliners, may be targeted if engaging in activities that make an effective contribution to military action, such as gathering intelligence or transporting troops or military materiel. Additionally, non-military aircraft that fail to comply with the orders of military authorities for landing, inspection, and possible capture, or that resist interception, also qualify as military objectives (ibid.: 126–130).

Civilian airliners have unique protections to safeguard their accidental targeting by military forces. A civilian airliner being used for military purposes may only be targeted if:

- diversion for landing, inspection, and possible capture is not feasible;
- no other method for exercising military control is available;
- the actions that render the civilian airliner a military objective are sufficiently grave to justify an attack;
- all feasible precautions have been taken;
- the strike will not violate the principle of proportionality; and
- a warning has been issued whenever circumstances permit (ibid.: 198–201).

Given the significant potential for the loss of non-combatant lives when targeting a civilian airliner, it is understandable that special rules attach to such a situation.

The principle of proportionality

Assuming a target is determined to be a military objective and that the attack method minimises potential civilian casualties, the operation must additionally comply with the rule of proportionality. This rule prohibits 'an attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated' (AP I 1977: Art. 51(5)(b)). It is important to state at the outset that this rule does not prohibit harm to civilians, referred to as 'incidental injury', or damage to civilian objects, labelled 'collateral damage', but rather precludes attack when the harm would be 'excessive' in comparison to the military advantage expected to be gained (HPCR 2013: 98). The proportionality analysis can be extremely difficult given the fog of war. Additionally, target values vary widely depending on the conflict and the context at the time of the attack.

The proportionality evaluation hinges largely on two factors: first, the amount of military advantage to be gained, and second, the level of incidental injury or collateral damage expected to be caused. This is not a strict mathematical calculation, but rather a reasonable evaluation based on available evidence. Unlike military necessity, which is a yes-or-no calculation, military advantage for the purpose of a proportionality calculation is measured for the amount of advantage gained. The military advantage must be foreseeable, not relying on potential but unanticipated effects. However, there is no temporal restriction on when effects occur.

The second portion of the proportionality evaluation concerns the amount of collateral damage or incidental injury. Here, the effects can be either direct or indirect (HPCR 2013: 97). Direct effects are 'the immediate, first-order consequences, unaltered by intervening events or mechanisms', whereas indirect effects are 'the delayed and/or displaced second-, third-, and higher-order consequences of action, created through intermediate events or mechanisms' (JP 3-60 2013: II-36). Although the fog of war will sometimes result in situations where unknown civilian personnel or objects were located at or near a target, this is an *ex ante* assessment based solely on what is known, or should have been known, at the time of the operation.

The principle of humanity

The principle of humanity encompasses a prohibition on the infliction of unnecessary suffering and serves as a counterweight to the principle of military necessity. Unnecessary suffering is any injury, death, or destruction that serves no military purpose; the principle applies to both civilians and combatants. It also encompasses the duty of commanders to take precautions against causing the unnecessary suffering of civilians.

An essential component of the principle of humanity is the ban on weapons that, by their nature, are intended to cause superfluous injury or unnecessary suffering. This long-standing and customary rule first appeared in the regulations annexed to the 1899 Hague Convention II and its 1907 counterpart and was affirmed in Article 35(2) of AP I. The ban applies to those methods and means of warfare that unnecessarily, by serving no military purpose, aggravate the suffering of combatants.

Closely related to this ban is the customary prohibition on attacks against those considered *hors de combat*, which is reflected in Article 41 of AP I. Combatants are considered *hors de combat* when they become incapacitated, either from injury, capture, or expressing a desire to surrender. IHL prohibits these attacks because they no longer serve a military purpose. This rule is particularly challenging to apply in the air context given the difficulty in determining whether

targeted combatants on the ground are injured to the point of being *hors de combat*. Commanders have a duty to employ all operationally available methods to determine whether a target on the ground is *hors de combat* prior to making additional strikes. Targets who continue to undertake hostile acts, even if injured, do not have this protection.

A third rule of humanity is known as 'precautions in attack'. The rule, as laid down in AP I, requires that 'constant care shall be taken to spare the civilian population, civilians, and civilian objects' (Art. 57(1)). This is not an absolute rule, but it does require taking 'feasible' precautions (AP I 1977: Art. 57(2)(a)). Feasible precautions are those 'which are practicable or practically possible taking into account all circumstances ruling at the time, including humanitarian and military considerations' (Protocol (III) 1980: Art. 1(5)). Specifically, those who plan or approve attacks are obligated to 'do everything feasible to verify that the objectives to be attacked are neither civilians nor civilian objects … [or] subject to special protection' (AP I 1977: Art. 57(2)(a)(i)).

Of particular note in this regard are guided munitions, such as laser-, electro-optical-, or GPS-guided weapons. The decision to employ guided versus unguided munitions in a situation is highly contextual; any categorical declarations that guided munitions must be used are simply incorrect. For instance, although guided munitions may be available for an operation, they may be of limited quantity and held in reserve for later operations. Moreover, the employment of some guided munitions requires additional personnel or platforms to designate a target. High levels of risk to these personnel may weigh against the use of guided munitions. Another example in the debate over precautions in attack is the use of remotely operated aircraft, and is taken up in the section on the use of drones and precautions in attack.

Current legal and ethical issues in the application of air power

The use of air power frequently presents issues that can be framed as ethical in nature, but require an understanding of international law. As both the nature of modern military campaigns and the technology used within them evolve, significant debate about the proper use and restrictions of air power continually surfaces. This section describes four modern areas of debate, drawing upon the principles of targeting as outlined in the previous section.

The first issue is the strategic targeting of war-sustaining objects, and the first subsection analyses the targeting of ISIS oil production and distribution facilities as an example. The primary question here is whether these objects meet the AP I 1977 Article 52(2) definition of a military objective. The second subsection addresses the challenge of targeting objects that are protected by human shields, whether voluntary or involuntary. The third subsection contemplates utilisation of remotely piloted aircraft, commonly referred to as 'drones', and whether the legal requirement to take precautions in attack requires their use in certain circumstances. The fourth and final subsection analyses autonomously operated aerial systems and whether systems acting without human control inherently violate international law.

Targeting war-sustaining military objects

Prior to the Second World War, the United States determined that the 'successful application of air power requires a predetermined plan calculated to destroy the enemy's will and war sustaining capability. Achieving this goal requires systematic analysis to determine which targets, if destroyed, would do the greatest damage to the enemy' (AFPAM 14-210 1998: Att. 2). Conducting operations to damage the 'enemy's will and war sustaining capability', rather than simply wearing down the enemy's fielded forces, requires deconstructing enemy systems to

identify objectives of particular strategic value. Sometimes those systems lie outside the traditional notion of a military target.

On 22 September 2014, a coalition led by the United States began aerial attacks in Syria against ISIS. This campaign included the controversial targeting of ISIS-controlled oil operations facilities. The coalition justified these attacks by stating that '[t]hese small-scale refineries provide fuel to run ISIS operations, money to finance their continued attacks throughout Iraq and Syria, and they are an economic asset to support future operations' (Johnson 2014).

The controversial issue is whether 'war-sustaining' objects should be included in the legal meaning of 'military objectives'. The United States argues that they should, defining war-sustaining objects as 'economic objects of the enemy that indirectly but effectively support and sustain the enemy's war-fighting capability' (NWP 1-14M 2007: 8-3). However, the characterisation of war-sustaining entities as lawful targets has been widely criticised (Schmitt 2006: 281). Opponents argue that the requirement to make an effective contribution to 'military action' suggests excluding objects that indirectly support the war effort, such as oil production facilities and oil transports not set aside for military use (HPCR 2013: 121).

The targeting of ISIS oil production is further complicated in that the oil facilities and subsequent revenues are controlled by an OAG, not a state actor. Although ISIS does engage in some governance-like activities, it is not a state entity and it utilises the revenues largely to fund insurgency and terrorism-related activities. Further complicating the matter, treaty law related to the targeting of civilian objects during a non-international armed conflict is quite limited as compared to the law governing international armed conflicts (Henckaerts and Doswald-Beck 2005: 26–29). Although general consensus exists that the targeting of civilian objects is prohibited during non-international armed conflict, the particulars of that prohibition have an increased level of ambiguity (Schmitt et al. 2006: 18–19).

Closely related to the targeting of oil-related facilities is the issue of targeting individuals operating those facilities. Clearly, facility workers who are not part of the OAG, in this case ISIS, must be considered as civilians when conducting a targeting analysis. More controversial is the targeting of members of ISIS whose function within the OAG is the operation or oversight of oil facilities, as opposed to those ISIS members with a combat function. Considerable disagreement has emerged over whether members of an OAG are required to have a 'continuous combat function' to be considered legal targets. If such a requirement exists, then members of ISIS whose function is solely to operate oil production and distribution would not be valid targets. If not, then these workers are targetable by virtue of their membership in ISIS alone.

It is tempting to view the lack of widespread objections by states to the targeting of ISIS oil assets as a signal that states are moving towards an acceptance of targeting war-sustaining objects. However, this may be a political decision based on the widespread rejection of ISIS's ideology and methods. Any analysis of potential war-sustaining targets must closely examine the intelligence linking the revenues of the object to use in military operations. The more direct that link, the more likely that the international community will recognise the target as legitimate under IHL.

Targeting objects surrounded by human shields

Perhaps few issues have vexed both practitioners and academics more than that of human shields, which is the use of protected persons, typically prisoners or civilians, near military objectives with the intent of deterring attacks on those objectives. The DoD *Law of War Manual* begins its discussion of human shields by stating 'adversary use of human shields can present

complex moral, ethical, legal, and policy considerations' (DoD OGC 2016: 5.12.3.4). This complexity accounts for its frequent inclusion in an overall strategy of 'lawfare', described as the exploitation of the enemy's adherence to international law to gain a military advantage (Dunlap 2008). Of particular interest to the application of air power is how those acting as human shields must be accounted for in targeting decisions, particularly the proportionality calculation and obligations to take precautions in attack.

There is no doubt that the practice of intentionally using human shields to protect military objectives is impermissible under international law (AP I 1977: Art. 51(7)). However, this tactic has been frequently and effectively used by insurgents in Iraq, Afghanistan, Gaza, and elsewhere. Although it is difficult to argue that the party using the shields does not bear primary responsibility for resulting civilian injury or death, the attacking force must still grapple with the obligations under IHL to protect civilians and civilian objects (DoD OGC 2016: 5.12.3.4). The intentional use of human shields can be broken down into two general categories requiring distinct legal and ethical analysis: the involuntary use of protected persons, such as prisoners, and the use of volunteer civilians with the acceptance of the defending force. In cases of doubt, the attacker should presume that the shields are acting involuntarily (HPCR 2013: 170). International consensus has largely formed around the issue of involuntary human shields and therefore will be addressed first.

An attacking force aware of involuntary human shields at the target must account for those civilians in their proportionality calculus and take all feasible precautions in attack to prevent incidental injury (JP 3-60 2013: E-2). Although some critics of this view hold that it potentially encourages the use of involuntary shields by less scrupulous parties to a conflict, this does not override the protected status of the civilian (Schmitt 2009: 49–51). Some states hold a more nuanced view of this requirement, finding that the proportionality analysis may be 'more relaxed' when involuntary human shields are used (HPCR 2013: 169). However calculated, if the attack on a target surrounded by involuntary human shields is not considered to be excessive to the military advantage, the attacker must still take all feasible precautions to limit the incidental injury or collateral damage (AP I 1977: Art. 57).

More difficult is the question of voluntary human shields. The debate is whether civilians who purposefully place themselves near military objectives to frustrate enemy operations lose its protections under IHL. The loss of protections is a result of the civilian committing an act considered to DPH, a concept previously discussed in relation to the principle of distinction. On one side of the argument is that all voluntary human shielding should be considered to DPH (Schmitt 2009: 41–42). The opposing position, taken by the ICRC, finds that only voluntary human shields constituting a physical barrier, as opposed to a legal or ethical barrier, constitute a DPH with the resulting loss of IHL protections (Melzer 2009: 57). Under this view, most voluntary human shields intending to deter aerial attack must be included in the proportionality analysis and be subject to feasible precautions in attack, as human shields rarely provide a physical obstacle to aerial attack.

The use of drones and precautions in attack

The strategic goals in counter-insurgency operations may necessitate a very different application of air power than traditional armed conflicts. Counter-insurgency doctrine reduces the priority of wearing down or destroying the enemy's fielded forces (FM 3-24 2006). Rather, it places an increased value on the use of military forces to safeguard a state's government, infrastructure, and civilian population, while simultaneously operating against a non-state actor within that state (ibid.: 5-1). This leads to an increased necessity for air operations to limit

incidental injury and collateral damage, which is the primary reason that rules of engagement are generally much more restrictive than IHL limits. Additionally, non-state actors operating among the civilian population, with or without their support, create immense operational and legal targeting challenges. Recognising these challenges, states began developing new air power platforms, such as remotely piloted, or drone, aircraft.

A drone, technically referred to in the Air and Missile Warfare Manual as an 'unmanned combat aerial vehicle', is an 'unmanned military aircraft of any size which carries and launches a weapon, or which can use on-board technology to direct such a weapon to a target' (HPCR 2013: 49). Drone aircraft evolved from surveillance systems into strike platforms due to the need to distinguish non-state actors from the civilian populace and monitor them until the optimal opportunity arises to strike while limiting civilian casualties. The use of drones has dramatically grown over the past two decades, a trend certain to continue (Entous et al. 2012). The reason for such growth is largely drones' ability to employ precision weapons using enhanced ISR capabilities while maintaining persistent surveillance over the target area, both pre- and post-strike.

The targeting rules flowing from the legal principles discussed in the section on air-to-ground targeting under international law apply equally to drone operations (Alston 2010: 79). Indeed, the unique persistent surveillance and precision strike capabilities offered by drones allow their operations to be particularly compliant with IHL principles. However, these same qualities, which greatly minimise the likelihood, or degree, of incidental injury and collateral damage, suggest that the requirement to take precautions in attack requires the use of drones in certain circumstances.

Recall that the requirement for precautions in attack extends only to those measures that are 'feasible'. In drone operations, this requires utilising the multiplicity of on-board sensors and adequate loiter time over the target to confirm identity and limit incidental injury and collateral damage before attacking. However, this requirement only exists within the parameter of operational requirements. Additionally, because drone operations do not include risk to aircrew, the attacking force should accept somewhat greater risk when taking precautions than when using manned aircraft.

Examinations regarding the requirement to use operationally available strike-capable drone aircraft must occur in the context of the conditions at the target location. Because of its sensitive sensors, ability to monitor a target for long periods, and use of guided munitions, a drone may pose far less risk of incidental injury and collateral damage than other attack systems. When the strike is to occur in a populated area, the ability of the operations centre to monitor the targeted individual for many hours and wait to attack until the target is no longer near civilians or civilian objects may require the use of a drone. However, this requirement only exists when other strike methods cannot match these capabilities and to the extent that use of drones is militarily feasible.

Aerial autonomous weapon systems

Perhaps no recent new class of weapons systems has attracted as much controversy in the technical, legal, and public spheres as that of autonomous weapon systems (AWS). Although much debate centres on what constitutes an AWS, the US Department of Defense recently defined AWS as 'a weapon system that, once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation'

(DoDD 3000.09 2012: 13–14). AWS can be divided into three classes: 'semi-autonomous systems' that require a human to direct the system to select a target and attack it, 'human-supervised autonomous systems' that maintain human operator oversight while the system selects targets and attacks them, and 'fully autonomous weapon systems' (F-AWS) that can attack without any human involvement (ibid.: 13–14).

The advent of AWS, particularly F-AWS, raises the issue of inherently illegal weapons. The IHL governing weaponry views their legality in two separate ways. The first focuses on the inherent legality of a weapon. If a weapon cannot be used in a manner that complies with IHL, then it is considered illegal per se. Conversely, if any circumstance exists where the weapon could be used lawfully, then it is not an inherently illegal weapon. The second line of prohibitions considers whether the weapon can be used in a legal manner given the particular operational context.

Critics of F-AWS frequently question whether they are inherently illegal under IHL. For example, Human Rights Watch (2012) stated that 'fully autonomous weapons would not only be unable to meet legal standards but would also undermine essential non-legal safeguards for civilians'. The critique of these systems primarily revolves around issues such as the ability to distinguish between military and civilian targets, assess human intentions, and make a proportionality analysis. Many see the question of responsibility for potential war crimes involving F-AWS as the primary issue.

These are certainly significant challenges for those developing fully autonomous aerial systems, particularly in the urban counter-insurgency context. However, as great as these challenges may be in particular operational environments, it is not hard to imagine a set of circumstances where F-AWS could be used in a lawful manner. Not every operational environment contains civilians or civilian objects. If a particular environment does not, a system with the capacity to distinguish protected persons and objects from lawful military targets is not necessary. However, the use of F-AWS in a more complex environment does raise significant technical challenges in seeking to comply with legal requirements.

The ability of any F-AWS to act in compliance with IHL depends on the capabilities of the system's sensors, its programming, and its processing capability. F-AWS will most certainly have the capability to deploy guided munitions against targets. Therefore, the issue is whether their processors and programming are advanced enough to consistently identify lawful targets, distinguish lawful from unlawful targets, make proportionality determinations, and properly analyse other IHL requirements. If the system has shown through testing that it cannot consistently and appropriately make these determinations in particular operational environments, then its use in those environments would be considered illegal.

As to the question of responsibility for attacks that may constitute war crimes, selection of targets by F-AWS would not absolve human operators of responsibility for attacks that violate IHL rules. Those making the decision to launch an F-AWS into a situation where the system is unable to consistently determine legal targets, prevent excessive incidental injury or collateral damage, or make correct proportionality assessments violate the relevant rules nonetheless. Additionally, those persons programming the system may be held accountable should the F-AWS be programmed to engage in actions that amount to war crimes.

Conclusion

The application of IHL to the use of air power has evolved rapidly, reflecting both the speed of air power's technological development and its ever-increasing importance at all levels of warfare. Scenes of carnage resulting from the application of air power to urban environments

result from almost every conflict, underscoring the need to balance humanitarian concerns with operational necessity. The interconnected principles of distinction, military necessity, proportionality, and humanity help achieve this balance, but have proven challenging in the air-to-ground targeting context. This is unsurprising given the speed and increasingly complex battlefield situations in which modern air operations take place. Modern counter-insurgency campaigns have further increased that complexity with the increased focus on prevention of collateral damage and incidental injury.

Modern legal challenges to the use of air power result primarily from complex targeting decisions in operational environments where the concepts of civilian and combatant may be intertwined, sometimes intentionally so, by the enemy. In many cases, unscrupulous forces utilise their opponent's reliance on international law to achieve their aims. The legal and ethical questions of strategic targeting, human shields, the use of drone aircraft, and aerial AWS all have their roots in these complexities. However, a deeper understanding of the rules of IHL often reveals goals that match tactical, operational, and strategic objectives. The study and understanding of IHL can and should assist all those involved in the planning and conduct of air operations.

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6
AIR POWER HISTORY

Peter W. Gray

This chapter gives a brief overview of the global application of air power at the operational and strategic levels. This should immediately set it apart from many other histories of air power with their traditional mix of tales of derring-do and details of technology and other tactical minutiae. Similarly, it is always tempting to take the reader back to humankind's earliest flirtations with the third dimension in Greek mythology and then through to Tennyson's 'Locksley Hall', with its invocation of the 'Central Blue'; but this has been done elsewhere and will not be pursued (Gray 2016: 37–40). Arguably it would be more useful to follow Mason (1994) and date the advent of military aviation back to Major J. D. Fullerton at the Chicago World Columbian Exposition in 1893, where he predicted that 'airships will in the future cause as great a revolution in the art of warfare as gunpowder in the past' (Fullerton 1894: 571–574). The key point here is that Fullerton and his co-conference colleagues were part of a global, active band of thinkers, engineers and practical individuals willing to share their ideas; they did not gather together in Chicago by accident.

The early years

The following twenty years, up until the start of the First World War, saw military thinking on the exploitation of the third dimension continue apace in many countries and many services, including armies, navies and marine corps. Clearly, the advent of powered flight accelerated the process, but before the war started, armies had actively experimented with the emerging technology and put considerable effort into conceptual thinking as to how it could be best exploited and how it was to be coordinated and organised (Pugh 2013). Equally important, in many countries, and certainly in the UK, armies had begun to experiment on a realistic scale with the integration of air power into army manoeuvres (Whitmarsh 2007). Notwithstanding the limitations caused by poor engine performance, limited manoeuvrability and no offensive armament, the information-gathering potential of air power was immediately evident, especially when used in conjunction with other forms of reconnaissance. This translated into operational reality in the early days of the First World War, when (British) Royal Flying Corps (RFC) aircraft were able to plot the location of the German Army and provide commanders with vital intelligence. The Battle of the Marne was won on 9 September 1914; as the Official Historians commented, 'Paris was saved' (Raleigh 1922: 334). In a few days of tactical action,

the operational and strategic potential of air power was proven beyond doubt, to the point where it could be argued that, in conjunction with appropriate command and control and with land forces, it determined the outcome favourably (for the allies).

Coincident with these early reconnaissance forays, it became increasingly evident, to all sides, that the opposition would do its utmost to prevent free access to airspace. Control of the air would become vital and nations would have to fight for it (ibid.: 329). The following four years exposed many of the challenges that organised air power would experience over the coming century. As the early combat reports acknowledged, the need for agility, power and speed, ability to gain height, and a weapon's carrying capability were all essential, but required trade-offs or continuous technological development. While the ground war soon stagnated into attritional trench warfare all at a massive industrial scale the air war epitomised the need for technical innovation in all fields of endeavour. No sooner did one side demonstrate a degree of ascendancy than the opponents had to at least match its capability.

Again, common to the experiences of the following decades, the conceptual thinking behind the employment of air power, along with the manner in which air power was organised and controlled, had to be skilfully intertwined with the technological developments. Hugh Trenchard, as commander of the RFC in France, remained absolutely determined to maintain a 'relentless offensive'. In common with his French opposite number, Commandant du Peuty, he shaped the allied approach to air power: that it was fundamentally an offensive, rather than defensive, weapon (Dye 2009: 8). Furthermore, both commanders agreed that air assets should be commanded at the highest level and not split into insignificant elements. Trenchard's mentality was very much in the wider spirit of the British Army and he was on the same hymn sheet as the army's commander in France (Douglas Haig). Furthermore, it is significant that the German air arm and army sought to replicate this in 1917, aiming to push deep into allied territory (Baring 1968: 200).

By this time in the war, all fully understood the vital nature of control of the air. They also understood the value of reconnaissance, especially when directly linked to artillery spotting and direction. As aircraft became more capable in the ensuing arms races, so payloads allowed limited ground attack on enemy positions on the battlefield and deeper into the supply lines and depots.

Ultimately, this was taken to its logical extension with attacks on enemy industry and populations at home. German Zeppelin attacks began in January 1915 with attacks authorised on docks and military targets on the coast and the lower reaches of the Thames (Biddle 2002: 21). Over time these attacks spread further into the UK and into London itself. The actual military damage, or effect, was negligible, but the attacks had a major impact on morale, on the press and on debate in the British Parliament. Again, air power was going beyond the tactical level to have real impact at the operational level, with units having to be withdrawn to see to protection of the homeland, and at the strategic level.

As the vulnerability of the Zeppelins became apparent, the emphasis shifted to heavier-than-air machines, with Gotha and Geant raids taking place. The ensuing furore, or more correctly anger, over the raids had several consequences which again would set the tone for the following decades. The first of these was the need to defend national airspace. Control of the air became the one role to rule all of the others. The next, in quick succession, were revenge and retaliation against industrial targets within Germany. The operational- and strategic-level collateral damage in these developments was to highlight the growing differences between RFC thinking and that of the Royal Naval Air Service (RNAS). The first disagreement was over aircraft and engine procurement and the second over home defence – neither wanted the role. The RFC did not want to dilute support for the army on the Western Front, but had to bow to political pressure.

The upshot was a series of reports by South African General Jan Smuts which led to the formation of the world's first independent air force – the Royal Air Force (RAF) – on 1 April 1918, and second, the formation of the Independent Force charged with bombing Germany.

By the end of the First World War, it had become evident to the participants and those in other countries who had observed what had happened in the war in the air that control of the air was paramount, but had to be fought for and then maintained. As aircraft carrying capacity grew, so did the scope for air mobility. Reconnaissance (or what would become intelligence, surveillance, target acquisition and reconnaissance – ISTAR) was vitally important and ground attack in its various guises had apparently unlimited potential to change the course of the next war – and ideally prevent a conflict from degenerating into costly trench sieges and battles. What also emerged from the First World War was confirmation that air warfare, and aviation in general, tended to attract more than its fair share of adventurers, entrepreneurs and, for better or worse, mavericks. Some of the latter ended up as renowned air power thinkers and strategists; they (and their courts martial) are covered elsewhere in this handbook. Suffice it to say in this chapter that many of the hard lessons of the First World War became wreathed in hyperbole, with more attention given to the promise or potential of air power than was warranted. The desire to leapfrog the battlefield and its associated carnage encouraged discussion about this potential without the commensurate investment in technology or training.

The inter-war years globally were overshadowed by the Great Depression and by dire economic prospects (Kennedy 1988: 364–365). This was accompanied by radical changes in many countries' political institutions with the rise of fascism and communism. At the same time, the dismantlement of empires grew more rapid (Reynolds 1991). Superimposed on these major trends was a significant pacifist movement which culminated in the Geneva disarmament process and attempts to achieve a worldwide ban on military aviation (Gray 2010: 9–40).

As the 1930s wore on, the tension mounted across Europe and indeed globally, as few commentators could imagine that Germany's territorial demands, and worse, could go unchallenged. Military planners, their political masters and the supporting arms in science and technology braced themselves for the onslaught. The spiral of air power thinking, technology demands similar to those of the First World War, and organisational change continued apace; the DNA helix of air power had to evolve. The Luftwaffe continued to grow at a rapid pace, fuelled by what was becoming a whole society war economy. The RAF embarked on a series of expansion schemes and reorganised its outdated command structure (Gray 2012: 129–143). The aforementioned belief, of almost religious magnitude, that the bomber would prevail was not matched by the reality of the equipment available and the defence industry simply did not have the capacity to bridge the gap in the likely timescales. The ability to work closely with army and the navy had been honed in Germany, but sadly neglected in Britain under budgetary pressures and unnecessary bickering over priorities and even the very existence of the RAF.

The Second World War

It is almost impossible to chronicle the history of the use of air power in the Second World War in such a short chapter, and the topic has been extensively covered elsewhere. It is worth, however, stressing that the key roles within air power were all exercised during the conflict with control of the air becoming ever more important. Crucially, commanders in all services, including those on the home front, learned very quickly that control of the air could not be taken for granted: combatants would have to fight for it and then maintain it, often at considerable cost. Terms such as 'air superiority' that had emerged in theory were rapidly supplemented in the air power doctrinal lexicon with concepts such as 'air parity' limited in

time and space. British forces on the beaches and the mole at Dunkirk, along with their commanders, soon realised that key episodes in the evacuation had to be planned and timed to coincide with the times when the limited air assets were available to keep the Luftwaffe at bay.

The Battle of Britain has been discussed, glamourised and debated over the years. Keeping Britain safe from a potential invasion was an inherently joint enterprise involving a very substantial navy and some vestiges of ground forces, including a very well-organised anti-aircraft artillery capability. While the bulk of the fighting involved predominantly fighter pilots, it should still be acknowledged that the Battle itself represented the culmination of scientific endeavour involving aircraft engines, fuselage design, air-to-air sights and the advent of radar. These had to be produced and then repaired by industry working closely with the RAF and the organisation had to be 'fit for purpose', as it certainly was under what became known as the Dowding system.

As the conflict progressed, in all of its global theatres of operations the importance of control of the air was an ever-present theme, both in what its attainment meant for unimpeded operations on the surface and in the consequences of surrendering it even briefly. This was as true in the deserts of North Africa as it was in the jungles of South East Asia. Above the tactical and operational levels of war, control of the air had vital consequences for the strategic-level outcomes. Critical industries had to be protected from enemy attack, as did government and command and control functions. These issues had been foreshadowed in the First World War but emerged in reality during the Second. It became increasingly apparent, as heavy bombers grew in size, payload and range, that nations would have to defend key infrastructure targets. Civilian morale may be a vague concept, but successful attacks on the seat of government or the vital production of oil or steel could prevent continuation of the war (Tooze 2007: 596–602). With the Combined Bomber Offensive raids on the heartland of Germany becoming increasingly effective by day and night the Luftwaffe had no option but to defend in force. This enabled the allies to conduct a concentrated counter-air offensive against the fighters, their command and control, and their bases; the means of production and fuel stocks were part of the campaign target set. Victory here effectively secured command of the air over the Normandy beaches and the rest of France.

The allies had profoundly hoped that strategic bombing forcing a German collapse and surrender could prevent the reoccupation of France and an Anglo-American ground offensive into Germany. The hopes of the air power visionaries, pundits and commanders were never realised and the combatants had to conduct total war, using all available means. The effectiveness of the strategic bombing campaigns, whether against Britain, Germany, or Japan, remains a hotly contested issue (D'Este 2008: 732). This applies to the military effectiveness as well as the ethical aspects, with the latter providing fertile ground for modern writers to cherry pick from history over both individual raids and the whole campaign (Addison and Crang 2006; Grayling 2006). Some commanders, either out of stubbornness or in the quest for an independent role which would bring about an independent air force, clung to the notion that pulverising enemy cities would bring about collapse of the opponent's regime. Yet while the bombing had real strategic consequences in some cases the use of the term 'strategic' became confused and remained so through the ensuing Cold War. 'Strategic' was taken variously to imply long-range, inter-theatre, or simply heavy weights of ordnance. This deflected attention from the actual effects of the bombing on the conduct of the war. In practice the 'heavies' were used in a variety of roles and against a range of target sets from submarine pens through transportation to close air support.

Of the other air power roles, ground attack was heavily utilised throughout the war in all theatres as, of course was anti-shipping attack. The requirement for land (or maritime) com -

manders to be closely integrated with air bosses was a lesson that was learned and forgotten and then painfully relearned many times over, with the clash of egos (especially those of Montgomery and Coningham), the army's desire to 'own' assets, and the conflict over resources as time-worn reasons. Yet as the war on all fronts wore on, the British Army came to rely increasingly upon air support to the point where Arthur Tedder, in a letter to the Chief of the Air Staff, Charles 'Peter' Portal, described the army as being 'drugged on bombs' (Gray 2012: 226).

Air mobility rose in importance over the course of the conflict, with all major armies embracing airlift and the use of airborne forces, albeit with varying degrees of success. The global scale of the conflict was such that serious air travel came into its own, enabling politicians and senior leaders to move between, and within, theatres with unprecedented speed. At an operational level, Field Marshal Viscount William Slim described the scale on which air transport was used in the Burma campaign as a 'new kind of warfare' (Slim 2000: 544) with divisions of ordinary (as opposed to specialist) troops being ferried about the front.

The war against Japan saw all the roles of air power in action, including major attacks on Tokyo and other cities growing in scale from the early Doolittle raids to the mass attacks carried out by B-29 Superfortresses. These raids were largely unopposed, as Japan had neither fighters with adequate performance nor the crews or the ground defences to reach the high-flying bombers. The bombing campaign culminated in the two nuclear attacks on Hiroshima and Nagasaki in August 1945, effectively ending the war.

The advent of nuclear warfare brought a new dimension to the conceptual world of air power theory and, arguably more important, to the wider field of international relations. Having seen the scale of devastation wrought upon Japan, Russia was quick to join an arms race to procure its own nuclear capability. As diplomatic and political relations soured, the Iron Curtain descended, heralding the transition into a long Cold War.

The Cold War

For the political leaders and their senior military commanders, the declaration of peace had become a matter of when rather than if, and they had turned their attention towards the shape of things to come often well in advance. They therefore prepared their positions looking internally as well as across the world stage. For some air power advocates, this meant an air force independent from its army ancestry, as happened in the US. In other countries, the memories of unpreparedness during the 1930s had left a legacy of 'never again', and this was certainly true in the UK even though the costs would be huge.

The external scene was dominated by the growth of nuclear-equipped states and in the pre-space era air power was the natural means of delivering nuclear bombs. The air power DNA spiral of science, technology, organisation and military thinking grew ever more expensive as aircraft had to carry more weaponry and be able to climb higher, fly faster, and so on. Both the Americans and the Russians seized on the German advances in rocketry, and surface-to-air missiles (SAMs) became an increasingly worrying factor in the developing arms race.

Lancasters, B-17 Flying Fortresses, and even the B-29 Superfortresses soon became obsolete as the age of the jet engine arrived. Replacements included the B-52; the British V-Bomber force of Vulcans, Valiants and Victors; and Russian Bisons, Badgers and Bears (the latter turbo-prop rather than jet). Nations acknowledged the lessons from the German and allied air defence systems and set up geographically immense radar chains to provide early warning of a pre-emptive strike. Intention to launch a ballistic missile attack required enough warning for the target nation to be able to launch a counter-attack, with the ultimate aim being to deter the enemy from any such action. Air power was paramount in the early phases of the Cold War,

gradually giving way to the triad of ballistic missiles, submarine-based systems and air-delivered weapons. The latter often would require a mass of aircraft maintaining airborne alert supported by fleets of air-to-air refuelling tankers.

The Second World War also saw a meteoric rise in electronic counter measures (ECM). Means to mask bomber streams from enemy radars such as Window and a whole range of other jamming and deception schemes were introduced. As soon as one new development was fielded, a counter was urgently sought, thus further feeding the air power DNA helix or spiral. Orders of battle were no longer merely lists of aircraft types, but also embraced electronic spectrum capabilities. Compiling an accurate register of these myriad systems required a massive intelligence-gathering effort by all sides (Barrass 2009). This grew in complexity to include ground-based listening stations, atmospheric sensors used to detect radioactive particles after nuclear tests, special flights to trigger air defence systems, and specific reconnaissance platforms designed to sample radio and radar frequencies (Wright and Jeffries 2015; Lashmar 1996). At the top of all sides' priority lists were nuclear weapons design, deployment and targeting issues. Key in all of this was to get wind of any intention to use the weapons or to make major new deployments.

In the Cold War stand-off, air mobility also had its opportunity to contribute an outcome-determining result. Tension over access to Berlin rose over the course of 1948 with the Soviets adding more and more restrictions on movement of cargo. The airlift lasted until 30 September 1949, with aircrews from the US, the UK, Canada, Australia, New Zealand and South Africa taking part. Lives were lost due to flying accidents and the like, but none to hostile action. The scale and success of the airlift surprised the world, because of both the feat of arms and the West's determination, and has been described as one of the 'wonders of the modern world' (Barrass 2009: 58).

Control over sovereign national air space was taken extremely seriously, as was the wider policing of North Atlantic Treaty Organization (NATO) airspace. It was standard Cold War activity for Warsaw Pact aircraft to be intercepted and shadowed in NATO airspace by Norwegian, American and British aircraft and obviously vice versa. Aircraft were kept on quick-reaction alert for the duration of the period. Beyond the alert system for fighters, a similar system existed for both nuclear-armed tactical aircraft and the strategic deterrent forces described above. NATO exercised its procedures and tactics on various scales throughout the period and they were taken extremely seriously (Hackett 1982).

The Soviets decided to move MiG fighter aircraft, Ilyushin light bombers, SA-2 SAMs and, crucially, medium-range ballistic missiles to Cuba over the summer of 1962. The SS-4 missiles (Soviet R 12) had a range of about 1100 nautical miles (nm) and could carry a one-megaton warhead; thirty-six were deployed with warheads (Fursenko and Naftali 1997: 216). In September 1962, the SA-2 deployments were assessed to be similar to those in the Soviet Union that protected ICBM sites. Full U-2 high-level reconnaissance confirmed the existence of SS-4 construction sites. This arguably represented an example of a combination between persistent ISTAR and immediate reconnaissance providing outcome-determining results. Despite pressure from the Joint Chiefs of Staff to undertake a full military invasion, President Kennedy and his advisors elected to quarantine the island and Premier Khrushchev eventually withdrew the weapons as the world tottered on the brink of a nuclear exchange. The withdrawal was again monitored by aerial reconnaissance.

Although the Cold War emphasis was on deterrence and the prevention of mutually assured destruction, certainly no outbreak of peace occurred. In both the Korean and Vietnam wars the risk of escalation constantly kept restraints in place on how air power, and other uses of force, could be applied. Where Communist forces in both theatres had logistic

and other forms of support from either Russia or China across national borders, or deployed *in situ*, there were serious political restrictions on US and allied targeting and rules of engagement.

Although both Germany and Britain had fielded jet fighters during the Second World War, these planes had not seen combat against each other. This came about in the conflict over Korea, with F-86 Sabres pitted against Russian pilots in MiG-15s (Showalter 2006: 123). Although the US, along with other nations including Britain and Australia, openly fought as United Nations (UN) combatants, the Soviet Union went to considerable lengths to downplay its pilots' involvement; President Eisenhower colluded in this charade to prevent American conservatives from calling for an escalation that neither side wanted (ibid.: 121). Wariness over potential escalation restricted UN bombing and interdiction missions to sorties only over Korean territory. Although there were occasional transgressions, adherence to these rules restricted the scope of air power. Not being allowed to cross the Yalu river into China also concentrated aircraft movements in the adjacent area, which quickly became known as 'MiG Alley'.

Ground attack missions included conventionally armed B-29s which experienced increasing losses and had, eventually, to switch to night operations. Other attack missions were flown by a wide variety of piston-driven aircraft against various target sets. Close air support was obviously in high demand when troops were in contact and there was a distinct phase when interdiction of supplies was deemed important. This was codenamed Operation Strangle, but in reality a combination of mountainous terrain, camouflage and the basic means used to move food and ammunition (people and pack animals) ensured that it could never be totally effective. Having to strafe women and children engaged in these tasks also raised many ethical concerns over 'terror' bombing (Showalter 2006: 135). Towards the very end of the conflict attacks focused on electricity supplies and the like in the hope that pressure could be applied in pursuit of an armistice. They were less than effective against a population and leadership that did not rely on such utilities and whose economic base was immune in other countries.

In the end air power played a supporting role throughout the conflict, but the jet combats over MiG Alley stole the limelight. The irony which was to permeate air power folklore for more than two generations stemmed from the UN kill ratio, which was claimed to be eight to one, whereas the air war over Vietnam could only produce a ratio of about two-and-a-half to one. This led directly to the establishment of programmes such as *Top Gun* and *Red Flag*, and especially the procurement of aircraft such as the F-15 and F-16. In reality, the ratio had been closer to three-and-a-half to one, but such is the power of legend (Showalter 2006: 136).

The air war over Vietnam has generated its fair share of angst and controversy over the years and the very title of Clodfelter's 1989 book *The Limits of Air Power* evokes some of the campaign's challenges and resulting emotions. Many of the same constraints on targeting in Korea were replicated in Vietnam, even down to not attacking SAM sites manned by Russians. Attacks on facilities manned by the Chinese were also prohibited, as were attacks on North Vietnamese leadership targets (Thompson 2010: 110). B-52s dropped many thousands of tons of bombs, but for the first half of the war the target sets were very limited. The situation was compounded by the instructions coming from the White House following President Lyndon Johnson's weekly 'Tuesday lunches', at which even individual targets were discussed (Clodfelter 1989: 120). These instructions were often precise as to a specific target, but hopelessly vague in general terms, and served to confuse commanders tasked with putting them into practice. Operation Rolling Thunder was also marred by inter-service rivalry and competition over sortie totals; there was no overall air component commander. The nature of the early part of the conflict was characterised by guerrilla warfare rather than combat between conventional units. Air mobility was highly important, and whereas in Korea helicopters were relatively new innovations and lightly used, they had become the work horses of Vietnam.

A new US president (Richard Nixon) and the removal of most US ground forces set the scene for the North Vietnamese invasion of 1972, which more closely resembled a conventional attack. Air power was used much more aggressively in Linebacker and proved extremely successful in aiding the South Vietnamese to repel the advance (Thompson 2010: 118). As the war wore on, the US again used air power as a tool of persuasion to influence ceasefire talks, and President Nixon unleashed the B-52 force against Hanoi in late 1972, causing considerable damage and killing over 2,000 people. The ceasefire was duly signed in January 1973. The extent to which air power had genuine strategic effect has been debated ever since. In trying to assess the effectiveness of air power in this conflict one immediately runs up against the political constraints that prevailed and the temptation to indulge in counter-factual history.

One of the major technological advances to come out of the Vietnam War resulted from the significant losses of aircraft to anti-aircraft fire from the ground and the concomitant need to fly out of its range. Flying above it, however, reduced bombing accuracy. The development, and introduction, of laser- and television-guided weapons proved significant for future air power usage.

Over the course of the Cold War, many other conflicts and insurgencies took place and air power was used for a range of humanitarian missions. Gordon (2010) has described the vital importance of air superiority in the Arab-Israeli conflicts between 1967 and 1982. Similarly, Freedman (2010) and Gray (2005) have discussed the use of air power in the Falklands campaign of 1982. In all of these campaigns the strategic overview has always encompassed the wider issues of international relations, superpower politics and the dire consequences of events getting out of hand.

Modern air warfare

The end of the Cold War was met by astonishment, confusion and widespread delight. In many nations, especially in European capitals, a clamour arose for a so-called peace dividend. The reality, however, was that the removal of overarching constraints had actually made the world a more dangerous place.

Saddam Hussein proved this by invading Kuwait in 1990. This provoked an immediate response from a US-led 'coalition of the willing' in first Desert Shield, aimed at preventing further incursions, and then in January 1991 in Desert Storm, designed to retake Kuwait. Air power was highly effective in degrading the Iraqi war machine.

The air war has been depicted as a high-technology affair even though precision weapons represented the minority of munitions expended. The coalition quickly achieved control of the air and maintained it throughout; this meant that other operations could be conducted at will. What Olsen (2010) has termed strategic attack neutralised the Iraqi command and control set-up and this effect was complemented by interdiction of supply and direct force attack. All of these actions were conducted on a massive scale and under the spotlight of prime-time news channels. A further factor in this conflict was the shift from a largely static NATO-type scenario to expeditionary warfare at long range. This brought its own logistics challenges in moving and tracking equipment. Critically, it also meant that *materiel* that had been sitting as shop-window dressing in Europe had to be used and replaced, which put a strain on industry and on government budgets. To some extent, a plethora of targets and an environment characterised by benign rules of engagement allowed weapons to be tested in anger and if necessary further developed, thus providing impetus to the air power DNA spiral.

This emphasis on operations at long range continued from 1991 through to the present day in Iraq, with the humanitarian operations in support of the 'Kurds in the snow' in northern

Iraq developing into the policing of no-fly zones in the north and the south. Northern Watch and Southern Watch ensured an immediate presence in the region and allowed pressure to be applied to the Iraqi regime relatively precisely, either in major operations such as Desert Fox or in degrading command and control facilities in the lead up to Iraqi Freedom in 2003. Where the first Gulf War was marked by a commendable unity of purpose, the second highlighted the potential problems of ambivalent political leadership. This manifested itself in several forms. In the US, there was considerable debate over whether Southern Watch should be extended into a major degradation operation as in Desert Storm; ground commanders argued for a synchronous start with land operations starting before all troops were in theatre (Murray 2010). In Britain, the Prime Minister did not have backing from Parliament, or even his own ministers, in the critical areas of aid and redevelopment; the repercussions of this are still evident today in the Chilcot Report (Clarke 2016).

Perhaps the greatest lesson from the series of wars over Iraq, including the present-day operations against the so-called Islamic State, is the disjuncture between political imperatives and military (including air) planning processes. The latter tend to be linear exercises based on an operational end state (such as toppling Saddam or capturing Baghdad). They take little account of the complex and ambiguous nature of the strategic level and almost invariably degenerate on the air power side into a target list. Much of the political planning is either non-existent or very short term.

Superimposed on operations over Iraq, the international community was faced with the violent unravelling of Yugoslavia. This was neither an ethnic nor a religious conflict, but one of nationalism. Air power as wielded by the Serbs and National Army played little part, but the establishment of a no-fly zone (Operation Deny Flight) provided politicians with a feeling that something was indeed being done. Operation Deliberate Force in 1995 was characterised by a plethora of complex rules of engagement and special instructions constraining crews (Owen 2010). Nevertheless, two weeks of coercive air power demonstrated to the Milošević regime that despite the political and diplomatic differences, NATO could take forceful action. The application of air power also provided the opportunity for the Croat and Bosnian forces to mount their own offensives. The groundwork was set for the ensuing Dayton talks.

A similar combination of factors came into play with Operation Allied Force in 1999. Although optimists in America and in Britain had agreed that, as a bully himself subjected to force, Milošević would quickly accede to NATO demands, the reality was that the air campaign lasted seventy-eight days. A combination of NATO solidarity against the odds, an apparently unlimited military potential, background diplomatic moves including with Russia, and the perceived threat of ground action all combined to force Milošević to reach an agreement over Kosovo. Although the air campaign had followed a typical pattern of formulating target sets, the reality was that, almost unwittingly, NATO had degraded the Serbian economy to the point where the black marketeers in the Serbian Socialist Party were no longer willing to support their president (Lambeth 2001).

The events of 9/11, with the al-Qaeda attacks on New York and Washington, highlighted the risk posed by bold and asymmetric attack. Where Western air defence systems had lapsed into some degree of comfort and complacency around their operations, they had to completely rethink what they should do in similar circumstances – or, more important, against some other form of attack. The inevitable military response against al-Qaeda and its Taliban protectors in Afghanistan followed in October 2001, with the United States establishing control of the air over the region and executing a range of precision attacks against known strongpoints. Air power, including extensive use of air mobility, ISTAR and attack was used in close conjunction with US Special Forces on the ground and in concert with friendly Afghan tribes to capture

Kabul. Operations in the region, including the frontier region with Pakistan, have continued ever since. The need for persistent ISTAR and ground force protection in what has become a dangerous environment has led to a marked increase in the use of unmanned aerial vehicles (or drones in the popular idiom). While not necessarily cheaper to operate, drones have provided a very effective means of surveillance and precision attack. Their use by non-military organisations such as the Central Intelligence Agency for decapitation operations has tarnished their reputation, but by no means prevented their use (University of Birmingham Policy Commission 2014).

The difficulty of squaring short-term political expediency with a clear vision for the long-term stability of a state was evident in operations over Libya in what was known in NATO terms as Operation Unified Protector. This effectively amounted to the provision of air support for rebel forces in their campaign against Gaddafi and his regime. It initially took the form of the imposition of a no-fly zone and expanded into a much wider campaign utilising all the roles of air power. The rebel factions supplied the bulk of the ground forces, although some have suggested that Special Forces, from various nations, coordinated targeting.

Conclusion

Presenting the tactical details of this operation is unnecessary, but the general trends illustrated in Libya are worthy of note and serve as something of an endnote. The first of these is again the difficulty of applying linear military planning techniques in a complex and ambiguous strategic situation. The second involves the growing gap between nations' capabilities in terms of real-time ISTAR used to facilitate precise attacks on time-sensitive targets. The third highlights a major issue in command and control terms of setting up a functioning headquarters in a NATO headquarters versus one in a multinational set-up versus a US-dominated coalition. Access to computer systems, targeting information, intelligence material, and the live feed from systems can all be problematic. Finally, the costs of building and maintaining sovereign defence industries capable of sustaining the air power DNA helix or spiral are out of reach for many nations.

The history of air power over the last century-plus shows that the early advocates and enthusiasts understood the core roles of air power very well. These have remained constant over time. On some occasions, air power has made a vital contribution to operational and strategic success; on others it has been outcome determining. The bottom line throughout all the history of air power is that control of the air is the one role to rule them all.

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PART II

Roles and functions

Delivering air power



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7
CONTROL OF THE AIR

Dag Henriksen

Securing and maintaining control of the air has become the *raison d'être* of any competent air force. Military experience in the First World War proved the importance of controlling the air, and immediately after that war, air power theorist Giulio Douhet named his most significant work *The Command of the Air*, noting: 'To have command of the air means to be in a position to prevent the enemy from flying while retaining the ability to fly oneself' (Douhet 1999 [1921]: 24). In a sense, this simple statement sums up what has since become conventional wisdom and has been at the heart of air power thinking during the past century. While various schools of thought have emerged regarding how air power can best be utilised, the fundamental understanding that the skies became a battlefield of their own, and that being able to control the air in and by itself gave huge military advantages for all services, paved the way for establishment of independent air forces with the first and foremost task of controlling the air (van Creveld 2011; Douhet 1999 [1921]; Gray 2012; Meilinger 1997; Olsen 2010; Warden 2000). While technology designed to influence the air domain – such as unmanned aerial systems, stealth, cyber, satellites, laser and long-range sub- and supersonic cruise missiles – continues to evolve, the conceptual fundamentals for controlling the air appear relatively stable.

This chapter first addresses the doctrinal prerequisites for controlling the air, and provides historical examples illustrating the importance of air superiority and air supremacy through offensive counter-air operations, defensive counter-air operations and passive air defence. Next, the chapter examines the need for controlling the air through ground-based ballistic missile defence (BMD). The threat of ballistic missiles was viewed mainly in the context of nuclear weapons during the Cold War, but has increasingly become a concern related to rogue states such as Iran that would seek political influence through increasingly powerful rockets. Finally, the chapter explores the concept of no-fly zones (NFZs) as a means of controlling the air. Even though the desire to establish NFZs in various conflicts appears to have increased over the past twenty-five years (Iraq, Bosnia, Libya), to date little academic literature analyses the nature and lessons of NFZs, and this chapter aims to shed light on the growing importance of this military concept.

Air supremacy and air superiority

Control of the air is a relative term and describes a certain level of influence in the air relative to that of an adversary. Although air power literature and doctrines use various terms when describing the desired level of air control, the terms *air supremacy* and *air superiority* appear to have universal validity. *Air supremacy* means that one side's forces can operate in the air without any significant opposition from the enemy (Royal Australian Air Force 2007; United States Air Force 2011; Warden 2000). In other words, one side's air resources outmatch the enemy to the degree that they control the air and can operate and use the air more or less freely to their advantage. The United States and the International Security Assistance Force (ISAF) had air supremacy in Afghanistan, as does the coalition fighting the Islamic State of Iraq and the Levant (ISIL) in Syria and Iraq. *Air superiority* denotes a more limited degree of air control, in which one side has the necessary degree of control in time and place without any effective interference from the enemy (Royal Australian Air Force 2007; United States Air Force 2011; Warden 2000). A typical method for achieving local air superiority in the past twenty-five years has been to fly so-called composite air operations (COMAOs). This means deploying a package of various aircraft that combined are strong enough to destroy or suppress enemy air defences and secure the air control, limited in time and space, necessary to get bombs on target. NATO, due to Serbian ground-based air defence systems, used COMAOs extensively to influence Serbia during the 1999 Kosovo War.

While the concepts of air supremacy and air superiority will probably remain constant in the foreseeable future, the means to achieve them are becoming more complex and elusive. The latest British Air and Space Power Doctrine asserts that 'traditional conceptions of air superiority have limited utility in contemporary operations. Instead, control of the air may be considered in terms of freedom and denial' (UK Ministry of Defence 2009: 38). Apparently driven by the deepening Russian and Chinese inventory of anti-access systems and regional denial complexes, the US/NATO debate in recent years has increasingly used terms such as anti-access (A2)[1] and area denial (AD),[2] which have their conceptual origins in sea power rather than air power. In its *Air Superiority 2030 Flight Plan*, the United States Air Force (USAF) states that future threats will advance along two major vectors over the next fifteen years. First, traditional threat systems such as advanced fighter aircraft, sensors and weapons will continue to evolve and proliferate. Second, potential adversaries will continue to develop a series of comprehensive capabilities such as increased threat capabilities to negate US 'advantages in the space domain, increased quantity and sophistication of cyberspace threats, and air threats including hypersonic weapons, low-observable cruise missiles, and sophisticated conventional ballistic missile systems' (United States Air Force 2016: 3). The future-looking document asserts that:

> The Air Force's projected force structure in 2030 is not capable of fighting and winning against this array of potential adversary capabilities. Developing and delivering air superiority for the highly contested environment in 2030 requires a multi-domain focus on capabilities and capacity … Adversaries are increasingly deploying integrated and networked capabilities as part of the Anti-Access/Area Denial (A2/AD) strategy in highly contested environments. To achieve air superiority against this strategy in support of joint force mission objectives, the Air Force needs to develop a family of capabilities that operate in and across the air, space and cyberspace domains – there is no single capability that provides a 'silver bullet' solution. This family must include both stand-off and stand-in forces, integrated and networked to achieve mission effects.
>
> *(United States Air Force 2016: 3–4)*

In more doctrinal terms, achieving control of the air has focused on counter-air operations to attain and maintain a desired degree of air supremacy or superiority. These operations are typically divided into two broad categories: offensive and defensive counter-air.

Offensive counter-air

Offensive counter-air (OCA) operations seek to destroy, disrupt, or degrade enemy air capabilities by engaging them as close to their source as possible (NATO 2009: 1–6; UK Ministry of Defence 2009: 39; United States Air Force 2011: 5). Doctrinally, OCA operations are typically divided into the following four categories.

First, *attack operations* are missions to destroy, disrupt, or degrade counter-air targets such as enemy air and missile threats, command and control, and supporting infrastructure such as airfields, launch sites, fuel, supplies, and runways. They are intended to prevent the opposing force from employing air and missile assets. Second, *suppression of enemy air defences* (SEAD) seeks to neutralise, degrade, or destroy enemy surface-based air defences. This normally entails close cooperation with intelligence, surveillance, and reconnaissance (ISR) assets that gather the information on enemy air defence systems which enables preplanned or time-sensitive SEAD operations. The third category, *fighter sweep*, is an offensive mission by fighter aircraft to seek out and destroy enemy aircraft or targets of opportunity in a designated area. Finally, *escort* signifies aircraft assigned to protect other aircraft during a mission – typically over enemy territory – to target and engage enemy aircraft and air defence systems.

OCA operations have become standard operational procedure for capable air forces, and more or less the doctrinally scripted beginning of any NATO- or US-led air campaign, such as Iraq (1991, 2003), Kosovo (1999) and Libya (2011). After intelligence preparation of the battlefield to gain situational awareness and map the enemy integrated air defence system (IADS), the first phase normally entails sea- and air-launched cruise missiles in an orchestrated OCA campaign aimed at destroying or disrupting enemy IADS in order to enable friendly forces to exploit the degree of air control achieved.

Perhaps the most successful and famous OCA campaign was Israel's pre-emptive attack that initiated the Six-Day War in 1967. For two years, Israeli combat aircraft had taken off from bases in the Negev Desert each morning at 07:00, heading west over the Mediterranean Sea, and gradually disappearing from Egyptian radar coverage – to return on Egyptian radar screens after some time, heading back to their bases. After weeks, months and years with this standard operational procedure, the Israeli modus operandi had become a familiar pattern. On Monday 5 June 1967, the same combat jets took off in accordance with their normal schedule, but this time their mission was an OCA mission to cripple the Egyptian air force. The Israelis knew that at 07:40 most Egyptian pilots were having breakfast and most top military commanders were on their way to work, which made it very difficult for most of them to receive information and make decisions. Within minutes, the runways of ten of the eighteen Egyptian front-line airfields were disabled, and the Israelis went on to attack Egyptian airplanes left out in the open. When this first wave of Israeli combat aircraft was returning to base, the second wave was halfway to its targets, and the third wave was about to become airborne. Within approximately three hours, thirteen of eighteen Egyptian airfields were non-operational (the last five did not have combat aircraft stationed that day), over 250 Egyptian aircraft had been destroyed or severely damaged, twenty-three radar installations and anti-aircraft missile sites had been destroyed or incapacitated, and approximately 100 of Egypt's 350 qualified air-combat pilots had been killed. By then the Egyptian Air Force was no longer a factor in the war (Bregman 2000; Dupuy 1978; Hammel 1992).

Defensive counter-air

Defensive counter-air (DCA) operations seek to protect friendly forces and vital interests from enemy air and missile attacks. DCA is synonymous with air defence, and comprises all measures to reduce or neutralise the effectiveness of hostile action and to prevent the enemy from gaining control of the air (NATO 2009: 1–6; UK Ministry of Defence 2009: 39; United States Air Force 2011: 6). DCA operations are divided into active and passive air defence measures.

Active air defence is any defensive action taken to destroy, nullify, or reduce the effectiveness of enemy air and missile attack against friendly forces. Active air defence typically includes air-to-air fighters, ground-based air defence systems and other assets (NATO 2009: 1–6; UK Ministry of Defence 2009: 39; United States Air Force 2011: 6). It is important to note that adequate air defence demands an entire system that integrates intelligence sources and radars to detect the enemy, and command and control agencies to make sound and timely decisions on how to employ various weapons systems. Typically, a NATO member nation such as Norway would have a system of early warning radars linked to the rest of NATO's command structure, and fighter aircraft constantly on fifteen minutes' quick reaction alert (QRA) to conduct missions ordered by higher headquarters.

Perhaps the most classic historical example of DCA-operations based on an IADS is the Battle of Britain during the Second World War. The defeat of France in June 1940 paved the way for concentrated German air action against Britain, and the Battle of Britain would last from 10 July to 1 October 1940. In 1936, Britain had reorganised its air defence system, and replaced it with specialised commands: Bomber Command, Fighter Command, Coastal Command, and Training and Maintenance Command. By September 1940, Fighter Command consisted of four groups, more than fifty squadrons of fighter aircraft, and roughly the same number of airfields.

The invention of what was called radio direction finding (RDF) in the 1930s – the predecessor of what later became known as radio detection and ranging (RADAR) – triggered profound organisational changes as well as new tactics for air-to-air fighters, and led Britain to establish an air defence system conceptually similar to the one modern air forces still use today. It meant that pilots no longer had to patrol the skies hoping to spot the enemy with their own eyes, but could instead stay on ground alert until it was tactically favourable to take off. The chain of radar stations along the coast (Chain Home) provided early warning and rough estimates of enemy strength, position, heading and speed. Higher echelons processed this information and made tactical decisions in terms of which aircraft from which airbase were to take off to meet the enemy in cost-effective and tactically preferable circumstances. The aircraft would receive directions from the ground, which had updated information on the unfolding air situation. It meant that anti-air artillery also received early warning and could direct and mass its resources against the approaching enemy.

Organising, consolidating and spending resources wisely were key factors against a numerically superior adversary, with Germany mustering some 1576 bombers and 1089 fighters – against Britain's roughly 700 Hurricanes and Spitfires. In the end, the combination of various factors integrated in the most sophisticated air defence system at the time enabled Britain (and a number of allied nations providing aircraft and fighter pilots) to withstand the German attack, leading to Hitler's decision on 17 September 1940 to postpone the invasion of Britain (Clark 1965; Collier 1962; Hough and Richards 1990; James 2000).

Passive air defence includes all measures (other than active air defence) taken to minimise the effectiveness of hostile air action by enhancing the survivability of friendly forces and critical assets. Elements of passive air defence include early warning, camouflage,

concealment and deception, hardening, dispersion, reconstitution and low-observable or stealth technologies (NATO 2009: 1–6; UK Ministry of Defence 2009: 39; United States Air Force 2011: 6).

An interesting case in point would be the Serbian Army in the 1999 Kosovo War. When facing the most powerful military alliance in history, with little or no chance to control the skies above the homeland, passive air defence became a key component of the Serb strategy. Stephen Hosmer argues that the Serb military was well prepared for air attacks, because the former Yugoslavia had considered the Soviet Union as the main threat for years, and subsequently had built an infrastructure designed to withstand attacks from an enemy with vastly superior air power. This included 'numerous deep and hardened bunkers, dispersed storage sites and redundant communication links that would prove difficult to identify and destroy' (Hosmer 2001: 80). The Commander of the Serbian 3rd Army in Kosovo, General Nebojsa Pavkovic, later commented that Serbia used other measures such as camouflage and decoys to avoid NATO air power (ibid.: 80). Although NATO's Supreme Allied Commander Europe (SACEUR) during the war, General Wesley K. Clark, argued that the deception was less effective than General Pavkovic would claim, he agreed that 'they did skilfully deploy lots of decoys' (Fitchett 1999). Reports after the war show Serb forces constructing fake bridges, mock artillery pieces, and fake two-thirds-scale SA-9 anti-aircraft missile launchers (Cordesman 2001: 160).

NATO's official withdrawal of the option of a ground offensive allowed Serb forces to disperse troops and equipment, which made them far less susceptible to detection and attack. Considerable controversy arose regarding how many targets NATO did hit, with some reports claiming that the actual destruction of heavy Serbian military equipment was very limited (ibid.: 159–161; Daalder and O'Hanlon 2000: 153–155; Hosmer 2001: 80–85). What surprised many immediately after the war was that the Serbian Army appeared to be relatively intact when withdrawing from Kosovo. In his memoirs, General Clark states that:

> [W]hen the press reported that the Serbs were pulling out a lot of equipment in good condition, there arose an immediate controversy about how much of the Serb force we had actually destroyed in Kosovo. That wasn't surprising. Ours strikes against Serb ground forces drove most of the men and equipment into hiding, many in Albanian villages and facilities.
>
> *(Clark 2001: 407)*

Still, he admits that 'at the end of the campaign, the Serb forces were organised enough to move out in relatively good order' (ibid.: 406). Thus, against a formidable enemy such as NATO, which had air superiority when needed, the Serbian 3rd Army managed to stay relatively intact after seventy-eight days of bombing mainly through effective use of passive air defence.[3]

Ground-based ballistic missile defence

As previously stated, controlling the air also means prohibiting the enemy from using friendly airspace to his advantage (freedom from attack). This includes defence against ballistic missiles with conventional high-explosive, chemical, biological, or nuclear warheads. In particular, long-range nuclear ballistic missiles, with their devastating potential, have heavily influenced military strategic thinking for decades.

Ballistic missiles fall into four general classifications based on the maximum distance the missile can travel (Masters 2014): *short range* (less than 1,000 kilometres); *medium range*

(1,000–3,000 kilometres); *intermediate range* (3,000–5,500 kilometres); and *intercontinental* (more than 5,500 kilometres). Ballistic missile defence is inherently multinational because both attack and intercepts are likely to cross several international borders and debris may fall on states that are not directly under attack.

Ballistic missiles have three stages of flight (Weiner 1984: 50–55). The *boost phase* begins at launch and lasts until rocket engines finish firing. This phase is easily visible to space-based sensors, but lasts only a few minutes and usually occurs far from the defended territory, making it difficult to attack the missile. The *midcourse phase* is the longest stage, when the projectile is on its parabolic path to the target. In this phase, the missile can climb to above 1,000 km and fall towards Earth in a predictable trajectory. Due to the long time available and the predictability of freefall, space-based or other BMD systems can utilise this phase for defence. The third and *terminal phase* encompasses the time when the detached warhead re-enters the atmosphere at extreme speed almost vertically down towards a target, often travelling less than a minute to impact. Because of the missile's speed, very little time is available to perform defence functions, leading to limited defence coverage and very little margin of error.

Ground-based BMD operates principally in a manner similar to ground-based air defence (GBAD). Stephen Weiner argues that all BMD systems perform the same sequence of functions, and that they differ primarily in how and where each of these functions is carried out. In essence, a BMD operation consists principally of the same stages (Weiner 1984): *acquisition* involves searching for and detecting any potentially threatening object; *tracking* involves determining the target's position and its future trajectory; *discrimination* is the process of deciding whether the object is a threat that should be intercepted; *interceptor control* and *target kill* ensure that the interceptor gets close enough to the object to destroy it.

US ballistic missile defence programmes

According to the US Council on Foreign Relations, the US has four primary BMD programmes today (Masters 2014). *Ground-Based Midcourse Defence* is designed to destroy intermediate- and long-range ballistic missiles in space. This is the most complex and costly component of the US missile defence systems. As of summer 2014, twenty-six interceptors were located at Fort Greely, Alaska, and four at Vandenberg Air Force Base, California, with plans to increase this arsenal to forty-four by 2017.

Aegis Ballistic Missile Defence is designed to intercept short- and medium-range ballistic missiles. This traditionally sea-based system is considered the most reliable component of missile defence. The Missile Defense Agency (MDA) and the US Navy plan to increase the number of BMD-capable Aegis warships from thirty-three in 2014 to forty-three by 2019. As of June 2014, the Pentagon said the system had twenty-eight successful intercepts out of thirty-four tests.

Terminal High Altitude Area Defense (THAAD) is a rapidly deployable, truck-mounted system capable of intercepting short- and medium-range ballistic missiles inside and just outside the atmosphere. Three THAAD systems were operational as of mid-2014, but the Pentagon is expected to expand this number to seven.

Patriot Advanced Capability-3 (PAC-3) is the successor to the systems deployed in the Persian Gulf War and the most mature system in the US missile defence arsenal. Rapidly deployable, the system is vehicle mounted and employs sensors to track and intercept incoming missiles in their terminal phase at lower altitudes than THAAD systems. The PAC-3 was used during combat missions in Iraq in 2003, and has been deployed to several nations, including South Korea, Afghanistan and Turkey.

The US approach to BMD might serve as a good historical example of the various political, strategic, and technological challenges that have marked the evolution of this particular weapon system. With the invention of nuclear weapons came new strategic thinking that would preoccupy politicians, military officers, political scientists and scholars for the ensuing decades. Leon Sloss argues that the purposes of US military power have been to deter adversaries from taking actions that would be inimical to US interests; to assure friends and allies of protection, thereby cementing alliance ties; and to defend US friendly/allied nations should deterrence fail (Sloss 1994: 25). The United States has come to depend heavily on nuclear weapons to deter its enemies across the conflict spectrum, in both conventional and nuclear wars (ibid.). One could, perhaps, presume a similar argument can be made for Russia's or other nuclear powers' strategic rationale for maintaining a robust and modern arsenal of nuclear weapons. Conversely, any nation that acquired an effective BMD system would immediately challenge the logic of deterrence and the larger systemic power balance of the world.

In 1972, the United States and the Soviet Union signed the Anti-Ballistic Missile Treaty, which severely restricted testing and deployment of BMD systems by the superpowers. The purpose was to ensure that neither the US nor the Soviet Union could field a capability to defend a major part of its territory effectively against a significant attack by the other side's ballistic missile force (Schneiter 1984: 222).

In the early 1980s, the Reagan administration expanded research and development on space- and ground-based defensive systems. The rationale for the Reagan administration's Strategic Defense Initiative, later nicknamed 'Star Wars', was 'a plan to develop a space-based missile defence programme that could protect the country from a large-scale nuclear attack' (US Department of State 2009). Shortly thereafter the US Army tested its Homing Overlay Experiment, the first successful demonstration of a hit-to-kill vehicle (Masters 2014). In the following years, tactical systems, or theatre missile defence, continued to evolve. Originally designed to intercept Soviet intermediate-range ballistic missiles in Western Europe, US Patriot missile batteries were deployed to the Middle East during the 1991 Persian Gulf War. Bradley Graham points out that by the late 1990s, the US focus shifted from Russia 'toward the growing possibility that resourceful Third World nations – principally North Korea, Iran, Iraq or Libya – would menace the US with increasingly powerful rockets' (Graham 2001: xxi).

Early in his first term, George W. Bush withdrew the United States from the ABM treaty and instructed the Pentagon to 'proceed with fielding an initial set of missile defence capabilities', leading to the installation of the first ground-based missile interceptor at an Army base in central Alaska in July 2004 (Masters 2014). In addressing the threat from Iran, the controversy over BMD was invigorated by the European Phased Adaptive Approach (EPAA) missile defence system initiated by the Obama administration in 2009. The system has been deployed on Aegis missile defence ships in the Mediterranean and at Aegis Ashore land sites later slated for Deveselu (Romania) and Redzikowo (Poland).

The EPAA system was conceived to defend against present and future Iranian missile threats to US bases in Europe and to the cities of NATO members and allied nations. The plan, however, garnered strong opposition from Russia. In particular, Russia cited Phase 4 of the system, in which Standard Missile (SM)-3 IIBs would be deployed in Poland as a threat to its nuclear deterrent. In March 2013, Phase 4 of the EPAA system was cancelled (Sankaran 2015: iii and xi). Thus, the technological quest for protection against nuclear and non-nuclear ballistic missiles continues to be balanced against the larger strategic interest and dynamic between nations that see their nuclear deterrent as a cornerstone of their national security.

No-fly zones

In his analysis of the lessons from Bosnia and Iraq, Alexander Benard uses the following definition of a no-fly zone: 'The term "no-fly zone" is used to describe a physical area of a nation that is patrolled using air power of another sovereign state or coalition' (Benard 2004: 455). Karl P. Mueller uses a wider definition: 'a no-fly zone can be defined as a policy under which an outside actor overtly prohibits some or all aircraft flight over a specified territory and undertakes to intercept aircraft violating the prohibition or otherwise punish those responsible for violations' (Mueller 2013: 2).

It is important to note that an NFZ is not a fixed concept and can therefore be tailored to the specific context at hand. As Mueller asserts, an NFZ might proscribe flights by military but not civilian aircraft, or it might prohibit flights by fixed-wing aircraft but not helicopters. It can be specific to one party in a conflict rather than apply to everyone. The rules of engagement (ROE) of NFZs can also vary with respect to enforcement mechanisms. For example, a shoot-on-sight policy might be adopted for military aircraft violating an NFZ, while civilian aircraft might be treated more cautiously to avoid unintended shoot-downs or unfavourable political consequences, and as a matter of adherence to the principle of discrimination in the law of armed conflict (ibid.: 6–7). In other words, an NFZ can be designed to fit the political, military and humanitarian situation the NFZ is set to address.

Benard argues that NFZs principally take three separate forms (Benard 2004: 456). No-fly zones used to provide assistance to peacekeeping troops in volatile situations which require a ground presence are referred to as *air cover*. When hostilities on the ground do not require a ground presence no-fly zones can serve as an alternative to ground intervention, that is, *air occupation*. No-fly zones can also be used as a buffer between belligerent states or groups in order to deter invasion or aggression, a form referred to as *air deterrent*.

Scholars seem to agree that the concept of the modern NFZ appeared in the 1990s, more specifically after the Persian Gulf War of 1991 (Benard 2004: 455; Mueller 2013: 3). The dominant Western experiences with NFZs occurred in Iraq, Bosnia and Libya. As examples of Benard's three separate forms of NFZs, the subsections below highlight the experiences from Iraq and Libya.

Air cover and air deterrent: Iraq, 1991–2003

After Operation Desert Storm, the Kurdish minority in the northern portions of Iraq rose up against the Baath regime. This prompted a violent response as Saddam Hussein's armed forces launched an operation on 22 March 1991, attacking rebels and civilians and causing more than one million Kurds to flee Iraq within weeks. In May, the UN authorised an international intervention as a peacekeeping operation, dubbed Operation Provide Comfort, which supplemented the ground component with an NFZ. It was not until Operation Provide Comfort II, which commenced in July, that coalition air power became the bulk of its military presence. The operation lasted until 31 December 1996.

On 1 January 1997, Operation Northern Watch took the place of Provide Comfort II. The NFZs were now no longer in place chiefly to provide humanitarian cover for the Kurds of northern Iraq, but rather to serve as a buffer between the Iraqi armed forces and neighbouring states and to ensure compliance with UN Security Council Resolutions (UNSCRs). US, British and Turkish aircraft enforcing the NFZ operated primarily from Incirlik Air Base in Turkey and flew more than 75,000 sorties of all types between 1991 and 2003 (Benard 2004: 463–464; Mueller 2013: 3–4).

Operation Southern Watch (OSW), designed to protect southern Iraq's Shia population from depredations by the Baghdad regime, was initially established in June 1992 south of 32° north, but was extended to 33° north in 1996. Like its northern counterpart, OSW prohibited Iraqi fixed- and rotary-wing flights in the zone. US, British, French and Saudi aircraft conducted OSW by operating from bases in Saudi Arabia and other Gulf states and from aircraft carriers in the Gulf; the operation ultimately comprised some 150,000 sorties (Benard 2004: 464; Mueller 2013: 4–5). According to Benard, the NFZ aspect of Operation Provide Comfort was a clear case of what can be deemed 'air cover', while Operation Southern Watch was a case of 'air deterrence'.

Air occupation: Libya, 2011

Anti-Gaddafi forces centred around Benghazi rose in rebellion against the Libyan dictator in February 2011, and when the regime's forces began moving to crush the rebels, airstrikes by Libyan Arab Republic Air Force jets and helicopter gunships were prominently featured in video accounts of the fighting. Political leaders and other actors in the Arab world and the West soon began advocating the imposition of an NFZ over Libya, a call endorsed by the Gulf Cooperation Council, the Arab League, and finally by UNSCR 1973 (Mueller 2013: 5). UNSCR 1973 authorises the establishment of an NFZ, but also exemplifies the context-based flexibility of an NFZ when demanding that it:

> … shall not apply to flights whose sole purpose is humanitarian, such as delivering or facilitating the delivery of assistance, including medical supplies, food, humanitarian workers and related assistance, or evacuating foreign nationals from the Libyan Arab Jamahiriya, nor shall it apply to flights authorised by paragraphs 4 or 8, nor other flights which are deemed necessary by States acting under the authorisation conferred in paragraph 8 to be for the benefit of the Libyan people, and that these flights shall be coordinated with any mechanism established under paragraph 8.
>
> *(UN Security Council 2011: Paragraph 7)*

Without entering the debate of whether the Libyan intervention was successful or whether NATO exceeded the mandate of UNSCR 1973, the intervention serves as an example of what Alexander Benard defines as an 'air occupation'. In Libya, UNSCR 1973 ruled out use of ground forces, and the NFZ became an alternative to ground intervention that had to be forced upon the Gaddafi regime (Henriksen and Larssen 2016).

Within the 'toolbox' of air power, establishing an NFZ might seem tempting for policymakers manoeuvring in complex political landscapes. Karl P. Mueller asserts that:

> Prohibiting a miscreant government from using air power for warfare or transportation within its own country may appeal to policymakers, primarily because it is perhaps the most limited way that military force can be used as a punitive tool. Compared to other forms of armed intervention, NFZs typically entail relatively little risk to the powers imposing them, as least when directed against militarily weak targets … It seems likely that similar uses of NFZs will continue to be of interest in coming years, particularly as many Western countries are cutting defense spending and states are seeking to maintain international good order 'on the cheap' in terms of both political liability and human and material cost.
>
> *(Mueller 2013: 1)*

The notion that an NFZ is 'on the cheap' in terms of both political liability and human and material 'cost must' be critically re-addressed. In Iraq, the NFZ lasted for twelve years, with the costs to the US government of OSW alone averaging somewhat more than $700 million per year (Gertler, Blanchard, Dale and Elsea 2013: 10). The NFZs over Iraq involved over 30,000 sorties per year (Benard 2004: 459), imposing costs in terms of the rapid ageing of aircraft and overwork of USAF personnel (Tirpak 2003: 50). Benard points out that, as in Iraq, the 'problem with no-fly zones directed at rogue regimes is that they can develop into a self-perpetuating policy from which decision-makers ultimately find it difficult to extract themselves' (Benard 2004: 460). As in Bosnia, if the resources and mandate are not adequate, one failure to deter tactical air operations (such as helicopter operations) and ground operations (ignoring hostile control of the air) would then undermine the credibility of the entire NFZ. In Libya, the deteriorating situation after Operation Unified Protector, with Libya in many ways becoming a failed state, challenges the very decision of engaging and establishing an NFZ from the outset (Kuperman 2015). The point here is that an NFZ potentially has enormous political, economic and military costs, and should not be mistaken for an easy fix of complex problems.

Conclusion

Securing and maintaining control of the air remains the *raison d'être* of any competent air force, and more temporary winds of war should not challenge this fundamental view. After almost two decades of ongoing unconventional wars in Afghanistan and Iraq and the fight against ISIL, the focus on controlling the air has declined because the opponents have little or no capacity to challenge allied forces in the air.

Thus, as noted by the US CENTCOM Deputy Combined Force Air Component Commander 2009–2010, Lt Gen. Stephen L. Hoog, concerning the joint community's perception of air control: '[T]here is a fundamental assumption that it [air power] will just be there when needed' (Hoog 2014: 238). On the other hand, Russia's improved military capability combined with its political will to exert its military influence, as proven by its annexation of Crimea in 2014 and operations in eastern Ukraine, would reinvigorate the need to control the air. The Russian ability to exert anti-access and area denial has become a growing concern.

Thus, controlling the air will continue to be imperative. It cannot be taken for granted. Furthermore, while the race to establish and maintain a technological edge relative to an opponent continues, and air power leaders will have to address new domains for influencing the ability to control the air, the more conceptual and doctrinal paradigms of OCA and DCA appear to be constants that provide useful analytical tools to understand and utilise in countering future air power challenges.

Notes

1 Anti-access (A2) is defined as 'action intended to slow deployment of friendly forces into a theater or cause forces to operate from distances farther from the locus of conflict than they would otherwise prefer. A2 affects movement to a theater' (US Air–Sea Battle Office 2013).

2 Area denial (AD) is 'action intended to impede friendly operations within areas where an adversary cannot or will not prevent access. AD affects maneuver within a theater' (US Air–Sea Battle Office 2013).

3 For a more thorough introduction to Operation Allied Force, see Henriksen (2007).

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8
AIR STRIKE

Frans Osinga

Air attack is one of the four key roles air power can play. Traditionally offensive air operations were divided into three types of attack: strategic attack (SA), air interdiction (AI) and close air support (CAS). These were generally equated with the strategic, operational and tactical levels of war respectively and were associated with different types of targets. The evolution of air power has long been marked by a continuous and often acrimonious debate between air forces and armies on the best employment of air power. Armies generally preferred dedicated CAS air assets, whereas air forces tended to favour AI and SA, arguing that in those roles air power could have a larger impact on the joint battle and contribute more directly to meeting strategic objectives than in the CAS role, which required close cooperation with ground units, against small and hard-to-identify tactical targets, in a highly threatening environment. While these types of attacks still exist, the debate has subsided.

Indeed, the rapid evolution of strike capabilities of air power during the past two decades, fuelled by advances in precision munitions, stealth technologies and information systems, and tied to novel targeting theories and organisational structures, has transformed Western militaries (Osinga 2010a). Recent wars, both conventional and irregular, have demonstrated the increased military and political utility of the resultant new air power capabilities. Air strike played key roles in the removal of regimes in Afghanistan (2001), Iraq (2003) and Libya (2011), and since 2014 air strikes have been the key offensive Western instrument to combat ISIS and other terrorist groups. Acknowledging these developments, rivals of the West have developed specific counter-methods – anti-access/area denial – in efforts to negate this Western military advantage. But the same experience demonstrated the necessity of ensuring proper strategic preconditions for realising the potential of post-industrial age armed forces, of which air power represents the cutting edge. Through a brief exploration of the two air power decades – 1990–2010 – this chapter describes the evolution of the strike role and identifies key factors that have influenced strike capabilities and their employment in contemporary operations.

The first air power decade: 1990–2000

Operation Desert Storm: interstate warfare

Operation Desert Storm, the campaign to liberate Kuwait in winter 1991, changed the face of modern warfare (Cohen 1996). The new style of warfare has been labelled 'precision age

warfare', 'spectator sport warfare' and 'postmodern war' – to laud, to criticise, but in any case, to indicate a sense of novelty and to contrast it with the devastating strategic bombardments of both World Wars and the threat of nuclear annihilation of the Cold War (McInnes 2002). While it saw familiar North Atlantic Treaty Organization (NATO) tactical air assets such as Airborne Warning and Control System (AWACS) radar early warning aircraft, specialised aircraft to suppress Iraqi air defence systems, air-to-air refuelling (AAR) aircraft, and F-16, F-111 and F-15 fighter-bombers, the intensive air offensive of thirty-nine days, including conventional strategic attacks against targets in downtown Baghdad, that preceded the four-day ground campaign, represented a break with the common and expected pattern of operations (Hallion 1992: 252). Five factors influenced this innovative campaign design that exploited the new attack capabilities of air power.

Three new technologies

Three factors were of a technological nature: stealth technology, precision weapons and improved situational awareness through new intelligence, surveillance and reconnaissance (ISR) capabilities. Stealth has been labelled revolutionary with some justification. With a radar reflection surface of a golf ball, the F-117 stealth bombers could strike targets almost unseen deep inside enemy territory from the first moment of the war. Precision-guided munitions (PGMs) also made a huge difference, enabling a new model of conventional warfare marked by a dramatic rise in the intensity, lethality and efficiency of air attacks (Hallion 1992: 205). Whereas a typical non-stealth attack package required thirty-eight aircraft to enable eight of those to deliver bombs on three targets, only twenty F-117s were required to simultaneously attack thirty-seven targets successfully in the face of an intense air defence threat. To illustrate, during the whole of 1943 Allied bombers attacked 123 target complexes in Germany, whereas during the first twenty-four hours of Desert Storm coalition forces attacked 148 target complexes.

Both technologies, in combination with electronic warfare and drones, implied a new dominance of the offence over the defence in air warfare. By rapidly crippling enemy air defence radars and surface-to-air missile (SAM) systems and effectively blinding the opponent, the attacks created a virtual sanctuary in the third dimension that could be exploited for various purposes, such as reconnaissance, surveillance, air interdiction, CAS and strategic attack. This stood in stark contrast with the past (and with extant doctrines) when air warfare involved an attritional struggle for air superiority, which could mostly be obtained and exploited only over a limited area and for a brief period. With air superiority, non-stealthy aircraft, if equipped with precision munitions *and* precision information, could now maintain accuracy of attacks even at high altitude. In contrast to historical experience, one fighter could attack several targets in one CAS or AI mission, including dug-in tanks and artillery. These missions were greatly aided by the recently introduced Joint Surveillance Target Attack Radar System (JSTARS) air–ground-surveillance system. In February 1991, AI and CAS strikes destroyed almost two entire Iraqi divisions while they advanced to Al Khafji, after the divisions were detected by a JSTARS (Titus 1996: 19). Within the Kuwaiti theatre, coalition air attacks sometimes managed to destroy more than 50 per cent of Iraqi armour and artillery equipment and Iraqi ground troops surrendered by the thousands after being pounded by B-52 strikes or showered with leaflets threatening such attacks. Roads and bridges leading into Kuwait were interdicted, isolating the Iraqi forces. The result was a drastic shortening of the time required and the risk involved for ground units to complete the coalition victory.

Targeting theory and command arrangements

The fourth factor involved strategic theory and targeting philosophy: parallel warfare based on the so-called Five Rings model. Updating the interbellum ideas of the Air Corps Tactical School (ACTS), Colonel John Warden III, a Pentagon planner, had recognised that precision, stand-off and stealth capabilities offered new possibilities for strategic attacks against multiple target-categories – centres of gravity – of a nation-state. His model distinguished five sub-systems that, combined, comprised the 'enemy system': military units, population, organic essentials (energy, water, food supply, etc.), critical infrastructure and, most important, leadership. Instead of focusing exclusively on the armed forces, this model offered the potential to strike at the heart of a country (the regime) from the first moment of a campaign, crippling the enemy's strategic command capabilities before attacking fielded forces. Even if targets were close to civilian objects, precision weapons had made it possible to attack those near-simultaneously in order to rapidly degrade the functioning of the entire enemy system (Warden 1995; Olsen 2007). With each bomb likely to strike within yards of a target, targeteers could now think in terms of the specific first- and second-order effects that had to be achieved, instead of merely hoping targets would be destroyed. This resulted in the effects-based operations (EBO) targeting philosophy developed by Warden's deputy, David Deptula (Deptula 1996; Meilinger 2007). These ideas informed the joint campaign plan.

The final and related innovative factor was the organisation of the targeting process. For the first time, a single commander for air operations – a Joint Force Air Component Commander – controlled all the theatre aircraft, including those of the Navy. At the same time, a Joint Targeting Coordination Board – also an innovation – was responsible for reviewing the targets nominated by the ground commanders and apportioning aircraft in support of the battlefield preparation plan, to ensure all services saw their interests appropriately cared for.

A new standard

The air offensive effectively neutralised Iraq's military in the sense that it was unable to coordinate an effective response to the coalition's other military operations. The new precision targeting capabilities set the stage for a quick and relatively low-risk ground offensive to liberate Kuwait. Another remarkable feature was that the level of collateral damage and the number of civilian casualties were, while still substantial, unprecedentedly low, despite massive air strikes on dual-use facilities and on government and military complexes in urban areas (Thomas 2001: 159). The era of industrial age warfare was drawing to an end, and a new popular image of modern warfare had been created. It also promised new low-risk options for politicians in the post-Cold War era.

Operations Deny Flight and Deliberate Force: constrained employment

Indeed, air power became the option of choice for Western politicians whenever a credible deterrent was required during the peacekeeping missions of the 1990s in the Balkans (Cohen 1994). This rekindled the interest in – and debate about – strategies for coercive diplomacy (Mueller 1998; Byman and Waxman 2000, 2002). Coercive mechanisms were explored, such as *decapitation* and *incapacitation* (paralysing the country or its military apparatus by eliminating command nodes or disrupting command processes), *punishment* (increasing the cost of achieving a strategic aim), and *denial* (eliminating the means to carry out the strategy, thus decreasing the chances of success). Another debate focused on the intensity of attacks, with some favouring

a gradually increasing intensification to provide room for political manoeuvre while air force commanders in particular advocated 'decisive force', massively and continuously applied for maximum political impact. Finally, contextual factors were discussed, such as escalation dominance, coalition cohesion and communication of clear demands tied to specific deadlines to create a sense of urgency (Jakobsen 1999).

Yet few of these insights informed strategic thinking in practice. Until the Srebrenica massacre in summer 1995, the United Nations (UN) threatened Serbia with air strikes on several occasions with very little effect. While the warring factions were engaged in a vicious high-stakes civil war, Western forces operated under a limited UN mandate and in a politically constrained environment with very restrictive rules of engagement (ROE) that prevented targeteers and aircrew from hitting significant military targets. Any targeting error, no matter the precautions taken, could result in civilian casualties that would produce dramatic media footage and, so it was feared, undermine the credibility and legitimacy of the NATO mission. This sensitivity was not lost on the warring factions. Skilful manipulation of the media, hiding military assets among civilians and civilian infrastructure, and hostage-taking of UN observers served as effective counter-coercion tactics (Jakobsen 1999). Regardless of target selection, air strikes during Operation Deny Flight were never able to inflict politically significant damage. This highlighted the conditional nature of the advantage high technology may offer when not tied to a proper strategy and suitable context.

This changed after the Srebrenica massacre: NATO altered the ROE, the dual-key arrangement that had required UN approval for each air strike was abolished, and peacekeepers regrouped to avoid the risk of being taken hostage. The impact of these changes was directly visible when Operation Deliberate Force started on 30 August 1995 against Bosnian Serb forces, coinciding fortuitously with a Croat ground offensive. A total of 293 aircraft flew 3515 sorties in two weeks to deter Serb aggression. Serb leadership stood powerless against this air offensive that destroyed the military capabilities it needed for defence against the Croats. As a result, all military and political objectives were attained: safe areas were no longer under attack or threatened, heavy weapons had been removed from designated areas, and Sarajevo's airport could once again be opened, as could roads to the city. The path to the Dayton Peace Accords had been secured (Owen 2010).

Operation Allied Force: a campaign without a strategy

Over Kosovo, between 24 March and 27 June 1999, NATO again lacked a strategy. Launched after a year of fruitless diplomatic efforts and incoherently communicated threats of air strikes, NATO's limited air campaign aimed to halt human-rights abuses committed against Kosovars by the Serb strongman Slobodan Milošević. Political consensus, rather than military and strategic value, often dominated decision-making. Disunity was a major concern for the Supreme Allied Commander, Europe (SACEUR), with France, Germany, Italy and Greece harbouring major misgivings about the war. The campaign plan precluded a ground invasion, and the operation began under the guidance that it would last only two to three days and involve only fifty targets. The objectives set by SACEUR General Wesley Clark betrayed the constrained political context:

- minimising loss of friendly aircraft;
- impacting Serb military and security forces in Kosovo;
- minimising collateral damage;
- achieving the first three goals in order to hold the NATO alliance together; and

- protecting allied ground forces, especially those in neighbouring Bosnia, from Serb raids (Byman and Waxman 2000).

The planned gradual approach assumed Milošević would be sufficiently impressed given the strategic impact of Deliberate Force a few years earlier. It was a phased operation with air defences as first-priority targets followed by Serb army, police and paramilitary units operating below the 44th parallel (including Kosovo). The third phase would involve strategic infrastructure targets such as power stations, communication facilities and government buildings in and around Belgrade. Serb military capabilities comprised the default target category.

But instead of aiming for clear-cut strategic goals, coalition planners performed no effects-based target analysis, just attacks on targets that key NATO governments happened to approve such as Serb forces, tanks and artillery in Kosovo. While obviously legitimate and politically uncontroversial, their destruction was of little value from the perspective of a coercive strategy. Moreover, in light of the requirement for visual identification of targets by pilots, these small, fleeting targets in mountainous terrain were hard to detect, track and engage from high altitude. Low-altitude operations, however, were prohibited due to the risk posed by the mobile Serb air defences.

These constraints undermined the campaign's coercive effect. Initially the stunningly limited level of intensity of the first air strikes (only forty-eight sorties a day, versus 1300 daily during Desert Storm) did not in any way convey power or a sense of urgency or commitment, thus violating any guidance that the literature on deterrence and coercive diplomacy offered. There were also deficiencies in NATO command and control (C2). The Combined Air Operations Centre (CAOC) in Vicenza was neither staffed nor trained for a sustained campaign, lacking state-of-the art air C2 software tools to plan and communicate complex offensive air tasking orders (ATOs). US national command lines were mixed with NATO command lines and instead of adhering to established arrangements, in which the JFACC reported to his direct chief, the Commander Allied Air Forces, Southern Europe (COMAIRSOUTH), SACEUR decided to command the air operation himself, using ad hoc informal communication formats such as email and, because of the geographical spread of key players, video teleconferences (VTCs) (Lambeth 2001).

Force escalation only became an accepted option when NATO credibility came to be at stake because failure loomed. As a result, to the surprise of many, after seventy-eight days and 38,000 combat sorties by 829 strike aircraft, Milošević's regime gave in. By then eleven railroad bridges had been destroyed, along with thirty-four highway bridges, 29 per cent of Serbia's ammunition storage facilities, 57 per cent of its petroleum reserves, all its oil refineries, fourteen command posts, over one hundred aircraft, ten military airfields, electrical and broadcast services, news media, and two of Milošević's homes, which were reportedly used as C2 facilities. Other factors too played a role, such as Russia's withdrawal of political support for Serbia, the increasing intensity of Albanian Liberation Army activities, NATO perseverance despite setbacks, and the exhaustion of possible Serb countermoves without marked effects. These, however, only came into play after and because of the continued limited air campaign, demonstrating the increasing military and political utility of air power's offensive capabilities (Byman and Waxman 2000; Posen 2000). With PGMs accounting for 40 per cent of the ordnance delivered, the trend of increasing use of precision weapons was continued. By flying at high altitudes and by launching weapons from stand-off ranges, NATO avoided allied casualties and only two aircraft were downed. To appreciate this accomplishment, two decades earlier in 1972, the US lost sixteen B-52 bombers in just eleven days during the Linebacker II campaign against North Vietnam (McInnes 2002: 92)

The second air power decade: 2000–2010

Operation Enduring Freedom: air power in irregular war

During Allied Force, for the first time, unmanned aerial vehicles (UAVs) such as the Predator, Pioneer and Hunter made a substantial contribution. New too was the deployment of Predators equipped with laser target designators. B-2 bombers saw their first offensive action, flying thirty-two-hour missions and, importantly, receiving target details over satellite datalink on their way to Europe. These developments heralded the transition into the twenty-first century. Yet Allied Force also demonstrated a persistent problem that had become manifest during Desert Storm when Iraq's Scud missile launchers could not be engaged due to the delay between detection and air strikes: the so-called sensor-to-shooter time. The Balkan air campaigns had demonstrated that Serb troops were adaptive opponents who quickly learned to exploit decoys, underground facilities, dispersal of equipment and troops, and frequent movement of SAM systems, which prevented NATO from employing potent but vulnerable AC-130 gunships and Apache attack helicopters and negated the asymmetric edge that air power conferred upon Western forces. In response to these problems, US Air Force leadership started to datalink the CAOC, other command and intelligence centres, surveillance and reconnaissance systems, and 'shooters' such as F-16s or B-2s – initiatives that dovetailed with a Pentagon-wide program designed to stimulate Network-Centric Warfare. Such a network of sensors, 'shooter platforms', and command nodes aimed at rapid dissemination of information, reduced response times, increased operational tempo, and enhanced air–land integration (Rumsfeld 2002; Osinga 2010b).

When Operation Enduring Freedom began in 2001, these new processes, procedures and doctrines were not firmly established in the joint community. Yet in the end this campaign stands out because it demonstrated the enhanced relevance of air power in irregular warfare, a context in which air power traditionally had played mostly supporting and 'non-kinetic' roles such as air transport, liaison and air mobile operations (Corum and Johnson 2003). Interdiction by high-speed fighters and bombers often was ineffective or irrelevant against opponents who did not depend on large infrastructure or a sustained logistical flow of materiel. In urban environments, the negative side effects of air attacks involving numerous civilian casualties often outweighed the potential benefits. CAS, while vital, always depends on good but difficult coordination between air and land units to target the enemy in time *and* prevent fratricide.

With such a track record, it was neither obvious nor predetermined that a heavy air power response to the 9/11 terror attacks would be more successful than the symbolic retaliation strikes in 1998, when the US launched cruise missiles against a number of Taliban training camps. In 2001, the US confronted an enemy trained in guerrilla fighting in landlocked mountainous terrain, with an impressive track record against the former Soviet Union and domestic rivals, and no significant infrastructure that could offer strategic coercive leverage. A large ground invasion was practically and politically infeasible. Yet, with only 300–500 Special Forces physically within Afghan territory, and by uniting and empowering local opposition factions totalling no more than 15,000 men, the US managed to evict a force of 60,000 Taliban fighters and the regime. It required a relatively limited operation of one hundred combat sorties a day, amounting to 38,000 sorties flown. Outside Afghanistan, a US/UK force of approximately 60,000 personnel supported this operation, dispersed over 267 bases at thirty locations in fifteen countries. The US lost thirty men (O'Hanlon 2002: 49). Again, the usage of PGMs increased, this time accounting for up to 60 per cent of all munitions expended, indicating that PGMs had become the norm.

Enduring Freedom was, in essence, an air campaign conducted in conjunction with, and supported by, Special Operations Forces (SOF), who acted as forward air controllers (FACs), and friendly indigenous fighters. This combination, enhanced by laser range finders and datalinks to connect the ground teams to command centres and strike aircraft, enabled the engagement of so-called 'emerging targets' such as small Taliban troop contingents by responsive accurate CAS strikes. Midway during the operation 'flex-targeting' dominated: 80 per cent of sorties took off without specific assigned targets. Instead, JSTARS, UAVs and Special Forces acted as eyes, spotting pop-up targets and relaying time-sensitive up-to-date accurate target information to shooter platforms inbound or already circling in the vicinity; they then handed the aircraft off to the FAC (Fyfe 2005; Biddle 2003). Response times averaged only twenty minutes (and sometimes less). This disproved any argument that high-technology weapon systems are useless against insurgents and suggested that from now on air strikes could be very effective in irregular warfare as well (Lambeth 2005).

NATO's International Security Assistance Force (ISAF) mission in Afghanistan relied strongly on this new capability (and on air transport, air mobility and medevac). Indeed, ISAF has been fairly successful due in no small measure to the new ability to be effective against small groups of enemy fighters and the force protection offered by the combination of ISR and strike capabilities (Mueller 2010). CAS missions sometimes benefited from new FAC equipment consisting of laptop computers and datalinks that allowed FACs and pilots to share the same air-to-ground image of the target. Faced with an increasingly potent Taliban insurgency, without rapid accurate offensive air support, operations with light ground forces in such vast, barren and underdeveloped terrain would be highly vulnerable, ineffective and sometimes simply unfeasible.

Operation Iraqi Freedom: regime change

The experience of Enduring Freedom and a decade of doctrinal and technological developments came together during Operation Iraqi Freedom (Lambeth 2013; Mahnken and Keaney 2007). The flawed Operation Anaconda of March 2002 had reaffirmed that close cooperation in planning and execution between air and land units was essential. It resulted in improved army–air force cooperation, enhanced training of and equipment for tactical air control teams, an increased number of such teams, and in air–land integration at ever lower tactical levels by assigning air liaison officers and joint tactical air controllers to companies, or, if required, even at the platoon level. Munitions meanwhile had gained in accuracy with miss distance often reduced to three feet, which allowed smaller yield bombs to be used, in turn reducing the risk of collateral damage. The demand for risk limitation resulted in extensive methods to mitigate collateral damage, new procedures and new software tools to aid planning. In addition, several high-level joint experiments and training exercises were conducted, focused on Scud hunting, dynamic targeting, solving C2 problems, smoothing joint targeting processes and testing various planning software tools.

The campaign plan aimed at seizing key objectives as rapidly as possible and preventing Iraq from using weapons of mass destruction (WMD) against coalition troops, launching Scud-type missiles against Israel, or destroying oil fields. Iraq was divided into the western, northern and southern sectors, each with a different focus. Applying the 'Afghan model', large numbers of SOF troops operated in the west and north of Iraq as part of a closely integrated team with airborne sensors, command nodes and offensive aircraft to detect and neutralise potential launches of Scud-type missiles and to restrict Iraqi freedom of movement on the ground. The south would see the rapid ground advance towards Baghdad, preceded and accompanied by

massive air support. The goal was to effect regime change while causing the Iraqi population as little suffering as possible. Therefore, the strategic attack portion of the plan included the targeting only of C2 networks, regime security forces, select palaces, government ministries, command bunkers and WMD facilities (Lambeth 2013: 33).

In the south, US Secretary of Defense Donald Rumsfeld placed his trust in a small, fast-moving ground-attack force 125,000 men strong, continuous air surveillance and responsive air strikes. About 15,000 sorties were allocated for combined 'kill-box' interdiction and CAS missions. Air–ground surveillance systems, unmanned aircraft and SOF located conventional Iraqi forces as a stream of strike aircraft delivered ordnance. A critical component was the ability of US and coalition ISR assets to find and fix time-sensitive Iraqi targets. Eighty US and coalition ISR platforms, flying approximately a thousand sorties, supported the effort, while space-based assets provided operational- and tactical-level support, including detection of Iraqi missile launches (Fyfe 2005: 21). The efficiency of the targeting process was such that, in some cases, it took as little as twelve minutes to destroy an identified emerging target; at times, this only required five minutes after detection. Proper training, technical connectivity and avoiding top-down detailed tactical control all contributed to targeting accuracy and responsiveness (Lambeth 2013: 203).

As a result, in a single week the coalition destroyed a thousand tanks and reduced the Republican Guard by 50 per cent. Close combat against Fedayeen fighters occurred, but most Iraqi armour and artillery was neutralised before it could deploy against coalition ground forces. Many Iraqi troops abandoned their armour once the first bombs fell, enabling a rapid advance towards Baghdad. Even urban operations saw enhanced air strike effectiveness. Intense intelligence preparations had produced detailed maps featuring codes for individual buildings in specific areas of Baghdad, thereby facilitating CAS coordination with ground troops. In the north, the combination of SOF, ISR, CAS and cooperation with Peshmerga irregular forces managed to fix and attrit thirteen Iraqi divisions (Andres 2007). In the west, no Scud or similar missile was launched. While the legitimacy, political soundness and neglect of post-conflict planning in Operation Iraqi Freedom have received justified criticism, the stunning military achievements and the role of offensive air power remain undisputed.

Targeting non-state actors

The experiences of the Israel Defence Force (IDF) in 2006 demonstrated once again the benefits, as well as the conditional nature, of technological superiority. During much of the 1990s the Israeli Air Force (IAF) had honed its skills in targeted killing of key leaders of Hamas and the Palestine Liberation Organization (PLO) by employing data-linked surveillance UAVs, combat helicopters and fighter aircraft. Combined with an aversion to casualties and instability this fostered a belief, shared by civilian and military leaders, that air power could offer a low-cost way to retaliate against and defeat adversaries such as Hamas and Hezbollah. In the summer of 2006 this doctrine was applied when Hezbollah fired Katyusha rockets against Israeli communities and abducted two Israeli soldiers.

The IDF ground advance encountered stiff resistance and incurred dramatic casualties with significant political repercussions, in large part because the IDF had lost the expertise in combined arms and joint warfare (Brun 2010). On the other hand, the IAF is thought to have eliminated about 500 of Hezbollah's most advanced fighters and forced many of the others to evacuate the areas south of the Litani River. It destroyed about half of the unused longer-range rockets, and much of Lebanon's infrastructure that was used to resupply Hezbollah. Indeed, as it demonstrated again in Operation Cast Lead in December 2008 and January 2009 against

Hamas, by virtue of an established network of multiple UAVs, fighter aircraft and artillery the IAF managed to strike targets within minutes after a launch had been detected. Although the Second Lebanon War was marred by huge IDF deficiencies in joint warfare and by effective Hezbollah media manipulation that suggested the IDF caused massive collateral damage, strategically it was a success in that it subdued Hezbollah for a considerable period and bought Israel time, which is the underlying strategic logic behind the various military operations from which Israel does not expect lasting solutions.

The Israeli successes, as well as the West's experiences in Afghanistan, have accelerated the employment of armed UAVs, or a combination of manned fighters and a targeting-pod-equipped UAV, for striking key leaders and small groups of Taliban, al-Qaeda and Islamic State in Iraq and Syria (ISIS) insurgents, and militants in Pakistan, Somalia, and Yemen. In fact, the first sortie of Enduring Freedom was an armed Predator UAV operated from an airbase near Las Vegas, a 7,000-mile distance. The use of small, medium and large UAVs is now part and parcel of counter-insurgency and counter-terrorism operations. The advantages are obvious. Small UAVs offer ground units organic reconnaissance capability. In Afghanistan and Iraq UAVs have provided effective surveillance for detecting – and deterring – the placement of improvised explosive devices.

Larger UAVs offer persistent presence over maritime patrol and combat zones, at strategic distances if required, routinely well beyond that of manned platforms. The key features that drones offer for these leadership attacks are real-time streaming video and very accurate sensors, which enable individuals to be found, tracked and, if their identity is confirmed, engaged. Equipped with small Hellfire missiles, drones engaging in missions not only against ideological leaders, bomb-making experts, and media operators, but also against 'foot-soldiers' caught laying roadside bombs are the final link in a long, intricate targeting chain involving numerous military and civilian intelligence agencies, foreign intelligence sources, legal advisers and sometimes even senior political leadership (Osinga 2015). Such air strikes have an attrition effect on such groups and affect their lethality and their attractiveness to potential recruits (Johnston 2012; Pryce 2012).

Both the US and Israel have leveraged precision weapons and the fusion of intelligence sources to craft a counter-terrorism strategy which is increasingly informed by the logic of crime prevention rather than war. In Israel, the effect has been periods of 'quiet' (Wilner 2013; Rid 2012). Israel aspires to restrictive deterrence, attempting to limit the risks and impact of terrorist attacks to a level Israeli society can cope with, rather than absolutely preventing such attacks. This demonstrates how the technology and organisation of modern air strike capabilities, developed for conflict between states, have also proved effective in engaging violent non-state actors.

Air power, media and postmodern ethics

Western air forces increasingly face the paradox that the demonstrated ability to attack with unprecedented precision has simultaneously raised the bar for future operations. On the one hand, the increase in accuracy of weaponry has broadened the realm of targetable objects and inspired new strategic approaches that promise military success which, moreover, can be achieved with fewer casualties on all sides. On the other hand, extraordinary precision has become a public and political ethical norm and thus a military one (Thomas 2001; Coker 2002). The risk of unintended 'collateral damage' from air attacks has become highly controversial, even when legitimate targets are struck. In 1991 images of a bombed military bunker in Baghdad which also happened to shelter civilians and of the so-called 'highway of death'

resulted in stringent targeting restrictions and a premature halting of operations, respectively. During the Balkan operations, offensive air operations were immediately halted when images appeared of peacekeepers held hostage. Counterproductive media coverage was the main reason why, in Afghanistan, ISAF Commander General Stanley McChrystal took pains in July 2009 to limit the risk of civilian casualties by drastically curtailing the use of force. As he stated, 'Air power contains the seeds of its own destruction if we do not use it responsibly. The tactical gains do not outweigh the costs' (Crawford 2013: 19).

Opponents of Western interventions have benefited from this sensitivity by making use of the proliferation of the Internet and social media such as blogs and YouTube, giving rise to the so-called 'War 2.0' (Rid and Hecker 2009). The connection between the popular perception of a war and the physical battlefield is more immediate, and therefore more volatile, than ever before. This offers non-state actors in particular a powerful asymmetric edge: waging 'lawfare' on a new virtual front where strict Western norms are exploited as a weapon against the West, for instance by deliberately hiding military assets in civilian infrastructure (Dunlap 2009).

Drone strikes in particular have produced widespread condemnation (Osinga 2013). According to the critics, such 'remote killing' has made 'killing too easy' and is 'unethical' because only one side in a conflict is at risk of attack, while the other side may remain several thousand miles from the front. They fear a 'PlayStation mentality' and moral disengagement because drone operators in their virtual reality may fail to properly assess the consequences of their actions and interpret targets as mere screen symbols rather than real human beings. As a result, the physical anonymity of both target and operator may result in de-individuation and de-humanisation of war, and thus in lowering the threshold for deciding to attack. Others critique the lack of transparency and legal accountability with respect to targeting procedures.

Most of these arguments have been countered in detailed analysis (Schmitt 2012; Strawser 2013). Indeed, the president of the International Committee of the Red Cross stated that drones 'allow belligerents to carry out their attacks more precisely against military objectives and thus reduce civilian casualties and damage to civilian objects, in other words, to exercise greater precaution in attack' (Kellenberger 2011). Still, the debate underscores that most challenges with air strikes no longer revolve around technological, doctrinal, or organisational factors but emanate from the 'mediatisation' of war, Western norms and public perceptions of legitimacy. Each of these factors produces pressure for increased transparency, accuracy and accountability and for strategic decisions based on public sensitivity.

Conclusion

Undeniably Western offensive air operations today stand in stark contrast to the massive destruction by air attacks in the total wars of the twentieth century. Indeed, the air power decades have spawned a new Western way of war. This is the result not just of new technologies – stealth, improved sensors, UAVs, datalinks and precision weapons – but also of experimentation with new C2 processes and targeting philosophies.

The combined effect has been dramatic. First, the ability to quickly achieve air superiority on a theatre-wide scale offers joint commanders a valuable asymmetric 'sanctuary' to be exploited for various purposes, and provides new levels of protection for ground forces, lines of supply, and logistics sites. Second, by exploiting air superiority, airborne sensor platforms can provide unprecedented levels of situational awareness to commanders and thus detect, and if necessary prevent, an adversary's massing of armoured forces, and delay, disrupt and destroy follow-on forces. Third, rapid dissemination of accurate target information enhances precision

of air strikes and reduces response times, enabling effective engagement of small and mobile targets such as insurgents, and thereby improving air support. Fourth, these capabilities enable an increased level of intensity of the air offensive, thus allowing a higher operational tempo for the entire campaign. Finally, they provide new options for coercive diplomacy and even enable targeting of individual terrorist leaders. Importantly, these developments have resulted in a significant reduction of risk for friendly ground troops as well as for civilians.

As a result, air power has increased its political and military utility in a wider variety of operations (i.e., peacekeeping, interstate warfare, humanitarian interventions, irregular warfare, counter-terrorism). However, this chapter has also suggested that reliance on precision air strikes has become a normative feature for Western militaries that can and will be exploited by adaptive opponents. Moreover, each operation discussed demonstrated the truism that without proper concern for the political context and strategy development, superior military technological capabilities do not guarantee success.

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9

AIRBORNE INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE

Gjert Lage Dyndal

From the earliest days of aviation, the military has discussed, fought over and explored the use of modern airborne platforms in support of the battlefield commander. The first and quite obvious role of aircraft was to 'scout' for enemy forces. Prior to the advent of aircraft, balloons were used for the same purpose. Already in 1794, French forces deployed balloons over the battlefield at Fleurs, Belgium, to observe the disposition and manoeuvre of enemy forces (Richelson 2007).

During the First World War, combatants employed tethered balloons mainly for surveillance (to use modern terminology) owing to their ability to remain in the air for a long time, and when sometimes used with telephone lines they could report down to the forces in support of the front line fighting (Boyne 2003: 64–65). Airplanes were instead used for 'scouting' – conducting reconnaissance along the battlefronts on land and the coastlines of the maritime theatre – and for directing firepower by land-based and sea-based artillery. In large part, however, experience during the First World War showed that the resulting information was usually relayed too late to the commanders who needed the information, and in support of artillery fire it proved too inaccurate. Additionally, both the earliest airplanes and balloons proved very vulnerable to ground fire on the front line. Their best use was for overall and somewhat deeper strategic field reconnaissance of force dispositions (Kennett 1991: 30–31; Layman 1996).

Overall, the airplane proved its worth during the First World War. The aerial role of 'reconnaissance', also called scouting or 'exploration' at the time, must therefore be considered the first and prime role of military aviation. There were many sceptics, but also strong believers in the prospects of the new technology.

This chapter describes the roles of 'reconnaissance' and 'surveillance', as well as how this and other information feed into tactical and strategic 'intelligence'. It presents a brief overview of the capabilities used for these purposes today, and outlines some trends in technological development and how intelligence, surveillance and reconnaissance (today widely referred to as 'ISR') are used and envisioned. Mainly, the chapter offers an understanding of airborne ISR, with its various types of assets, and of the overall ISR process used in Europe and the US today. It focuses on airborne and to a lesser degree space-based capabilities for reconnaissance and surveillance of the land and maritime domains. It does not include discussions of surveillance of the air and space domains, which are examined elsewhere in this book.

Additionally, the chapter highlights two main challenges the air power community has experienced over the last years: the air power community seems to have an overly strong belief in the speed of processes and great trust in current and timely data from high-resolution reconnaissance. However, air power reconnaissance and surveillance data provide only a portion of the background for thorough intelligence analysis. When air power becomes involved in new areas, air power professionals tend to act too quickly, with too little understanding of the consequences.

Partly as a response to this challenge, but probably more as a consequence of the extraordinary technological progress experienced over the last decade in autonomous data analysis, numerous debates have emerged about 'fusion' and 'actionable' intelligence. The very terminology and the first 'fusion cells' came about in the aftermath of the 9/11 terrorist attacks (Carmichael 2015). The chapter highlights some promising ideas of 'fusion warfare', as this places modern ISR within the overall vision of future air warfare that dominates air power conceptual thinking these days. However, this increasing trend towards complete system integration for military technologies and concepts, like the global commercial trends of big data analysis and 'the Internet of things', also presents some difficulties. The Western way of conducting war, including modern ISR, where all intelligence data and operations are becoming ever more interconnected, actually makes it increasingly difficult to share intelligence, which can severely hamper coalition cooperation and operations.

Evolution of intelligence, surveillance and reconnaissance

Historical developments

As described in the introduction, 'reconnaissance' was the first role of air power. However, the air forces that evolved in the aftermath of the First World War became preoccupied with independence from the other military services, and air power discussions between the two World Wars centred on the roles of 'strategic bombing' and the fight for control of the air. Tactical reconnaissance became a task for armies and navies. Later, during the Second World War in support of allied strategic bombing, and increasingly during the Cold War, strategic deep reconnaissance became an important role for the US Air Force (USAF). With the exception of the Vietnam War, this divide largely endured during the Cold War. Tactical reconnaissance over land was the task of the armies, while the larger independent air forces took care of strategic reconnaissance – 'strategic' in the sense that it focused on areas and facilities deep inside adversaries' borders and was often linked to intelligence on and for strategic nuclear weapons. The term 'strategic' also became a label for electronic and communication intelligence deep inland, because this type of information collection spanned far more than just the dispositions of military forces. As for the maritime domain, navies have taken care of both tactical and strategic reconnaissance, as well as continuous surveillance of strategic submarines and naval forces.

Following the end of the Cold War, ISR technology development, use and doctrine became centred on theatre and tactical support to land forces and special operations (Morton 2012; Deptula 2015; Brown 2017). The developments in unmanned aerial vehicles from the late 1990s on are part of this story, and are described in the section on today's ISR assets. However, today, with an increased focus on great power competition in an increasingly multi-polar world system, strategic ISR is again increasing in importance. This changing strategic framework and the accompanying technological developments have led to numerous discussions about the development of modern ISR, 'fusion' and 'fifth generation' air power, especially in American circles.

Defining the roles today

ISR comprises the two roles of 'reconnaissance' and 'surveillance', as well as the 'intelligence' production derived from the information provided by the two other functions. Even though today's air power concepts and theories view them as one, these roles are quite different.

Reconnaissance consists of obtaining information on the positioning, activities and resources of an opponent. This level of information gathering is more local in both time and space than surveillance. Reconnaissance basically consists entirely of spot observation, and is an integrated part of most activities at the tactical level. Surveillance, by contrast, is the systematic observation of all the dimensions: space, air, land and surface and subsurface. It is about tracking activities and little changes to the everyday situation. Surveillance is conducted and the findings are compared over a period of time. Air and space surveillance and reconnaissance are important to both land and naval surface forces. The triad of air power, Special Operations Forces (SOF) and intelligence agency operations has been central to modern warfighting and to hunting terrorists.

The surveillance and reconnaissance roles consist of collecting information, while intelligence is something more, ranging from the collection of information, through analysis, to an achieved level of knowledge for a purpose. David Omand has argued that intelligence is about 'improving the quality of decision making by reducing ignorance' (Omand 2010: 22). Much of the foundation for that knowledge rests upon open sources, but of course also upon various types of classified information collection, to which air power contributes through reconnaissance and surveillance missions. However, the creation of knowledge must also have a purpose, and Omand argues that intelligence is fundamentally intended for building situational awareness, including explanatory reasoning, but should normally lead to intelligence estimates and consequently strategic predictions about future developments. Most often intelligence analysis presents a range of outcomes with varying levels of likelihood, thereby whittling down the options that military and political leaders must consider (ibid.: 24–25).

The current USAF doctrine for ISR defines intelligence as 'The product resulting from the collection, processing, integration, evaluation, analysis and interpretation of available information concerning foreign nations, hostile or potentially hostile forces or elements, or areas of actual or potential operations. The term is also applied to the activity which results in the product and to the organisations engaged in such activity' (USAF 2012). In this definition of intelligence, the USAF also includes the roles of reconnaissance and surveillance as *part of* intelligence.

In contemporary air power doctrines and concepts the roles of reconnaissance, surveillance and intelligence are simply referred to collectively as ISR. Current USAF concepts and debates even use the term 'global integrated ISR' and define it as 'cross-domain synchronisation and integration of the planning and operation of ISR assets; sensors; processing, exploitation and dissemination systems; and, analysis and production capabilities across the globe to enable current and future operations' (ibid.). The doctrine stresses that this is an inter-agency and global activity, and that speed, from collection through analysis to action, is essential for 'superior decisions' and action relative to adversaries.

Intelligence operations range from the lower tactical levels to the top political level. As for air forces, they are constantly involved in intelligence operations through their collection of data. Still, some aircraft and crews are more specialised for this role than others. Military intelligence must truly be considered a necessity for both military and wider state interests and power. By providing relevant intelligence, even in peacetime or early phases of conflicts between states, the political strategic decision-makers are able to take the correct decisions and

diplomatic steps. Well-informed diplomacy will in most cases stop potential conflicts before the parties reach unnecessary military confrontation. Obviously, intelligence is also a tool for getting a competitive edge over opponents.

Intelligence, surveillance and reconnaissance processes

The purposes and impetus for ISR are complex. ISR serves both general political and military purposes, as well as scientific and technical purposes. Intelligence operations are as important in peacetime as in times of crisis and war. In times of crisis, intelligence operations provide indications and warning about developments. In military operations current intelligence for situational awareness and own safety, as well as for targeting, is of crucial importance across all services.

The most basic model of intelligence operations normally centres on at least four steps: direction and planning, collection, analysis and dissemination. No matter the type of intelligence operation and analysis – be it for political or military use, in peacetime, crisis, or war – it always starts with requirements and directions from higher authorities. Based on the directions from the user, agencies or military units develop collection plans and task various units to deliver pieces of information to meet the overall needs. The necessary collection of information is aligned with available assets from other agencies and units. This has always proved a great challenge even within single nations, and even more for coalition operations. A later section of the chapter describes this issue in more detail. Concrete collection planning for the use of air assets must draw on input about the ISR aircraft available, with which sensors and capabilities, and must take place after an evaluation of threats and urgency. Intelligence collection planning includes identifying, prioritising, coordinating and positioning available assets.

After the information is acquired, it is evaluated and processed for follow-on multi-source analysis by analysts. This equally applies to military units or agencies, from the tactical to strategic level. In both conventional high-end warfighting and counter-terrorism operations, where time is an essential factor, the information obtained sometimes is fed straight to the user, without contextual analysis. However, normally the collected information undergoes multi-source analysis. The information collected from aircraft or space assets is only part of the puzzle and must be analysed together with other information. As noted previously, all the snapshot information collected must be put into context on the basis of existing knowledge.

Intelligence analysis comprises interpretation and integration of multi-source data with existing knowledge, aimed at meeting the intelligence requirements identified at the start. Additionally, the general knowledge base is further expanded for general intelligence as a baseline for new requirements. The analysis normally ends by generating products that answer the requirements of the customer. These intelligence products are in turn disseminated from the agencies in support of operations or the military intelligence staff at the operational level (known as the J2), or at the tactical levels (S2/N2/A2) to the users, be it for planning or execution of operations.

New requirements and needs for intelligence arise constantly, be it in peacetime, crisis, or for planning operations in times of war. To prioritise among the many types of information and intelligence needs, some standard doctrinal processes and terminology have become widespread within NATO and beyond: 'Commander's Critical Information Requirements' (CCIRs) are information requirements identified by the commander as being critical to timely decision-making. They start with the identification of needs for intelligence across the operational environment, while 'Priority Intelligence Requirements' (PIRs) identify the intelligence needed to answer the most important requirements of the CCIRs. The PIRs are often defined

down to specific information requirements, known as 'Essential Elements of Information' (EEIs). The CCIRs, PIRs and EEIs drive the standardised processes to refine information requirements and support the commander's alternative courses of action (COAs) in planning.

Challenges: too speedy; limited basic knowledge

If Western nations should learn one lesson from intervention wars – from Korea and Vietnam and from the conflicts of this generation in the Middle East, in the Balkans, and in Afghanistan and Libya – it concerns the lack of understanding of consequences and developments following those interventions and actions. The West must acknowledge that fundamental local and regional knowledge about societies, cultures, religions and domestic dynamics, as well as the regional actors' true interests, and thus their indirect support to various actors, are of crucial importance. This goes to the core of the Western way of warfare, which focuses on technological superiority, (often too) simple models for analysis and planning, and not least arguably an overreliance on 'speed'. Actually, the platform of basic understanding and open source intelligence provides the core baseline knowledge – before more detailed information is fed in from air- and space-based intelligence collection and from a broad range of signals intelligence (SIGINT) and human intelligence.

Without this basic knowledge, it is hardly possible to understand the detailed classified intelligence information collected and to analyse it in a meaningful way. Western intelligence agencies and military intelligence units can produce actionable intelligence, inside the OODA Loop of the enemy, but the West has again and again misunderstood the effects and impacts its actions lead to, not least second- and third-order effects. Speed may be crucially important, often in conventional high-end tactical warfighting, as well as in high-value targeting or for support of troops in contact during intervention and stabilisation operations. However, for the overall ISR effort in intervention and stabilisation operations, speed is more often not crucially important, and will when prioritised be at odds with the need for systematic building of situational awareness of complex and politically tense situations.

The current challenge is that military forces and the intelligence communities must be prepared for many types of warfare, where speed versus systematic building of knowledge, as well as wider political considerations, must be balanced differently from situation to situation. Western air power communities' continuous reliance on simplified models will often prove counterproductive in the face of such realities, and air power enthusiasts and commanders should be wary of advocating that offensive air power take a leading role in warfighting if they have no adequate knowledge base in place.

Intelligence, surveillance and reconnaissance resources

Today's intelligence, surveillance and reconnaissance assets

Manned aircraft have long been the preferred assets for obtaining information due to their responsiveness and survivability against defensive forces. In the earliest days, long-range reconnaissance aircraft carried out their missions largely unhindered. With the advent of effective air defence radar and anti-air missile systems, a reality by the 1950s, the world saw a constantly evolving technological race, wherein speed, altitude and radar cross-section became important attributes of the aircraft assigned to a collection role. The Lockheed U-2 aircraft and later the Lockheed SR-71, better known by the nickname 'Blackbird', are the most prominent examples from the 1960s and the Cold War.

A famous incident involving a U-2 plane was the shootdown of American pilot Gary Powers over the Soviet Union in 1960 while he was en route to Bodø, Norway. By the end of the Cold War, the development of such dedicated strategic ISR aircraft had largely halted, as strategic surveillance and reconnaissance roles were by then better served by space assets. Today the world is witnessing another great leap forward in space capabilities, addressed later in the section on new ISR capabilities. Also, by the late 1980s, stealth aircraft such as the Lockheed F-117 Nighthawk came to be used in a similar type of mission, even though they were designed as strike aircraft.

However, ISR is not only about platforms, but also about the reconnaissance and surveillance capabilities of the different types of sensors carried. Sensors for air and space ISR have evolved gradually. Today the types of sensors range from those that collect electro-optical and infrared imagery intelligence (IMINT) and radar intelligence (RADINT), which includes technologies such as synthetic aperture radar (SAR), inverse SAR (ISAR) and ground-moving target indication (GMTI), through signals intelligence (SIGINT), including electronic intelligence (ELINT) and communications intelligence (COMINT), to the wider collection of measurement and signature intelligence (MASINT), which essentially means 'all other technical collection capabilities', ranging from nuclear sniffing to hyperspectral imagery (Richelson 2007).

For modern wars, where Western aircraft have gone largely unchallenged, various types of basic and vulnerable, but still effective, unmanned aircraft have been developed. Platforms such as the Northrop Grumman RQ-4 Global Hawk and the General Atomics MQ-1 Predator, later followed by the MQ-9 Reaper (Predator B), took over many of the collection roles of dedicated, manned ISR aircraft. Still, some of the legacy manned ISR aircraft – with the series of Boeing RC-135 aircraft and the SIGINT 'Rivet Joint' being the best known, and the Northrop Grumman E-8 Joint Surveillance Target Attack Radar System (JSTARS) – as well as the maritime MPA+ and SIGINT aircraft of the Lockheed P3 Orion series, have all proved effective for theatre ISR and even direct tactical support. These aircraft are also operated by some European nations, in addition to some European aircraft, for instance the legacy Atlantic. As for Russian ISR capabilities, the equivalents today are the most modern Tu-214R, as well as some Il-38 May and TU-142 Bear aircraft.

To supplement these dedicated ISR aircraft, it has become increasingly common to equip various types of fighter aircraft with advanced targeting pods for imagery and full-motion video (FMV). These fighters have often been used for tactical support and reconnaissance, in what has come to be known as 'non-traditional ISR'. Such use has come about due to the lack of dedicated ISR aircraft and the spare capacity of fighter aircraft to assist in low-intensity scenarios. However, robust and resilient fighter aircraft with high-resolution reconnaissance pods will also be efficient and necessary in the reconnaissance role against capable conventional air forces.

In fact, the issue of ISR in contested airspace has again emerged as a necessity, and vulnerable aircraft successfully used in low-intensity scenarios (as the first generations of ISR unmanned aircraft) will have to be further developed for survivability in a confrontation with a peer enemy (Haffa and Datla 2014). Various unmanned stealth aircraft, for instance the Lockheed Martin RQ-170 'Sentinel', which has already seen service, and unmanned combat aerial vehicles (UCAVs) such as the EADS Barracuda and the Northrop Grumman X-47B are already being tested. An even more extreme aircraft is under development: the SR-72 hypersonic ISR and strike aircraft, designed to fly at Mach 6.

Unmanned aircraft have become a much sought-after asset in these recent wars and conflicts because they meet a need that spans the tactical to political levels. From the very start of US engagement in Afghanistan, high-resolution images were provided directly to politicians in Washington, for instance by the 'Afghan Eyes' operation in the fall of 2000, and the politicians

and high-level military leadership wanted more (Knutsen and Røkke 2016). It must be noted that the established air power communities and the USAF were reluctant all along to adopt unmanned systems (ibid.). However, the development and use of the larger unmanned systems received a strong backing, even push, from the top. The availability of detailed imagery was important, but the overall new concept of combining unmanned aircraft, intelligence operators and SOF immediately proved an effective tool not only for the missions needed, but also as a means to avoid larger 'footprints' on the ground and in sensitive areas. With a gradual trend towards miniaturisation of sensors (discussed later in this chapter), these platforms have become very capable assets to support forces with tactical reconnaissance and targeting in the field. Various types of smaller tactical unmanned aircraft have filled the need of SOF and army forces for organic ISR in Afghanistan and Iraq from 2000 onward.

Since the late 1990s, the processes and concepts for tactical reconnaissance for army forces have been labelled ISTAR (intelligence, surveillance, target acquisition and reconnaissance). ISTAR has been defined as 'the prioritised integration, coordination and synchronisation of capabilities and activities to acquire, process and disseminate information and intelligence, to support the planning and execution of operations' (UK JDP 2011). Even though the larger air forces, even the USAF, have been more occupied with strategic ISR, they have also been pressed to accept and become involved in tactical support to the army and SOF over the last two decades.

Unmanned aircraft have proved very efficient for reconnaissance and long-endurance surveillance. However, the use of unmanned strategic ISR assets changes both the limits on their use and on their downing in comparison to manned aircraft. It is obviously easier to approve missions over other nations' territories when no pilots are at risk – an issue that has received considerable criticism (Larsdotter 2016: 312). In numerous cases unmanned aircraft of 'unknown' national origin have been observed over, and even have fallen down on, other states' territories. A less-discussed issue that will most likely gain traction in the near future is that of the acceptable threshold for shooting down or hacking and taking control of surveillance drones operating close to other states. In several incidents drones have been taken down, but this has caused far less discussion or diplomatic tension than the downing of manned aircraft. An example is the so-called Hainan Island incident in 2001, when a US E-P3 had to land after a mid-air encounter with a Chinese fighter aircraft, versus the example of an advanced RQ-170 Sentinel unmanned aircraft taken down over Iran in 2011. Several incidents involving similar but smaller types of unmanned aircraft happen quite often. The threshold for both using and attacking unmanned aircraft is different than that for manned aircraft.

For more than a century, airborne ISR assets have been important for dynamic support to naval and land forces. For much of the Cold War, advanced high-performance ISR aircraft were the main strategic ISR platforms for gaining information deep inside the Soviet Union. Large, dedicated, manned ISR aircraft have been and remain important for stand-off long-range surveillance and reconnaissance. For the last two decades, unmanned aircraft and effective infrastructures have proven their worth for both strategic and tactical use. Western nations have reached a point where space-based SIGINT collection and imagery reconnaissance, long-endurance unmanned aircraft and dedicated ISR aircraft have made it practically impossible for conventional military forces at sea or on land to operate in concealment.

Additional intelligence, surveillance and reconnaissance for the future

For decades, most air forces have devoted their attention mainly to manned aircraft for ISR. Space has been the purview of defined communities, mostly because of the secrecy that surrounds space-based assets and capabilities, and unmanned aircraft have not been the

'favoured' capabilities of airmen. However, space assets have since the 1980s taken over much of the strategic intelligence collection from long-range aircraft (Richelson 2007; Seagle 2015). Similarly, unmanned ISR aircraft have proven their worth for theatre and tactical ISR over the last decade. Already satellites in orbit and unmanned aircraft deliver the bulk of air power ISR. This has not led to the obsolescence of manned aircraft, which have their advantages, but air power communities and air forces must certainly recognise that satellites and unmanned aircraft are equally important ISR assets.

The importance of space assets and unmanned aircraft is rapidly increasing further, owing to the technological trends of extreme miniaturisation, big data analysis and autonomous processing. The most noticeable feature of miniaturisation is that it improves data processing while increasingly requiring less space than earlier equipment. The same applies to sensors, navigation systems and digital radios. Moreover, these systems require substantially less power and weigh far less than earlier equipment. All of this enables the development of smaller, more affordable, yet more capable systems.

The ever-increasing amount of digital information available from the Internet and cloud storage, social networks, email, cellular phones, etc., has created a need for massive processing of data in civil society and the commercial sector. This naturally also transfers to intelligence services. Big data analysis has become a business of its own. Those who own the most information – and are able to utilise it – dominate the commercial sector as well as intelligence analysis. To enable use of the enormous amount of information available today, autonomous data processing has become a necessity. Humans simply cannot comprehend and analyse such huge amounts of data.

Space-based assets and unmanned aircraft are now available to numerous actors. Already now, the great powers no longer monopolise space assets; many nations (and other actors) are also procuring them or are buying valuable services from commercial sources. This is no longer science fiction; the pace of development is remarkable.

A new approach to intelligence, surveillance and reconnaissance

System integration, ISR fusion

As noted, today's military forces have access to enormous amounts of data. However, the ability to process and integrate the data for analysis and decision-making in a timely manner poses an enduring challenge. How can Western nations better correlate all available information and analysis across units, services and agencies, and across partner countries in international coalitions? This question is becoming ever more critical when looking ahead, when the West must increasingly integrate data in an open information construct and autonomously process and analyse it to take advantage of the benefits of big data analysis. Additionally, the interfaces between intelligence analysis and end-users should be constructed in such a way that end-users will be able to access the information needed at the right time for decisions and action, which will allow superior responsiveness (USAF 2015).

To answer the needs and questions put forward over the last few years, experts have formulated the concept of 'fusion warfare'. The aim is that tactical, operational and strategic leaders can and should enjoy 'an asymmetric decision advantage through the integration and synchronisation of information from multiple sources and domains into analysis' (Jamieson and Calabrese 2015). Proponents stress that today's technologies make it possible to compress the time variable of the processes; however, they also believe that analysis should be as central to this concept as collection, fusion, integration and speed. At the core, they advocate that multi-

source and -domain intelligence across services and agencies be connected via a 'combat cloud' that synthesises and integrates the span of information and analysis.

Challenge: fusion also makes intelligence sharing more difficult

The future concepts of air power and ISR described above are visions; however, they are not just ideas. Even though these visions are not fully synchronised across all services or agencies of even the US Intelligence Community (IC), modern air forces are heading in that direction. Nevertheless, not all agencies across the Western intelligence environment will fully integrate their approaches, given the many reasons for secrecy in this field. Intelligence organisations need to protect their capacities and capabilities, be they technical or human (Hatlebrekke and Smith 2010). Even within NATO – a long-lived, well-integrated standing defence organisation – this presents a great challenge, where nations remain restrained from sharing much national intelligence within established NATO networks (Seagle 2015). Every now and then one reads about scandals involving even friendly nations and allies spying on each other or using intelligence for various political reasons. Examples such as the *Pentagon Papers* in 1971, the Iraqi WMD case before 2003, and later the Snowden case of 2013 prove this point and constantly remind the current generation of the national focus of intelligence work (Dover 2014).

Still, a modern military force must take advantage of technological possibilities to stay ahead of its adversaries and work towards ever-better integration and efficiency. In the aftermath of 9/11 the wider US IC still confronted grave difficulties in effectively sharing intelligence even though improved sharing was a hot national topic (Putbrese 2006). As for international cooperation, be it in NATO or in coalition warfare, accommodating to the unstoppable and necessary trend towards increased integration will most likely pose significant challenges in the years ahead. Many observed this problem during the coalition warfare in Afghanistan and Iraq over the last decade, and it has proved quite frustrating, especially for non-US air commanders (Meulman 2014: 72).

The reason for this – and it will not change – is that intelligence is profoundly national. For any given state, intelligence-gathering is performed across domains and for both military and civilian use. Intelligence products are shared or traded, but nations must protect the tools and collection capacities and capabilities (which go far beyond the airborne imagery that many airmen see and think of most often). Nations share intelligence products, but not sources and capabilities. The ever-greater integration of systems for intelligence data collection and analysis will increase the difficulty of sharing any type of intelligence securely.

Carmichael's analysis of the Intelligence Fusion Cells/Centres (IFCs) that have emerged over the last decade found that national homogeneous IFCs tend to be more effective than multinational initiatives (Carmichael 2015). Jamieson and Calabrese (2015) also note this, but the topic receives so little attention in their concept paper that it may be missed. To best overcome this challenge, work on concepts and technological solutions must also focus on how to integrate international partners' systems in future system architectures. Most future operations will involve coalition partners, and to make the most effective operational use of them nations must plan the integration of their systems and doctrines from the start. Nations should engage coalition partners in more than symbolic partnership.

Conclusion

Aerial reconnaissance, called 'scouting' or 'exploration' in its early days, was the first role of military aviation. What is now labelled ISR remains crucial for military commanders and

soldiers on the ground, just as it remains important to policy-makers and diplomats. Intelligence forms the foundation for international relations, military operations and security for Western forces.

To provide this, space assets and unmanned aircraft have supplemented classical manned ISR aircraft and 'non-traditional ISR' aircraft over the last decades. Collectively, air and space ISR have become so effective that no enemy conventional forces can operate in concealment. Because of this, asymmetric warfare has emerged. The opponents of the more technologically advanced militaries have found it necessary to operate covertly.

Recently, however, the prospects for future conventional (air) war have again come to the forefront of academic discussion at a time when international relations and great power politics and military build-ups are on the rise. Discussions continue on anti-satellite technologies to counter US dominance in space and on ways to secure space. Similarly for aircraft developments, air forces are replacing the vulnerable unmanned ISR aircraft designed for asymmetric warfare with more robust stealth aircraft. Thus, the world is witnessing the dawn of a new military technology race, mostly because of the West's current ISR dominance. Even though other great powers assume continued US ISR dominance, Western ISR communities still find reason to improve so that they can ensure information superiority and mitigate the vulnerabilities of both existing aircraft and new and improved ground-to-air systems, as well as satellites and various new types of disruptive anti-satellite technologies.

Today, Western ISR communities find themselves at an uncertain, challenging and exciting point. The global security situation is fluid, and the West needs tactical ISR to support ground forces in intervention wars while also meeting new requirements to fight conventional wars against militarily strong enemies. Airborne ISR must perform effectively in both permissive and hostile environments. This does not always require the same type of assets. Simply assuming that 'if you can do it in a hostile environment, you can also do it in a more permissive environment' will not lead to cost-effective solutions. The reality is that most operations take place in a permissive environment, and these operations must be effective every day. Balancing forces and capabilities involves hard choices for leaders. Still, as Pillar (2007) argues, the IC should not change its fundamental and enduring way of working. Even though the trend will continue towards ever greater integration, intelligence activities still require cleared personnel, control of classified information and the enduring intelligence principle of 'need to know', as well as necessary internal counter-intelligence (ibid.).

The technology developments of today are unprecedented, including miniaturisation, big data analysis and autonomous processing, and consequently they raise debates about new concepts for warfighting. Given current uncertainty about the future and today's increased military spending and build-up, nations must decide upon new requirements and capabilities. Decisions on future capabilities must – or should – be based upon a conceptual framework. The USAF is headed towards a 'fifth-generation air force' and 'fusion warfare'. This also points to the way forward for the Asian, Middle Eastern and European countries that align themselves with the United States. The need for integration of systems, including for ISR, is obvious and essential, but meeting it will prove challenging for national collaboration on intelligence and not least for international cooperation and coalition warfare. System integration, no matter how necessary, will present even greater challenges to intelligence sharing and operational integration in the future. Western nations must mitigate this challenge from the start by making it a central issue for the development of concepts, technology and doctrines in the coming years.

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10
AIR MOBILITY

Robert C. Owen

This chapter provides a baseline for air forces to understand how to plan, acquire, and employ air mobility forces of any size and strategic circumstances. It presents key considerations, concepts, and choices involved in extracting maximal air mobility capabilities in scale and mission coverage from available budgets. Accordingly, it begins with discussions of airlift forces, then considers the special case of air refuelling, and ends by laying out the conceptual and organisational implications of these discussions for air forces wishing to handle their air mobility responsibilities well.

Planning airlift forces

Airlift force planning must consider important elements that include strategic priorities, budgetary constraints, expected operational roles, and threats. In the complexity of their interactions and sensitivity to even minor changes in the details of planning scenarios, these elements comprise a force structure calculus as complicated as that for any other element of air and space warfare.

Strategic priorities

National strategic priorities constrain the desirable scales and composition of airlift arms. Countries whose strategic priorities embrace long-distance force projection will want airlift forces of substantial range, payload, and cargo deck dimensions. Countries focused on local defence usually will place less emphasis on long-range aircraft and more on short-range fixed- and rotary-wing systems. South Africa, for example, fields a squadron of C-130 aircraft in reflection of its own territorial extent and participation in peacekeeping actions throughout sub-Saharan Africa. Though defending a country with more than twice the gross national product of South Africa, the Swiss Air Force operates only helicopters, light fixed-wing transports, and business-class jets, in keeping with the rigid own-territory defence policy of its government. At the very high end of mobility forces, the United States fields thousands of long-range military and commercial reserve air transports and lift helicopters to create a global air mobility continuum for land and air combat forces from their home garrisons to their forward-most operating locations.

Budgetary constraints

While strategies constrain the *desirable* scales and composition of airlift arms, budgets define their *possible* make-ups. Airlift aircraft are expensive, and their flying hours and their personnel, logistics, cargo handling, and command and control support systems likely will become even more expensive over time. Even the most fiscally fortunate air forces, consequently, should not expect to buy enough airlift capacity to cover all possible requirements. Even the US military has for decades settled for 'fiscally responsible' airlift forces rather than the mobility fleet that its studies and war plans have called for. Inescapably, then, airlift force planning for all air forces must be an exercise in marginal-return and opportunity-cost analyses in the context of all the other demands placed on their budgets (Owen 2013).

Given the inevitable budget restraints they will face, air forces also must conduct continual assessments of existing and emerging capacity and mission-coverage gaps in their airlift programmes and their implications for national strategies. The United States Air Force (USAF) provides a clear example of how such gap analyses should work. Despite their unequalled scale and scope, USAF airlift forces do not include aircraft capable of delivering medium-weight (25–40 tonne) loads into unsurfaced forward airstrips, open fields, or damaged air bases. The lack of this capability sharply limits the USAF's ability to support forward-deployed air combat forces or to enable US Army strategic mobility and deep manoeuvre concepts based on medium-weight, mobile, protected firepower vehicles (Owen 2014). Given the compelling importance of these missions, the US defence establishment must either address them effectively or accept that it cannot undertake certain missions under all circumstances.

Expected operational roles

Air force planners can usefully categorise the general roles of airlift as liaison, transport, and mobility. The air liaison role involves the movement of high-value information (mail, orders, etc.), personnel (leaders, important staff officers, technicians, casualties, etc.) and express cargos (high-cost repair items, medical supplies, etc.). Liaison operations link forward and rearward command staffs, high-priority logistics, and other critical support elements to enhance the command, velocity, and sustainment of operations. The air transport role encompasses the logistical support of air and ground combat forces already deployed into the field. This role does not involve the movement of entire military units, but it can include the maintenance of robust flows of personnel, supplies, replacement vehicles, and other heavy equipment items to and from combat zones. It also includes the aeromedical evacuation mission, which is specialised enough to be seen as a separate role by some air forces. Finally, the air mobility role provides movement and sustainment of complete ground and air combat forces of any size – from small special operations teams to whole combat brigades and small flights of aircraft to whole air wings – and their support echelons.

This categorisation of mobility roles allows national leaders and mobility planners to understand the sub-elements of the airlift mission and the burden that each is likely to place on their military budgets. The modest demands of the liaison mission, for example, allows most nations to cover it with relatively small aircraft, such as Shaanxi Y-8s, Pilatus PC-12s, PZL M28s or helicopters. The increased demands of the air transport role usually call for larger civilian- or perhaps military-type transports. Small airliners might be adequate for supporting peace-keeping forces operating from or near developed airfields, while support of combat operations likely will call for military-type transport aircraft to deliver or recover replacement fighting, logistics, and engineering vehicles, along with heavy artillery and other large items. Finally, the

air mobility role generally calls for substantial military air transport fleets, configured to deliver heavy equipment and many people and supplies over substantial distances and often into austere airfields characterised by short, unpaved runways of limited weight-bearing strength, limited parking areas, and non-existent fuel facilities. Currently, this class of aircraft would include the Airbus C295, Airbus A400M, Shaanxi Y-8, Lockheed C-130J, Embraer 390, Xian Y-20 and Antonov-70.

Threats

Airlift aircraft have always been vulnerable to a wide range of threats, some of them peculiar to the mission. On the ground they are big, hard to hide, and usually constrained to park at specific locations for servicing and cargo operations (Vick 2015). In the air they are giant radar reflectors. They can be seen and heard for miles. In sustained logistics operations, transport aircraft tend to cycle back and forth along predictable routes, at least in their airfield departure and arrival phases. The physical threats to airlift forces include, but are not limited to, precision attacks by aircraft and long-range missiles, en route interception by ground- and sea-launched missiles, electronic attacks on their command and control systems, short-range attacks by weapons ranging from anti-materiel rifles to shoulder-launched missiles, and special operations forces striking aircraft and personnel on the ground.

It is worth noting here that transport and tanker forces usually are acutely sensitive to losses. In the first place, most air forces possess limited numbers of airlift and tanker aircraft, often only handfuls or less of the larger types. Therefore, the loss of even one aircraft can degrade operational capabilities substantially. In the second place, transport aircraft carry important and politically sensitive loads. A plane going down with dozens of soldiers, senior leaders, or even some cargos can influence the military and political balances of some conflicts. For example, a single such loss could drastically increase the count of friendly losses and degrade political support for a low-intensity conflict that otherwise only involved a slow trickle of casualties. Popular support or acquiescence in a country intervening in such a conflict likely will become even more sensitive to the sudden loss of a large number of personnel. Clearly then, military planners must take seriously the intensifying threat environment confronting air mobility forces in almost any foreseeable conflict.

Acquiring mobility forces

Even with the calculus of airlift force structure planning understood, air forces still face the challenging questions of how much capacity to acquire and the sources from which to acquire it. Indeed, the possession of airlift capacity tends to create the need for even more to cover unanticipated requirements, add new mission areas, accelerate operations, bring in reinforcements, reduce risk, and so on. Consequently, the foundational task of obtaining the most airlift capacity in scale and configuration from available funds requires a clear understanding of the sources of airlift forces, their operational relationships to one another and the missions they support.

Sources of airlift forces

Air forces typically acquire their airlift capabilities from a mix of sources. These sources include their own military airlift arms, partnering arrangements with allied air forces, commercial chartering, and partnering with commercial airlines and operators. Each of these sources

presents distinct interactions of cost, usefulness, and reliability that will suit or unsuit it for use by specific air forces. Thus air mobility planners should expect to adjust their force structure plans to the unique strategic and financial circumstances of their countries.

All air forces maintain organic airlift arms. Some, such as those of Slovenia, Belize and Malawi, have airlift as their primary function and possess few or no combat aircraft. Organic transports offer the advantages of usefulness and availability. Military-type designs can perform the whole range of mobility, transport and liaison missions in combat environments, but their initial acquisition and ongoing support costs generally constrain air forces to acquire only the organic capabilities needed to service core missions that must be flown by military airmen.

Many air forces have partnering arrangements that allow them to access the air mobility capacities of other air forces. The Heavy Airlift Wing (HAW) (NATO 2016b), activated in 2008, provides an important contemporary example. The HAW programme allows ten NATO members and two additional countries to 'own' shares of the flying hours of three C-17 aircraft. Thus, even a small state such as Estonia can access C-17 flight-hours proportional to its financial and personnel contribution to the HAW programme (NATO 2016a). From 2009 to 2015 the HAW flew some 18,058 hours (it has a target of 1,000 hours per aircraft per year) to move nearly 76,000 passengers and 54,000 tons of cargo (NATO 2016b). In a complementary programme, the European Air Transport Command (EATC) employs its Air Transport and Air-to-Air Exchange of Services (ATARES) system to supervise the exchange of equivalent (C-130) flying hours (EFHs) between participating nations. In 2015 the programme managed 4,053 EFHs and saved member air forces millions of euros in reduced operating costs, outsourcing of critical missions, disruption of other airlift missions, and personnel and infrastructure expenses (EATC 2016).

It is difficult to identify any fatal drawbacks of these capability-sharing programmes. Engaged in what essentially is a fractional-ownership programme, some HAW participants have now and again been unable to use all of their flying hours, and the programme does carry the risk that aircraft or flight crews might not be available when a participating country needs them. The EATC programme seems to avoid those risks, since participating nations retain full ownership of their airlift resources and are not obliged to make their aircraft available to other users unless they want to do so. Not surprisingly, then, both programmes enjoy broad support and EATC leaders have plans for significant expansion of their airlift and air refuelling capabilities (EATC 2015).

Commercial chartering represents a cost-effective method of obtaining as-needed airlift capabilities for many, perhaps most, air forces. The cost-effectiveness of the programme accrues from the ability of air forces to buy charter airlift services only when they need them and at competitive commercial prices. This is not to say that charter operations are cheap. In late 2016, a typical high-quality charter operator offered 130-passenger Boeing 737s for about $10,000 per flight hour and a 450-passenger Boeing 747 for about $16,000 per hour (Private Fly 2016). These rates must be paid for positioning and de-positioning flight hours as well as those used to carry passengers and cargo. Still, say, for a small air force supporting a peacekeeping force deployed on another continent, chartering a civil aircraft once a month likely will be a less expensive way to maintain the necessary air link than acquiring a large aircraft of its own.

Civil charters do present airlift planners with operational risk concerns. Few charter companies will fly into airfields under a significant threat of attack. Further, if exposed to combat, civilian aircrews pose Geneva Convention protection concerns that military aircrews would not. During heavy fighting in the Central African Republic in 2013, for example, the South African government was unable to charter heavy-lift aircraft to fly reinforcements and armored fighting vehicles to its beleaguered peacekeeping force until well after the fighting was

over (Olivier 2014; Heitman 2013). Additionally, not all operators maintain their charter fleets with equal care, so air forces using these sources should have procedures in place to evaluate them (Wyndam 2012).

Given the costs and uncertainties of commercial chartering, many air forces have programmes in place to facilitate their mobilisation of partner airlines. The US Civil Reserve Airlift Fleet is the largest and most sophisticated airline reserve programme in the world. In return for priority access to US government air charter and individually ticketed passenger business, about twenty US airlines and charter carriers in January 2016 were making 450+ passenger and cargo aircraft available for mobilisation in times of crises or conflict (US Department of Transportation 2016). Aeroflot Russian Airlines has functioned since the early 1930s as an organised reserve for first the Soviet Union and now Russia (Jones 1998). Other approaches included bailment or lease-back arrangements whereby partner airlines operate government-owned or -subsidised aircraft in commercial operations until the aircraft are needed by the military. In still another approach, the Royal Air Force (RAF) entered into a private funding initiative with a commercial operator in 2007 to provide nine Airbus A330 Voyager strategic tanker/transports on an on-demand basis for a period of at least twenty-seven years. To incentivise the commercial provider and reduce costs to the RAF, the company is allowed to charter the aircraft to commercial customers when they are not immediately required by the military. While this £13 billion programme exceeds the needs or at least the resources of most air forces, it does offer a potentially useful way to equip at least parts of their mobility fleets.

Special considerations for the acquisition of airlift capacity

Acquiring airlift forces that are appropriate to their strategic circumstances, budgets, and threat contexts imposes complex choices on air force leaders. Options include acquiring commercial- or military-type aircraft, used or new planes, and larger or smaller transports. To select the best solution, air forces must take into account a number of considerations, including:

- realistic assessments of the types of missions that specific aircraft must perform in terms of load characteristics, range, distance, scale, and threat;
- the ability of other aircraft to conduct some missions better than aircraft under assessment and, thereby, narrow the range of missions they must cover;
- the types of aircraft available;
- the ability of assessed aircraft to perform other missions, such as air refuelling, airborne warning and control, maritime patrol and attack, search and rescue, gunship support, support of special operations, humanitarian relief, wildland firefighting, and intelligence, surveillance, and reconnaissance missions;
- the supportability of specific aircraft over the full terms of their service;
- affordability.

Commercial or military?

Assessing the choice between acquiring commercial- or military-type transports begins with an understanding of their distinctive and very different design philosophies. Commercial transport designs emphasise *profitability* between airports built or altered to accommodate them. Larger, turbofan-powered airliners generally are distinguished by long, tubular hulls, wings mounted through the bottoms of their fuselages, and wings swept back in the vicinity of 37°. In combination, these aerodynamic features maximise the number of passenger seat-miles or

cargo ton-miles these aircraft can produce, even as they also increase their take-off and landing speeds and consequently their runway length requirements. Military-type transport designs, in contrast, emphasise *throughput* at a wider range of locations, including parachute drop zones and austere airfields. These aircraft feature enhanced cargo handling systems, comparatively short and large-diameter fuselages, and wing sweep angles in the range of 0° to 25°. These features allow military designs to land and take off from shorter and rougher runways than those generally useable by commercial jets. The offsets for these advantages are lower cruise speeds and payload/range performance in comparison to commercial designs of equivalent size and engine power.

A class of turboprop-powered airliner designs expands the choice between military and civilian transports. This class includes aircraft ranging from light transports, such as the ten-passenger Cessna 208, to medium-weight commercial designs, such as the eighty-passenger Bombardier Q-series aircraft. All of these aircraft have some capability to operate on shorter and unpaved airstrips, and many aircraft in this class have high-mounted wings that place their fuselages and optional cargo doors closer to the ground for ease of loading and unloading. Still, the small diameters of their fuselages sharply limit their ability to carry military vehicles and weaponry.

New or used?

The choice between acquiring used or new transport aircraft is largely shaped by the relationship of their probable returns on investment in terms of initial and life-cycle operational costs. The purchase cost differential between old and new aircraft can be profound. The fly-away or sticker price of a new Lockheed C-130J, for example, is around $69 million, plus millions more for support equipment, spares, and servicing.[1] In contrast, the Philippine Air Force recently purchased two refurbished KC-130Ts from the United States for $17 million each – a price that included installation of air-to-air refuelling equipment and servicing support for three years (Defense Industry Daily 2016). New/used price differentials for commercial aircraft can be even greater. In 2016, seventy-seat DeHavilland DHC-8-400s less than a quarter of the way through their service lives were selling for $6–12 million, while equivalent Bombardier Q-400s sold for $32+ million new (Controller 2016). But before air forces' leaders are seduced by the lower purchase costs of older aircraft, they must accept that their higher maintenance and operating costs and reduced reliabilities may actually make them the more costly options *per mission accomplished*.

Larger or smaller?

Perhaps the most complex force-structure issue facing air mobility planners is whether to buy larger or smaller transport aircraft, or mixtures of several types. No aircraft type is likely to economically match all possible mission requirements in range, payload, airfield requirements, cabin dimensions, and self-defence systems. As a result, the primary imperative in any airlift aircraft acquisition is to buy aircraft that cover the range of truly critical mission requirements well and less-important missions 'well enough' or perhaps not at all. In practice, the broad range of 'must-do' missions facing most air forces obliges them to acquire several types of transports.

At the time of this writing, the Royal New Zealand Air Force (RNZAF) provides a useful case study in how considerations of range, payload, airfield requirements, and cabin dimensions shape fleet-structure decisions. Though a relatively small air force, the RNZAF has global responsibilities in support of its country's involvement in military, peacekeeping, humanitarian,

and scientific operations throughout the Antarctic, the western Pacific, the Middle East, and elsewhere (New Zealand MOD 2016). Currently, the RNZAF supports these varied missions with two 1990s-vintage, ex-airline Boeing 757 cargo/personnel transports and five half-century-old C-130Hs. Both types are experiencing increasing maintenance costs and reliability problems, including breakdowns while transporting national-level 'very important persons' (VIPs) on diplomatic missions (Davidson 2016). With no combat air units to support (other than missile-armed maritime patrol aircraft) and the New Zealand Army fielding only infantry units, the RNZAF transport arm typically lifts personnel, piece cargo, light vehicles, and sometimes 19-tonne-class New Zealand Light Armoured Vehicles (NZLAVs) and partially disassembled NH-90 helicopters. The RNZAF routinely delivers these loads into the short and weakly paved or unpaved runways typical of small Pacific islands and forward combat zones. Given that the materiel to meet all of these basic lift requirements will fit into a C-130-size aircraft, the RNZAF's assessments of its airlift modernisation options has included a wide range of in-production aircraft (Greener 2015; Burr 2016).

Based on these requirements and the characteristics of the aircraft available, the transport modernisation options before New Zealand are actually quite narrow. Aircraft produced by China and Ukraine, the Xian Y-20 and the Antonov AN-70, offer attractive initial costs, but also present serious drawbacks in terms of long-term sustainability and their linkage to governments pursuing political goals and values repugnant and inimical to those of New Zealand.

The Kawasaki C2 presents several disqualifying features to the RNZAF. In the first place, it is the most expensive available option, with an initial-production flyaway cost of around $170 million per aircraft (Japan Times 2016). Further, while Kawasaki has not made the aircraft's take-off and landing data publicly available, the absence of high-lift devices on its swept wings and the author's own consultation with Kawasaki engineers in October 2015 suggest that it would have limited ability to operate into short and unsurfaced tactical fields.

The Lockheed C-130J (Hercules) has obvious attractions for the RNZAF, given New Zealand's long history with the C-130H. The 'J-model' has a good cruise speed (350 knots), transoceanic range, and legendary ability to operate into short and rough tactical airstrips. Its approximately $69 million flyaway cost also makes it the least expensive modernisation option per unit. Further, the aircraft is a proven air refuelling platform: a potential advantage in light of New Zealand's emerging need for enhanced projection of air mobility, surveillance, rescue, and perhaps even future combat aircraft (New Zealand MOD 2016). A point of concern is that the 'Herc' offers no expansion space to accommodate up-armoured versions of the NZLAV or any larger protected firepower vehicles or equipment items that the army may need in the future.

The Embraer KC-390 has received favourable reviews from several New Zealand defence writers (Bradley 2016; Burr 2016). In general, this aircraft is equivalent to the C-130J in cargo deck dimensions and lift capacity and, thus, also shares that airplane's limited ability to accommodate vehicles larger than the basic NZLAV. Its 470-knot cruise speed is an advantage, particularly in the aerial refueller role. At around $85 million, the KC-390's flyaway costs are moderately higher than those of the KC-130J, while the aircraft tends to be a little more capable than the C-130J in range/payload characteristics for flight from and into developed airports, and moderately less capable when operating into tactical airfields (Embraer Defense Systems 2015; Lockheed Martin 2013).

The Airbus A400M is significantly larger than the C-130J and KC-390 and offers an attractive set of capabilities in relation to New Zealand requirements. With a mid-range cruise speed of 410 knots, transoceanic range, large cargo deck dimensions, and tactical airfield capabilities equivalent to those of the C-130J, the aircraft can support the country's global

engagement operations, deliver Army mechanised forces into austere airfields, and allow significant increases in equipment size and gross cargo capabilities. The aircraft is also a proven air refuelling platform. For perspective on the importance of the A400M's size, the aircraft can carry a 19-ton NZLAV for 3,700 nm, compared to 1,700 nm for the C-130J and 2,100 nm for the KC-390 (Owen 2017; Embraer Defense Systems 2015). A reasonable estimate of the A-400M's flyaway price tag would be around $130 million.

Case study

To underscore the value of this section as a case study in airlift force structuring, it is useful here to propose two simplistic but reasonable outcomes of an assessment of all the considerations and aircraft performance characteristics so far mentioned. Of course, the New Zealand government will make the final choices, but that only reinforces the value of the two optional outcomes proposed here.

Option 1 (minimised technical and institutional risks)

Preserve long-range VIP, passenger, and piece cargo capacity by replacing the current fleet of Boeing 757s with newer, but still used, medium-weight airliners, and replace the current fleet of five C-130Hs with the same number of C-130Js or KC-390s. The C-130 is a proven aircraft representing minimal technology risk, has excellent short-field capabilities, and is fast enough to be a useful refuelling platform. The KC-390 is over a hundred knots faster than the C-130, making it an excellent refuelling aircraft, and offers better range/payload characteristics, but almost certainly will require longer and stronger runways on which to operate. As an estimate, an Option 1 fleet based on two used Boeing 767s ($60 million each) and five C-130Js ($69 million each) would cost about $505 million to acquire, while the Boeing 767/KC-390 ($85 million each) option would cost about $585 million.

Option 2 (median purchase costs offset by reduced long-term sustainment costs)

Preserve long-range VIP, passenger, and piece cargo capacity by replacing the current fleet of Boeing 757s with new aircraft of smaller size, such as business versions of the Boeing 737 or Airbus A320, and replace the current fleet of five C-130Hs with three A400Ms to maintain gross capacity and lower sustained personnel and operating costs. Depending on configuration, the smaller airliners would seat 30 to 80 passengers and have ranges equivalent to those of the Boeing 757. Three A400Ms would actually enhance New Zealand's general lift capacity, particularly over longer ranges. For example, on a 2,500 nm, non-stop route a A400M could deliver a 32-ton load, while a C-130J would deliver 15 tons. A fleet based on new business jets ($80 million each) and three A400s ($130 million each) would cost about $550 million and offer significant offsets in economy of operations, lower maintenance costs, and reduced personnel complements. Given the larger size of the A400Ms, the RNZAF might also consider acquiring one or two smaller tactical transports, such as the Airbus C295W ($34 million each) or Lockheed/Leonardo C-27 ($45 million each) to relieve the larger aircraft from flying with small payloads. This relatively modest investment also would improve the flexibility and 'depth' of RNZAF mobility capabilities, reduce ongoing costs, and stretch out the operational lives of the larger and more expensive aircraft (Owen 2017).

Employing airlift forces

The art and science of employing air mobility forces begin with national and military leaders embracing them as distinct elements of national power. Airlift in particular can be, and historically often has been, the lead operational instrument of national power and engagement for many air forces. In internal and external military engagements, the air movement of even modest forces can signal national intent, stabilise domestic unrest, or prevent the loss of territory and prestige that must be won back later. Airlift also provides opportunities for nations to build domestic and international legitimacy by underpinning government services, rescuing citizens, contributing to peacekeeping and humanitarian relief operations, and a host of other actions. Airlift aircraft also have the capacity to perform additional missions, including special operations, communications relay, maritime reconnaissance, and ISR operations (Chapman 1989).

Air mobility forces are systems of systems that can be no stronger than their weakest parts. An air force that has air transports, but lacks the training and educational process to mature junior personnel into knowledgeable staff officers, trainers, and commanders will always be short sighted and restricted in its opportunities to give its nation the greatest benefit from an expensive investment. Similarly, if they intend to respond effectively to unexpected emergencies or tasks, air forces must develop doctrines and units for laying down expeditionary loading, aircraft servicing, and communications elements. The absence or under-treatment of air mobility in the curricula of staff and war colleges also presents a danger signal, even in air forces with only modest air mobility arms.

Nations can adopt a number of force employment approaches to conduct successful air mobility operations in circumstances of medium and even high threat. General air superiority is a prerequisite for sustained airlift operations along predictable routes. However, in the face of significant, but sporadic threats, air forces can still conduct mobility operations by employing tactics such as deceptive basing, surprise, flexible and unpredictable routing, fighter escorting, flight at night or in poor weather, low-level flying to avoid radar detection, high-level flying to avoid ground fire, minimum-time-on-ground offloading procedures, and many others (Skorupa 1989; Chapman 1989). Indeed, recent studies have proposed reviving dispersed and agile basing as methods to reduce aircraft vulnerability to long-range air and missile attacks while on the ground (Owen 2015). Other conceptual solutions include arming transports with guns, missiles, or energy weapons; equipping them with electronic and infrared detection and jamming systems, and developing a class of radar-stealthy airlift and air refuelling aircraft (Seligman 2016; Vick 2015).

All air forces should consider these tactics and technology concepts objectively to determine their applicability to their individual circumstances. 'Exotic' concepts such as arming transports and designing large-platform stealth aircraft are potential budget-busters for all but the most affluent air forces. Stealth concepts for tactical transports are also problematic, given emerging counter-stealth radar technologies, long-range weaponry, and the 'de-stealthing' effects of the fuselage 'dings' and contamination inherent in operations from unpaved airfields. Smaller air forces also must consider whether such capabilities would be necessary or even helpful in the face of their likely enemies.

The special case of air refuelling

In simplistic terms, air refuelling is another form of airlift, distinguished mainly by the delivery of its cargo in a unique 'terminal' environment – the choreography of tankers and receiver

aircraft in mid-air. Otherwise, many of the airlift planning factors described above with regard to force structuring, acquisition strategies, and operational considerations have parallels, sometimes exact analogues, in the air refuelling mission. Perhaps most notably, the air refuelling force structure problem reflects a divide between wealthy and less wealthy air forces. Wealthy air forces, such as those of the United States, Great Britain, Australia, Japan and so on, tend to equip their core refuelling fleets with new-build, repurposed airliner designs, today most commonly Boeing KC-46s, Airbus A330 Multi Role Tanker Transports (MRTTs), and Ilyushin Il-78s. These large and efficient aircraft maximise the operational range of refuelling operations and allow larger air forces to employ them as orbiting gas stations to maintain more-or-less continual patrols and strike operations by combat and support aircraft. In contrast, poorer air forces tend to acquire very small numbers of hand-me-down airliner-tankers or sometimes new medium-weight tanker-transports, most commonly today Lockheed KC-130Js, Airbus A400Ms and, soon, Embraer KC-390s. As tankers, these aircraft are less efficient than their airliner-derived alternatives. Even so, since most operators view them as out-and-back range-extenders for combat and support aircraft, their reduced fuel loads are less troublesome than they would be for the sustained-refuelling-track operational profiles used by other air forces. Some of these slower aircraft also have the advantage of being able to refuel helicopters, which the airliner-derived types cannot.

Despite their inefficiencies compared to airliner-derived tankers, tactical tanker-transports offer unique and valuable advantages in terms of their capacity and operational resilience in threat environments. Because these aircraft can operate from short and unpaved runways, they can disperse and shift basing locations faster than enemies may be able to detect and attack them. Such agile basing may permit air forces to push tactical tankers into enemy weapons engagement zones, from which they can support combat operations efficiently and survivably. What they lose in aerodynamic efficiency, in other words, they can gain back in terms of positional flexibility (Owen 2015).

Of course the air refuelling and airlift missions differ both operationally and tactically. While air transport forces tend to base rearward to be close to major transportation nodes, tanker units tend to base forward to maximise their operational range and offload capacity. The operational advantages of forward bases are often offset by their typically increased vulnerability to many forms of enemy attack. Also, since tankers normally operate at high altitudes in forward battle areas to give best support to their receivers, they can be acutely vulnerable to attacks by enemy aircraft and long-range surface-to-air missiles.

These air and ground vulnerabilities oblige tanker operators to integrate into the ebb and flow of combat operations continuously and in detail. As vital elements of air battles, they must communicate on the same channels as their supported forces, be ready to adjust their mission plans to accommodate unexpected developments and operational emergencies, and make continual risk assessments in rapidly changing tactical contexts. Put simply, tanker operators, and particularly aircraft commanders, must know when to run for home and when to stand and complete their missions, all the while employing a wide range of tactics and defensive systems to mitigate the resulting risks.

Conclusion

The salient implication of this discussion is that the planning, acquisition, and employment of air mobility forces are complex undertakings requiring a human and materiel system of systems to accomplish. Air force leaders intent on providing their nations with maximum capabilities from available budgets consequently must ensure that they have the institutional pieces in place

to satisfy the requirements and exploit the opportunities presented by air mobility in their strategic contexts. Providing maximal mobility forces is a big task that goes well beyond pragmatic decisions to buy whatever transport aircraft might happen to be on the market at a given time at an affordable cost.

It follows from this examination of the air mobility system of systems that doctrine, vision, and expertise constitute the foundations of any effort to build the best possible forces. In this context, doctrine can be understood as the distilled wisdom of air mobility policy and operations – a body of explanations of how things work and ought to be done to achieve success. As they would in any other important realm of air power, astute air leaders must ensure that their air forces possess published air mobility doctrines relevant to their circumstances, and that the right people read them. From doctrine comes vision: knowing how things likely will work in the future, and planning accordingly. Finally, relevant doctrines and actionable visions only come from the minds of expert personnel who can embrace the full range of global air mobility knowledge and apply it to their particular circumstances.

Thus, at the top of any air force commander's air mobility to-do list must be the creation or refinement of a body of planning and operational experts appropriate to the scale and anticipated tasks of their respective services. Drawing either on their own national resources or on the capabilities of partner air forces and other sources of lift and aerial refuelling capabilities, commanders must ensure that a system of training schools, exercises, staff courses, electronic forums, and personnel policies is in place to develop and retain air mobility leaders and reward them equitably with other service elements for their dedication and potential to assume greater responsibilities in the future. Air forces that successfully establish and nurture such a body of expertise will have good chances of developing optimal air mobility capabilities. Those that do not are unlikely to see their mobility programmes rise much above inefficient and haphazardly equipped taxi services.

Note

1 Aircraft manufacturers as a rule do not share the prices and operating costs of their aircraft publicly. Consequently, all of the price data in this study are based on indirect sources, such as government purchase announcements and informal discussions with manufacturer representatives. They should, therefore, be taken as credible 'ballpark' numbers (±10%) and not as definitive.

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11
COMMAND AND CONTROL

Christopher McInnes

In a matter of days in 1940, the German Luftwaffe seized command of the air over critical parts of France and Belgium from French and British air forces. In 1967, the Israeli Air Force (IAF) effectively destroyed Arab air forces in a single day despite a three-to-one numerical disadvantage in pilots and aircraft. On paper, these struggles ought to have been more prolonged as all sides possessed large numbers of aircraft of comparable quality. But in both cases, one side prevailed decisively because of a command and control (C2) system that enabled it to think and act more coherently and much faster than its opponents. The German and Israeli C2 systems enhanced the potency of the available technology because they suitably blended concepts of air power unity, equivalency with surface forces and responsiveness to changing circumstances. But more important, German and Israeli air power were led by people with the intellectual and interpersonal acuity to exploit the potential offered by technology and ideas. Superior C2 allowed the German and Israeli air arms to defy the odds and deliver decisive victory.

This chapter examines the development of Western operational-level air power C2 into its contemporary form. The quests for unity, equivalency and responsiveness have been central ideas in air power C2, but they have often been competing priorities. Technology has profoundly shaped C2; the rise of precision weapons and advanced communications has shifted air power C2's principal challenge from massing aircraft to massing information. Finally, while ideas and technology mould the efficiency of air power C2, the depth of relationships and the intellect of the people within the system ultimately determine its effectiveness.

An overview of contemporary command and control

German and Israeli air commanders exercised both *command* and *control* of their arms but this rarely happens now. Understanding the difference between *command* – ownership – and *control* – authority to direct activities – is important, as reconciling differences between the two has presented a constant challenge for air power C2. In most contemporary operations, units under different chains of *command* are, by agreement, under the *control* of a single officer for operations in a particular area or task. The popular term 'air component commander' is often inaccurate, as the officer frequently only has *command* of a selection of the air assets under his or her *control*. Most American air component commanders are United States Air Force (USAF) officers who have *command* and *control* of USAF units but only *control* of US Navy (USN) and Marine Corps

(USMC) assets that remain under the *command* of their respective services. Contributions to coalition operations similarly remain under national command, even in well-established alliances such as the North Atlantic Treaty Organization (NATO).

Atop most air power C2 structures is a headquarters comprising a staff and an air operations centre (AOC). The AOC manages the air operations cycle while the staff is responsible for functions outside the cycle, such as logistics and long-term plans. The air operations cycle is a time-based method of synchronising activity across organisations to optimise unity of effort. The cycle typically occurs over seventy-two hours and focuses on generating an air tasking order (ATO) and supporting documents. The ATO directs all air operations over a time period, usually twenty-four hours, and supporting documents provide coordination information such as airspace control instructions. Vital long-term planning occurs outside the air operations cycle and compressed planning occurs inside the cycle, but the seventy-two-hour process is a central feature of air C2.

Success depends upon activity conducted within and beyond the cycle, reinforcing the importance of the separate functions of the AOC and staff. The same personnel often perform staff and AOC roles in smaller forces, but distinguishing between the functions is important as a tendency to focus on the air operations cycle has resulted in an overemphasis on the AOC. Britain's development of expeditionary C2 capabilities in the late 1990s initially assumed 'that a medium-scale air operation could be executed just by the elements of an AOC' but operational experience highlighted that a staff was necessary (Thompson 2004: 76). In 2016, the American air commander in the Middle East felt that his AOC's prominence had resulted in a perception that it and his staff were distinct organisations rather than elements of a single headquarters, creating 'self-induced operational gaps and seams' (Brown and Fournier 2016: 13).

Below the headquarters, the C2 system is distributed geographically and organisationally. Although geography has a limited impact on air operations, it has a defining influence on airbases and on air power's surface partners. Accordingly, a web of people and systems known as the theatre air control system (TACS) ensures the air commander remains abreast of partner activities and enables the execution and management of air operations. Surface-based, airborne, and space-based surveillance, communications, and control assets are distributed geographically to act as the air commander's eyes and ears. Some assets, such as airborne early warning and control aircraft, can exercise control over particular tasks depending upon levels of delegated authority. These control assets are complemented by personnel and structures within partner organisations, such as surface units and headquarters. These organisations include air support operations centres and tactical air control parties that directly coordinate air support to surface operations, as well as liaison elements that focus on enhancing cooperation by providing air power representation and expertise.

The TACS is critical to the provision of responsive air power, as illustrated by the pursuit of Taliban and al-Qaeda targets in Afghanistan's Shah-i-Kot Valley during Operation Anaconda in 2002. Inadequate TACS resources leading up to the operation contributed to poor coordination between air and land forces that hampered the operation. But the superb improvisation of tactical elements of the TACS during the operation ensured that ground forces received vital air support despite 'near-pandemonium … as numerous aircraft of all types literally were forced to dodge one another as well as one another's falling bombs' (Lambeth 2005: 223).

Finally, air operations could not happen without C2 structures that sustain and generate air power. Best summed up by the 'one base, one wing, one boss' slogan, the wing is the lowest command echelon with all the necessary resources – flying units, maintenance and base services – to generate air power on a sustainable basis. A wing that operates the base and its resident units as a coherent whole is an enormous asset. Israel's triumph over numerically superior Arab

air forces in 1967 depended on bases that could rapidly re-provision and relaunch aircraft (Gordon 2010). Similarly, air power's strategic agility hinges upon the capacity of aircraft and support services to rapidly re-base. Wings primarily generate and sustain air forces, but they also conduct detailed planning prior to mission execution and can, if authority is delegated to them, fulfil broader coordination roles.

The pursuit of ideas: unity, equivalency and responsiveness

The single greatest influence on the development of C2 has been the quest to unify air power. In January 1946, Arthur Tedder – the principal architect of unified Allied air power during the Second World War – articulated the reason for the quest.

> Air power in penny packets is worse than useless. It fritters away and achieves nothing. The old fable of the bundle of faggots compared with the individual stick is abundantly true of air power. Its strength lies in unity.
>
> *(Tedder 1946: 61)*

Tedder made these comments after a war during which Allied air power penny packets had led to catastrophes in France in 1940 and the Soviet Union in 1941, and to humiliating setbacks in North Africa in 1942. Following these setbacks, the Allies generally adopted the model pioneered by Tedder in North Africa of having a single airman control air power for a theatre.

However, exceptions remained even during the war and disunity was a recurring pattern in post-war air operations. The nadir was reached in Vietnam, when dizzyingly complicated American C2 arrangements 'compartmentalized our air power and reduced its capabilities' (Momyer 2003: 106). Following Vietnam, reforms in American air power C2 culminated in the reappearance of the single controller model for Desert Storm, the air campaign against Iraq in 1991. Desert Storm has served as the template for Western operations ever since. Tedder's model provides the greatest unity of effort yet achieved, but its appearance, disappearance, and reappearance underscore the challenges to unity.

Initial efforts to unify air power sought unity of command over national air power in the form of independent air forces, starting with Britain's Royal Air Force in 1918. The intention was to realise efficiencies and develop capabilities to conduct air operations independent of surface forces, such as strategic bombing. The second goal was particularly important for C2, as air operations independent of surface forces required C2 capabilities, such as the TACS, that may not have otherwise existed. USN and USMC aircraft flew 75 per cent of the strike sorties during the initial phase of operations in Afghanistan in 2001, but their activities were controlled and enabled by USAF C2 systems (Lambeth 2005). In contrast, British carrier-based air operations during the Falklands War in 1982 were impeded because they relied upon a naval air C2 system that was optimised for local fleet defence but poorly suited for broader operations (Freedman 2010).

Independent air forces command the preponderance of air power but unifying command of national air power has proven impractical, with few exceptions. Consequently, measures to unify air power C2 have been most successful when they sought unity of control without command (Winnefeld and Johnson 1993). This pragmatic approach has succeeded because it enables compromises between command prerogatives – such as discipline, and specialist requirements – and the benefits to be gained through unity of effort. For example, American doctrine states that while USMC aviation's primary mission is to support Marine ground forces, the USMC commander will 'make sorties available' to the joint air controller for specific

missions as a 'distinct contribution to the joint force effort' (US Department of Defense 2014: 11–16). Reconciling the differences between command and control demands constant effort, even during the execution of air operations.

This reconciliation is particularly important to maintain political and operational unity during multinational air operations. National identities and sovereignty, as well as differences in capability, are sensitive issues and must be accommodated. Legal issues present particularly challenging problems. NATO's difficulties in managing targeting during Unified Protector over Libya in 2011 typify the friction that arises when diverse national rules of engagement are poorly managed.

> National 'red cards' often were played, and considerable differences also arose about the rules of engagement across the Alliance. All of these factors added unnecessary frictions during the first month.
>
> *(Goulter 2015: 166)*

Nonetheless, the red card system used during Unified Protector to exercise national veto rights was more flexible than the cumbersome committee system used to authorise individual air strikes during NATO operations in the 1990s (Owen 2010). Good cooperation and relationships mitigate this friction but legal issues present a key C2 challenge during multinational operations.

Air power C2 must also be capable of accommodating national views on the direction of operations, as national contributions are aimed at garnering influence on decisions. A large presence in the American-led AOC during the 2003 invasion of Iraq allowed Britain to shape operations even when British forces were not directly involved (Lambeth 2013). The C2 system must harmonise differing cultures and technical capabilities in a manner that maintains unity. American use of US-only systems for tasking advanced US capabilities, such as stealth aircraft, during NATO's 1999 air campaign against Serbia amplified friction because of 'US aircraft suddenly showing up … when and where they were not expected' (Lambeth 2001: 188). Multinational air operations have become the norm and C2 must demonstrate diplomatic, technical and legal acumen to harmonise diverse contributions into a united effort.

A self-imposed obstacle to unity of effort has been air power leadership's desire to demonstrate independent decisiveness. This led to separate C2 arrangements for tactical and strategic air power. During the Second World War, Anglo-American strategic bomber forces in the Pacific and Europe were frequently not subordinated to local theatre commanders out of fear joint commanders would divert air power. Even Tedder was unable to establish formal unified control of Allied air power in Europe due to opposition from strategic bombing advocates (Day 1998).

The separation between tactical and strategic air power proved a key feature in the American C2 debacle during Vietnam. Air operations over North Vietnam were considered strategic and were controlled from Hawaii while tactical operations over South Vietnam were controlled from Saigon. Meanwhile, the USAF's 7th Air Force commanded all USAF tactical fighters even when they were conducting strategic missions in North Vietnam. The USAF's Strategic Air Command (SAC) in Nebraska retained command of strategic bombers that primarily conducted tactical missions over South Vietnam throughout the war (Momyer 2003). The desire to demonstrate independent decisive effect has been a source of disunity, but Western air campaigns from Desert Storm on have demonstrated that unity and decisiveness are not mutually exclusive.

Air power's quest for equivalency with other forms of military power has shaped C2. Equivalent status was sought to ensure that air-centric objectives, such as air superiority,

received due consideration among surface forces' demands. The American defeat at Kasserine in 1942 was the last Allied setback that could be partly attributed to subordination of air power to land forces. This realisation was apparent in the US Army's declaration in 1943 that 'land power and air power are co-equal and interdependent forces; neither is the auxiliary of the other' (US War Department 1943: 1). The American declaration reinforced Tedder's earlier efforts and enabled a common approach for the rest of the war.

The most equal air–land partnership of the Second World War occurred in Burma. Allied land forces in the area, commanded by William Slim, relied upon air power for fire support, mobility and supply. Limited resources meant the Allied air forces were spread thinly and were less dominant than in other theatres. Close cooperation saw air and land forces adapt to accommodate the other. Slim's army reduced its supply demands and prioritised capturing and reopening airfields so that the air arm could sustain the land operations (Ritchie 2004). Slim's view that the Japanese position at 'Gangaw was taken by the air force and occupied by the Lushai Brigade' (Slim 2009: 264) summed up the partnership's ethos. Although the scope and unity of air power under the senior airman's direct control have varied since that time, the practice of maintaining an airman with equivalent status to the land and sea commanders has persisted.

An enduring challenge for C2 has been reconciling responsiveness with unity and equivalency. The penny packets that drew Tedder's ire represented attempts at optimising air power responsiveness to army requirements. A key part of Tedder's model was a TACS-like system that ensured the single air controller remained abreast of surface force activities and requirements (Smyth 2007). Improving air power's flexibility and responsiveness has remained a high priority in air C2 development but has also clashed with measures taken to bolster unity and ensure equivalency.

A key contemporary issue is the sluggishness of the air operations cycle. In 1990 the USAF chief of staff likened the use of a three-day ATO cycle for air operations to 'hitching a fast jet to a hot air balloon' because it 'forfeits much of the combat edge we know accrues to air power because of its flexibility and speed of response' (cited in Winkler 2006: 1). Even Desert Storm demonstrated that the cycle resulted in, at best, 80 per cent of missions being executed as planned. This number dropped to 60 per cent when ground operations began but even these figures were only achieved through a 'brute force' effort that bore little resemblance to the formal process (ibid.). Measures to further improve responsiveness since Desert Storm, such as accelerated targeting processes, have reduced engagement timelines to minutes but have circumvented rather than reformed the cycle. Air power's responsiveness during Desert Storm's ground war and the subsequent operations testifies to its ability to overcome a sluggish process. But the cycle's central role in air power C2 more than twenty-five years after Desert Storm is lamentable.

Responsiveness has also been degraded at times due to an inflexible approach to equivalency that sought to unify air power at levels that resulted in joint disunity (Missler 2009). Equivalency is contextual. During the Second World War, differences in scale meant that in Europe tactical air forces cooperated with army groups comprising several armies, while in the Pacific air forces were aligned with individual armies. For the wars in Iraq and Afghanistan from 2001, the USAF controlled air power across the entire US Central Command theatre from a single headquarters in Qatar. This arrangement persisted as leadership of operations in Iraq and Afghanistan transitioned to multinational organisations below the level of Central Command. Over time, the reliance on a theatre-level air C2 construct that was not matched to the right level of command became unwieldy, degrading the responsiveness and influence of the air component (Hukill et al. 2012).

The USAF made efforts to improve responsiveness by establishing liaison elements, but these lacked authority and were consequently not granted 'a seat at the table' (Wilsbach and Lyle 2014). In 2010, the USAF established a command in Afghanistan with delegated authorities for air power in that country. Theatre-wide operations continued to be controlled from Qatar but the presence of an empowered officer at the appropriate command level enhanced air–land integration in Afghanistan. Tension between the desire for responsive air power and the pursuit of unity and equivalency reinforces the need for flexible C2 that can adapt to changing circumstances.

The impact of technology: precision weapons and communications

Advanced communications and precision weapons have reshaped C2 by increasing the volume, velocity and value of information in the system. Precision weapons have 'redefined the meaning of mass' because forces can use fewer weapons to strike larger numbers of targets with greater discrimination (Meilinger 1995: 18). These individual precision weapons require more information to guide them to their target than dumb weapons, while attacking individual targets requires more detailed information than striking area targets. The capacity to hold multiple targets at risk simultaneously compounds the demand because information must be generated to support each option. Improvements in communications and the normalisation of precision air power have amplified these effects through higher expectations and greater scrutiny over individual targeting decisions.

Precision air power's redefinition of mass has shifted the paradigm from sorties per target to targets per sortie. This new paradigm, along with increased expectations and greater scrutiny, means air power C2's principal challenge has gone from massing aircraft to massing information.

The technologies that allow air power to unleash a deluge have paradoxically resulted in its frequently delivering a 'drizzle' (Deptula 2015) that underscores the magnitude of this challenge. One of the reasons for the drizzle is because C2 has been clogged by tactical generals. Peter Singer describes a tactical general who 'proudly recounts how he spent "two hours watching footage"… [and] having personally checked the situation, he gave the order to strike [and] even decided what size bomb his pilots should drop on the compound' (Singer 2009: 78).

The tactical general wielding a thousand-mile screwdriver is a reality that can, and must, be managed. American C2 efficiency for the invasion of Iraq in 2003, particularly targeting approval, improved markedly compared to earlier operations in Afghanistan. This was largely due to a new air commander, General Michael Moseley, who built a decision-making framework that accounted for political realities and enabled faster decisions through delegation (Lambeth 2013). When not managed effectively, however, the transaction costs of multiple levels of authority involving themselves in individual targeting decisions reduce the C2 system's flow to a drizzle.

A more pernicious impact of the tactical general phenomenon is the erosion of the division of labour within C2. Senior officers can impose themselves on junior tasks but junior officers cannot substitute for senior personnel (Singer 2009). NATO's air war for Kosovo in 1999 exemplified the problems caused by an eroding division of labour. Senior leaders – military and civilian – substituted individual target approvals for building a coherent strategy (Kometer 2007). This focus on small decisions meant that the larger issues that only senior leaders could resolve, such as the proscription of strikes against Serbia proper, were neglected. Meanwhile, the junior personnel who could have made small decisions more rapidly if given strategic guidance felt so disempowered that they appeared to lose the capacity to coordinate with others.

But it does not have to be this way. During NATO's 2011 operations over Libya, the Danish and Norwegian contributions were particularly useful at critical times because they could 'act rapidly and decisively' (Anrig 2015: 300–301). Danish and Norwegian leaders had delegated authority based on a clear understanding of their national rules of engagement and sovereign interests. These two examples show that the eroding division of labour results from a choice and that reinforcing traditional roles can enhance C2.

Improvements in remote awareness and capacity to intervene in mission execution have enabled the rise of tactical generals. Where once aircraft crews alone had the awareness to find targets and deliver weapons, they may now simply transport weapons that will be guided to a target the crew cannot see by information provided from around the globe. The real-time coordination of diverse actors and inputs necessary for networked execution management has so far only been possible in an AOC. Consequently, the AOC has become highly specialised, with increasing levels of procedural automation, and more focused on execution management (Kometer 2007).

The automation of C2 processes can over-simplify complex choices and make qualitative evaluation of decisions and plans more difficult (ibid.). The emphasis can become one of turning all the traffic lights green rather than understanding the specific circumstances, particularly in time-sensitive situations. Procedural automation can also intensify the lure of execution management by outwardly reducing it to an engineering process, and thus appealing to the cultural bias of air forces for technical solutions. This impact is apparent in the frequent use of quantitative measures, such as the number of hours flown or weapons employed, in assessments of operational effectiveness. Improved communications certainly increase the granularity of information in the C2 system, but in so doing they can reduce clarity. Giving commanders a better view of the trees may mean they cannot see the forest.

Processing masses of information has so far required masses of people, prompting a dramatic increase in C2 personnel. In 2014, more USAF personnel were specifically involved in C2 activities (53,000) than were serving in the British and Australian air forces combined (Welsh 2014). NATO's air operations over Libya in 2011 revealed C2 resource shortfalls in non-US NATO member countries. Even though 'the United States sought to play a non-dominant role … US personnel represented by far the largest contingent of strategists, targeteers, and other directors and managers of the campaign' (Kidwell 2015: 107). British ground forces during the invasion of Iraq in 2003 discovered that their 'handful of air liaison officers … [was] completely inadequate to fulfil a demanding, high tempo, role' (Smyth 2007: 276). American commanders duly allocated a USMC air support element of over sixty personnel. In both cases, some of the world's most advanced militaries relied on American resources to plug holes in C2 systems that could not cope with precision air power's information demands. The C2 resources needed to employ precision weapons, rather than the weapons themselves, would now seem to represent the distinction between first- and second-tier air powers.

Advances in communications have also broadened the span of control for air power C2, yielding substantial benefits. Distributed operations in which remotely piloted aircraft are controlled by crews around the globe, under the direction of an AOC located elsewhere, epitomise flexibility as they operate worldwide without re-basing. Assets based almost everywhere except close to Afghanistan fired the opening salvoes of operations against the Taliban in 2001. Fighters and cruise missiles launched from vessels in the Arabian Sea and bombers from Diego Garcia and Missouri came together to deliver synchronised strikes against targets across Afghanistan (Lambeth 2005).

These operations depended upon networks and space-based assets that must be incorporated into air power C2. Space teams feature prominently in the C2 arrangements for current

operations over Syria and Iraq because of the criticality of satellite communications (Pomerleau 2017b). NATO's limited space C2 resources in 2011 meant that the air campaign was unable to fully exploit available space assets (Owen 2015). The increased span of control enabled by advanced technologies enhances air power C2's flexibility and reach but also adds to the complexity that the C2 system must manage.

Air power C2's exploitation of communications has resulted in a physical separation from partners that has consistently amplified friction. The Second World War air–land partnership in Burma was facilitated by the air and land commanders living in the same quarters. In contrast, the tensions between the air component in Qatar and its partners in Afghanistan since 2001 were exacerbated by physical distance. The eventual USAF commander in Afghanistan noted that 'challenges that sometimes persist for days and weeks in repeated e-mail exchanges can often be resolved in mere minutes by putting the right people in the same room' (Wilsbach and Lyle 2014: 14). Echoing Slim's experience in Burma, he found that 'the people we meet in the dorm, gym, chapel, or dining hall supply the social inroads and information needed to stay abreast of rapidly changing events' (ibid.: 15). Technology shapes and enables new C2 approaches, but C2 remains a social activity by nature, which places a premium on personal links across organisations.

Geographic separation between commanders and subordinates also presents a leadership challenge because it disrupts the nexus of a commander's authorities and responsibilities. Distributed operations create 'power struggles galore' because aircraft can be launched from one location and flown from another while executing a mission over yet another, and 'each commander thinks he's in control' (Singer 2009: 82). One can be reasonably sure that those commanders are less enthusiastic about accepting responsibility for the units.

Problems due to separation between commanders and commanded are not new. In 1973, B-52 crews on Guam effectively chased the SAC commander off the base during a visit that followed substantial B-52 losses over North Vietnam, partly as a result of orders from SAC headquarters that ignored advice from Guam (Clodfelter 2016). Distributed operations also challenge personnel motivations that have traditionally been based on geographic and social proximity to combat, and the intrinsic attractions of flight (Andrews 2011). Advanced communications have made it easier to communicate farther and faster, but this has not yet translated into an ability to establish the deep relationships necessary for optimal C2 performance.

The centrality of people: relationships and credibility

The preceding discussion reinforces that the utility of the best ideas and best technology will be determined by the quality of the people that implement them. Deep command relationships and robust intellects are critical (Kometer 2007). The span of control and physical separation of contemporary C2 makes building relationships more difficult, while the scrutiny and tempo of precision air power make those relationships more important. Michael Moseley's success in having targeting approvals delegated to the air component in 2003 owed much to his efforts to deepen relations with key partners. Moseley's proposal to destroy bridges in western Iraq to reduce the missile threat to Israel was supported by the land component commander over the objections of land component staff because the land commander 'trusted General Moseley's judgement on the issue' (Lambeth 2013: 131). Similarly, British and Australian officers in Moseley's headquarters believed that 'deep mutual trust at all levels, especially deep and strong interpersonal relations at the most senior levels' were crucial to the success of the 2003 air campaign (ibid.: 105).

By contrast, the fundamental C2 challenge during the Kosovo operation in 1999 was that there was 'no relationship – only constraints on actions that could have negative consequences' (Kometer 2007: 84). Consequently, diverging opinions between the joint commander and his senior airman devolved into arguments and the people conducting the air war felt powerless. Deep relations across organisations have always been important, and they are more important than ever as even air-centric operations now involve an array of partners.

Matching technical and tactical excellence with similar strategic perspicacity has presented a consistent challenge for air power. The precision drizzle paradox illustrates the problem: technical and tactical excellence has made air power easy to use, but the creativity and cogency to see it used well have been elusive. Desert Storm is frequently touted as a triumph of technology. However:

> There was nothing whatsoever preordained about the outcome. The Bush administration could have applied a Vietnam-style strategy of gradual escalation instead and easily generated 20,000 or more allied combat fatalities as a result.
>
> *(Lambeth 1997: 79)*

Instead, the Bush administration was convinced by sophisticated concepts masterminded by Buster Glosson and David Deptula, based on John Warden's idea for a decisive air campaign. But Warden's concept typified two of the consistent weaknesses in air power thinking and Glosson and Deptula had to significantly amend Warden's 'naive' starting point (Waters 2010). Firstly, Warden's plan for independently decisive air operations had not accounted for the roles and requirements of ground forces. Secondly, Glosson believed Warden's concept underestimated the duration of the operation, reflecting air power's consistently poor consideration of friction (Watts 1984).

Failures to account for friction and an overemphasis on independent air operations have too often left airmen with few ideas that were convincing in reality – a situation compounded by airmen's traditional reluctance to write ideas down. Air power's technical and tactical excellence has paid dividends in improving C2 efficiency, but enhancing the effectiveness of air campaigns through better thinking has been less successful.

Conclusion

New ideas are already shaping C2's response to fifth-generation air power. More flexible constructs that reduce air power's reliance on a central AOC by allowing authority to be adjusted rapidly appear to be a priority (Hostage and Broadwell 2014). This includes delegating authority to wings or expecting wings to operate autonomously when isolated. Understanding and integrating cyber and electromagnetic operations into air power is also a focus, particularly as these operations are less constrained by geography than air power and introduce new cultural challenges. In 2015, the USAF envisioned bringing air, space and cyber C2 into a multi-domain version of an AOC (US Department of the Air Force 2015), but it has subsequently initiated a comprehensive multi-domain C2 study (Pomerleau 2017a). Air power's adaptation to new domains will be interesting after air power's own struggles for unity and equivalency.

Air power thinkers recognise that future C2's biggest challenge will be fighting for, rather than with, information. This recognition is driven by accelerating technological advances and the proliferation of advanced weapons systems. The volume and velocity of information in C2 systems will continue to grow at an increasing rate. The application of artificial intelligence and automated processing 'to extend human capacity' (Deptula 2014: 10) rather

than simply manage processes will be a defining feature of future C2, as it already is for platforms such as the F-22 and F-35. Automation and distributed decision-making may reverse the ever-greater focus on execution management and free up human capacity for higher-order thinking.

Rapidly advancing technologies and more contested operations will challenge air power C2's premises and habits, and require faster adaptation than seen since Desert Storm. The proliferation of high-technology systems, including to non-state organisations, means Western air power confronts a more contested environment than it has faced since 1991. In particular, the assumption of assured communications at the heart of concepts such as distributed operations is untenable in an environment marked by threats to air, space and cyber assets.

However, within these future C2 systems fashioned by technologies and ideas will be human beings in an environment characterised by friction. Information will be central to future C2, but only because humans interpret information to make decisions. Human adaptation will remain the mechanism by which technologies and concepts designed for one set of purposes are tailored to different challenges. C2 systems' capacity to adapt will depend upon the depth of relationships among individuals and organisations. The system's effectiveness will ultimately rest on the intellect and credibility of personnel who can convincingly advocate realistic solutions to real-world problems. C2 relationships will take on a different character as connectivity grows and geographic separation increases. These relationships will have to be deeper than technology and endure without connectivity.

The tempo and character of multi-domain, distributed operations will present new welfare and morale challenges with which commanders must grapple. The humans at the heart of air power C2 represent the key continuity within a system that will undergo dramatic change over the next few decades.

The Luftwaffe in 1940 and IAF in 1967 prevailed decisively because they could think and act faster and better than their opponents. They demonstrated that C2 can provide a decisive edge in combat when the mix of ideas, technology and people is optimal for the situation. Unity, equivalency and responsiveness have been central, yet often competing, ideas in the development of air power C2. Technology has fundamentally shaped air power C2, including reorienting it from massing aircraft to massing information. However, the ultimate determinant of effective C2 – and thus effective air power – will always be people, their relationships and their intellect.

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12
AIR POWER LOGISTICS

Richard Knighton

The importance of logistics to military operations has been understood for thousands of years. Sun Tzu said that 'the line between order and disorder lies in logistics'. Philip II of Macedon, the father of Alexander the Great and one of the great conquerors of Greek history, transformed the way his army was supported, which reduced its 'logistics tail' and gave him a larger and more mobile army than any of his potential enemies (Engels 1978). The industrial age and the employment of increasingly complex machines have only enhanced the importance of logistics to military operations. Reflecting on the Axis forces' defeat in Europe, Eisenhower said of his experience during the Second World War that 'throughout the struggle it was in his logistic inability to maintain his armies in the field that the enemy's fatal weakness lay' (quoted in British Army Doctrine 1996: 1–2).

As the complexity of military forces has grown, so has the demand on the logistics network. Today, military logistics covers a broad range of disciplines. In NATO doctrine, logistics includes supply and services, maintenance and repair, movement and transportation, infrastructure, medical, and contracting. Despite the increasing complexity of modern military forces, the range of disciplines that logistics now encompasses, and advances in the science of logistics, the fundamental requirement of military logistics to enable and sustain military forces has remained unchanged. Much of the writing and doctrine on logistics draws on experience in the land environment. While the principles that underpin the logistics planning and support of an army also apply to an air force, the very nature of air power and its reliance on aircraft and 'high-tech' equipment for its delivery calls for consideration of important and distinct logistic demands. Commanders must incorporate these requirements in the development of their operational plans if they are to succeed. Specialised advice and understanding from air logistics experts is therefore vital to the success of any air operation.

This chapter briefly sets out the fundamental principles of military logistics, but its main focus is on the specific logistics demands of an air force. The role of air power in the movement and transportation of materiel in support of military operations and the role of industry in delivering air power are both covered elsewhere in this book. The particular logistics demands of delivering air power from a carrier would require a chapter on their own and are therefore not addressed here, although the principles and challenges are largely the same, albeit amplified by operating from the sea. The chapter explains that the special logistics requirements of air power stem principally from the use of aircraft and advanced technology for its delivery. It then

explores in more detail the particular logistics demands of air power, including infrastructure, maintenance and repair, fleet management, and spares. The chapter finishes by considering some of the future challenges and opportunities of logistics support to air forces in the light of changing threats and developments in technology.[1]

The fundamentals of logistics planning

The fundamental objective of logistics is to enable operations by providing the right materiel and services in the right quantities, at the right place, and at the right time. If logistics is not to become a constraint on an operation, then careful planning is required.

At its simplest, logistics planning is based on four key factors, sometimes called the four Ds: *destination*, *distance*, *demand* and *duration*. The destination determines the nature of some of the equipment and support required, perhaps as a consequence of the climate or the geography of the location. The distance and accessibility determine the design of the supply chain and the time it will take to resupply forces. The demand determines what materiel is required and the rate at which it is likely to be consumed. The duration then determines how long an operation is expected to last. By understanding these four factors, planners can build the logistics network that will be needed to support the operation.

As part of the supply chain design, logistics planners need to decide matters such as the location and levels of stockholding, sources of supply (including local purchase), the resupply routes, and the requirement for regular resupply. In designing the logistics network needed for any operation, planners constantly seek to strike the right balance between the size of the stockpile held forward at the point of need and what can be resupplied. Holding a large a stock forward provides assurance of supply during the operation, but it can take time to build up these stocks and lead to delays in the start of operations. Conversely, relying on rapid or regular resupply minimises the deployed footprint and enables greater agility, but it can leave the operation vulnerable to the disruption of the supply chain.

These four basic considerations form the basis of logistics planning in any environment. For air operations, the commanders will build their plan around the effects they want to achieve and the air power capabilities available. Very quickly this high-level planning must be translated into specific guidance covering the intelligence, surveillance, and reconnaissance requirements, the targets to be attacked, the distance from operating bases, the necessary sortie rate, weapon requirements, and the number of aircraft needed to meet the objectives. Understanding these details will allow logistics planners to calculate the materiel requirements and start to build the logistics network needed to support the operation.

In an ideal world, the logistics support model would be perfectly matched to the operational demand and there would be no risk to operational output. Designing a logistics support model that gives this degree of assurance is unlikely to be cost effective and may not even be practical. Commanders and logistics planners must therefore work to find the right balance between an acceptable level of operational risk and the cost of establishing the logistics network to support the operation. Making these judgements requires operational and logistics planners to understand the operational demands and the associated logistics requirements.

Key characteristics of air power

This requirement to have logistics expertise as part of the operational planning process is particularly important for air operations. Several characteristics of air power generate specialised logistics demands, which in turn shape how logistics support for air operations is provided.

Understanding these demands is vital. Ineffective air logistics support can have a significant effect on the operational tempo and ability to sustain air operations. Rommel's Afrika Korps found this out to their cost in North Africa in 1941, when even before offensive operations started, aircraft serviceability was down to 66 per cent and at times the Luftwaffe was limited to only one hundred sorties a day, which fundamentally undermined Rommel's ability to prosecute the German doctrine of blitzkrieg (Pavelec 2010).

Perhaps the most important characteristic of air power is its inherent reliance on aircraft for its delivery. Most of the key considerations for air logistics planners stem from this simple fact. It drives obvious requirements for resources such as airbases, fuel, and specialised infrastructure, but it also drives particular logistics requirements because of the technology required to keep aircraft in the air. From the earliest days of powered aviation, when the invention of the internal combustion engine finally provided a means of propulsion to enable sustained flight, the delivery of air power has relied on the application of leading-edge technology. In military aviation the need to out-manoeuvre or defeat an enemy has meant that the bounds of technology have constantly been stretched. At times, particularly during war, this has led to rapid development. The First World War, had a profound effect on the rate of technical innovation during aviation's infancy. Necessity proved the mother of invention in the deadly game of cat-and-mouse as each side sought to gain an advantage over the other in the air and on the ground. Today, the requirement to maintain combat advantage over potential adversaries means that air power still depends on advanced technology.

Operating at the very edge of what technology can deliver carries with it an inherent risk of failure. This risk and vulnerability were obvious in early military aircraft such as the Royal Flying Corps' two-seat biplanes that were sent to Sudan in 1916 to put down the rising of Sultan Ali Dinar, which were 'frail contraptions of fabric and wooden bracing struts, with wires and glue holding the aircraft together' (Roe 2017). This fragility is much less obvious in modern military aircraft, which are much stronger and able to operate at speeds, heights, and 'g' loading unimaginable a hundred years ago. Nonetheless, modern aircraft still rely on high-tech equipment as part of the increasingly complex system that makes up the aircraft. To remain in the air and useful as warplanes, all of the parts of the 'system' that make up the aircraft must be working properly. Keeping these systems 'airworthy' and operational drives important specialised requirements, including the need to carry out scheduled preventative maintenance on aircraft, the need for careful fleet planning, and the need for spare parts to be readily available.

The reliance on advanced technology has always made air power expensive to deliver, but over the last century the relative cost of aircraft has grown considerably. In 1918 the cost of a Sopwith Camel with its 150 horsepower Bentley BR1 9-cylinder engine and guns was around £1,585. The cost of a complete Spitfire in the 1940s was around £10,000. The equivalent cost today of a Sopwith Camel would be around £581,000 and a Spitfire would be around £2.7 million.[2] By comparison, each F-35 Lightning II will cost around £100 million. This dramatic rise in the cost of military combat aircraft over the past century is largely a function of the increasing complexity of the aircraft and systems which are needed to provide a combat advantage against contemporary threats. Alongside improvements in capability and lethality, this increase in cost explains in part the reduction in the number of aircraft operated by modern air forces over the past few decades. The high costs of aircraft and the relatively small numbers of aircraft have important implications for logistics planners, particularly for the provision of spares and the supply chain.

So, in summary, the delivery of air power relies on the application of advanced technology in increasingly complex, expensive, and scarce aircraft. The requirements for airfields and specialised infrastructure are important and obvious logistics demands. Less obvious, but equally

important, are the requirements that stem from the need to keep aircraft airworthy and operationally available. Logistics planners must therefore consider the requirement for scheduled maintenance, fleet management, spares inventory, the supply chain, the logistics information system, and specialised personnel. Each of these factors is examined in more detail in the following sections.

Airfields and infrastructure

Winston Churchill remarked that 'strange as it may seem, the Air Force, except in the air, is the least mobile of all the Services. A squadron can reach its destination in a few hours, but its establishment, depots, fuel, spare parts and workshops take many weeks, and even months, to develop' (Churchill 1940). Providing the infrastructure needed to deliver air power and doing it quickly is a key logistics task. During the Royal Australian Air Force humanitarian operation in the then-East Timor in 1999, for example, the airbase at Dili was critical to the rapid deployment of forces, but the airport infrastructure had been badly damaged. Specialised personnel, systems, and infrastructure had to be deployed to ensure that the airlift into East Timor could be conducted safely.

In the early days of aviation, aircraft operated from airfields which were largely unprepared grass or dirt surfaces with no defined runways. As aircraft weight grew, a requirement emerged for most aircraft to land on and take off from hard runways. Today, while some tactical transport aircraft are still able to operate from semi-prepared landing strips, most aircraft must operate from well-prepared surfaces. The length, width and strength of a runway as well as the location and facilities available, such as fuel, air traffic control, and communications, are all important logistics considerations.

Air-to-air refuelling allows aircraft to operate over vast distances from well-found airbases away from potential enemy threats (such as the attacks on targets in Kosovo mounted by USAF B-2 aircraft flying from the continental United States in 1999). Yet if a commander requires high-tempo operations with long loiter times over targets, then it will almost certainly be necessary to operate aircraft from airfields much closer to the potential targets. Although some air forces retain the ability to construct runways and operating surfaces, the time it takes to build new airfields means that air component commanders are largely constrained in their planning to use airfields that already exist. The location of these airfields and the availability of supplies such as fuel will have a significant effect on the operational plan and the logistics effort required to enable it.

'Austere' airfields, with limited facilities, might be suitable for short-duration deployments, but operations lasting beyond a few days will require specialised fuel and support infrastructure to be put in place. The precise requirements for support infrastructure will depend on the host-nation support available, the climate and the nature of the operation. Aircraft often need to be sheltered from the harshest climates, both to protect them and to allow work to be carried out on them. Component failures, particularly avionics components, are more common in hot or damp conditions. In hot climates sun shelters are needed to protect the aircraft and their systems from direct sunlight. Many nations use commercially available temporary hangars and sun shelters to provide rapidly erected protection where more permanent facilities are not available and when the operation is expected to last for more than a few weeks. The investment in these types of facilities can pay dividends, as coalition air forces found in April 2013 when a freak hailstorm hit Kandahar airbase and caused extensive damage to helicopters and aircraft left out in the open. The damage to UK transport aircraft alone was estimated to be £13 million (Farmer 2015).

Another key driver for specialised infrastructure is the requirement to store air-launched weapons. In May 1965 a huge explosion ripped through the flight line at the USAF airbase Bien Hoa in Vietnam. The demands of round-the-clock operations had led to weapons being stored under the wings of aircraft. When a turbine blade from an aircraft engine let loose and hit the fuse of a 500-pound bomb nearby it set off a chain of explosions that destroyed twenty-six aircraft, killed twenty-seven people, and wounded over a hundred. This infamous incident is often used to highlight the need to store air-launched weapons in specialised facilities away from the flight line. Constructing these facilities can require major ground works to build the blast walls that prevent the sort of chain reaction seen in Bien Hoa. Modern, air-launched weapons have also become increasingly sophisticated with the introduction of precision guidance. These changes bring with them the requirement for facilities to allow the weapons to be assembled and, for some munitions, the need for environmentally controlled storage.

Maintenance and repair

To keep aircraft airworthy, operational, and safe to fly, air forces must perform regular inspections and maintenance. This routine 'preventative' maintenance aims to avoid having components or systems fail unexpectedly. The work carried out as part of preventative maintenance is broad, ranging from regular inspections and lubrication of moving parts right up to replacing major components or carrying out modifications to address flaws in the design.

Preventative maintenance is 'scheduled' to take place at times that should ensure that any faults are detected or components changed before a significant or potentially catastrophic failure occurs. To make planning easier and to ensure that work is carried out efficiently, preventative maintenance activities are grouped together into maintenance events or 'servicings'. This allows the most significant and intrusive maintenance activities to be carried out when the aircraft is already stripped down, minimising the time away from the front line. The timing of these servicings is usually governed by the hours flown, although other factors such as the fatigue life of the aircraft can be important.[3] While it is possible to extend the period between these servicings if operationally essential, the risk of failure and potential loss of the aircraft increases.

If a commander wants a period of relatively maintenance-free flying to ensure the availability of aircraft during an operation, then aircraft must be serviced ahead of the operation. This preparatory work can be significant and can denude the commander of aircraft for training in the period before an operation. Commanders need to consider these requirements as part of their operational planning.

Where an operation is likely to be prolonged, and it is clear that aircraft will have to undergo some form of scheduled maintenance activity during the course of the operation, planners need to build in a requirement to swap out aircraft that must be serviced. This can place a high demand on the overall fleet as well as the engineering and logistics resources, especially when aircraft are flying on long sorties. Typically, aircraft, particularly fast jets, require some form of scheduled maintenance that will keep them on the ground for several days (and potentially much longer) every 150–200 flying hours. A squadron of aircraft that routinely flies six-hour or longer missions several times a week (quite typical for modern fast-jet operations), generates a significant maintenance demand.

Fleet management

Planners need to consider at both the tactical and strategic levels how to manage the fleet of aircraft and its associated maintenance to fulfil the operational demand and training

requirements. At the tactical level, planners must manage the fleet to ensure that enough aircraft are available to meet the immediate demands of the operation. At the strategic or air force level, planners need to consider the overall size of the fleet that will be required to meet the operational demand throughout a fleet's service life.

When aircraft are designed, they are given a 'life' based on design factors and testing of the aircraft structure and components. This design-life represents the known safe limit of aircraft operation. In procuring a modern fleet of aircraft, air forces need to understand the flying hours required to meet training and potential operational demands. In practice, the majority of hours flown on modern aircraft, particularly combat aircraft, are flown in support of crew training. To calculate the size of the fleet needed to meet an air force's requirement, planners need to understand the number of flying hours that must be generated each year (usually based on the crew training requirement), the number of years the air force wants to operate the aircraft, and the flying-hour life of the aircraft.

At any moment in time, some of the fleet of aircraft might be deployed on operations, some involved in training, and some undergoing maintenance or repair. While it might be possible for short periods to deploy almost all of the aircraft in a fleet, this level of activity is not sustainable. Sustaining operations for a prolonged period will require pilots and crews to be rotated through the front line and for aircraft to be serviced. This is why air forces deploy only an element of their fleet of aircraft for operations. The ratio of the total number of aircraft in the fleet to the number of aircraft deployed is sometimes called the 'buy-to-deploy' ratio. The requirement for the buy-to-deploy ratio is often misunderstood, but it is fundamental to efficient force generation and sustainment of a modern air force, and is a vital consideration for engineers and logistics planners.

Spares and inventory

With combat aircraft operating in demanding environments and relying on leading-edge technology, components sometimes fail. Spare parts are therefore essential if aircraft are to remain available to the commander. Getting the inventory or supply chain wrong can be catastrophic. During the unsuccessful Battle of France in 1940, for example, Great Britain sent 452 Hurricane fighters to France. Only 66 returned. Of those that did not return, no fewer than 178 were grounded due to a lack of spares and had to be abandoned or destroyed (Dye 2000).

Planners must consider a wide range of factors when deciding what spare parts are required. The number of aircraft deployed, planned flying rates, types of sorties, and the mission will all affect the rate at which components will fail or have to be replaced. In addition, an understanding of the nature of the operation will provide an indication of the critical systems and components needed to ensure mission success. Taken together, this information will allow planners to make estimates of the likely demand for spares during an operation. When it is coupled with an understanding of the supply chain and forecast resupply times, planners can determine the quantity of spares that must be held forward to support an operation.

Any risk that arises from a lack of spares can be mitigated by building up very large stocks close to where the aircraft will be operating. Lord Trenchard in his pamphlet *The Principles of Air Power in War*, published in May 1945, argued that one of his four principles of air power was:

> To maintain the battle without any interference by the Enemy, which means to enable the Commanders to build up the colossal supplies and reinforcements necessary for the battle, and to be able to maintain them without interruption by the enemy.
>
> *(Trenchard 1945: 6)*

Although simple and effective, building up huge stockpiles has drawbacks, particularly for modern air forces. It takes time to move these stocks from warehouses or home bases and can place a heavy burden on the supply chain and lines of communication. This can deplete the stock of spares available to the aircraft being used to train ahead of the operation at the home base, and can result in delays to the start of operations as the stocks are built up. The cost of generating large stockpiles of spares is also a major drawback: the cost of the spares mirrors the increasing cost of the whole aircraft. Each engine for the F-35A, for example, costs around £10 million. The total cost of the avionics (made up of several subsystems and components) is around £13 million. Some of the 'line replaceable units' that make up the avionics system could be worth up to £1 million each.[4] It is therefore not economically viable in a modern context to build up 'colossal' holdings of these very expensive items.

The high cost of spares and support has driven air forces and aircraft manufacturers to develop leaner and more efficient supply chains. Planning the provision of spares needed to support a fleet of aircraft is a complex and sophisticated science. In general terms, however, if components can be made more reliable and those that do fail can be repaired and returned to the spares pool quickly, the overall requirement for spares in the 'system' and the associated costs can be reduced.

The pressure to realise the benefits of a 'lean' support chain has led many air forces to rely increasingly on industry to repair, maintain, and manage spares. Although these changes have, in many cases, greatly improved efficiency, they have also led to a proliferation of support models. Integrating this plethora of support solutions into a single, often joint, supply chain out to an operational theatre has become an important challenge for modern logistics planners and requires a detailed understanding of the support contracts as well as operational military logistics. The physical and 'virtual' interfaces between contractor and military logistics information systems requires close management and consideration as part of the planning for major operations.

A key requirement of the lean support models now used extensively is an effective 'reverse supply chain'. The need to ensure that faulty or broken parts are moved back to repair facilities is not new. Air Vice-Marshal Dye explains that during the First World War 'unlike traditional military logistic systems, it was not dominated by a one-way flow of consumables, but by scarce, high value items that moved to and from the front line in a constant cycle of replacement, salvage and repair' (Dye 2006). Today, however, the requirement is particularly acute. The support model for the UK's Rivet Joint aircraft, for example, is set up in such a way that items taken from the local pool of spares are only replaced when the faulty item has been received back in the United States. When focused on building up forces for an operation it is easy to neglect the reverse supply chain, but it is a vital part of the logistics support system for air power and must be designed in from the beginning.

The high cost of aircraft spares and the need to track spares carefully in order to maintain airworthiness and safety make an effective logistics information system vital to the delivery of air power. A global view of the location of spares, their life, and modification state enhances efficiency and is an essential requirement of a modern and lean supply chain. The logistics and engineering information systems used to manage maintenance and spares have become 'mission essential' to the delivery of air power. Ensuring their resilience and connectivity is a key task for engineers and logistics planners.

People

The spares to repair aircraft are useless without the specialised and trained personnel necessary to carry out the repairs and maintenance. The need for technically trained specialists to support

aircraft has existed throughout the history of military aviation. At the strategic level, air forces must ensure that they have an assured supply of technically trained people to carry out repairs and maintenance on aircraft. Lord Trenchard foresaw the requirement to generate a pool of skilled aircraft technicians to support the Royal Air Force after the First World War, which prompted him in the 1920s to establish what was, at the time, a truly revolutionary aircraft apprentice training scheme. While today the complexity of many of the aircraft systems has led to much greater involvement of industry in the repair of components, the need for specialised skills to support aircraft operations has not diminished. At a tactical level, engineers and logistics planners have to consider both the size and specialised nature of the demand for people associated with a particular operation. It may be that flying rates and the associated need for maintenance and repairs are much higher on operations than they are in a normal peacetime training environment, which may mean that more manpower is required. There may also be a need for specialised repair teams to carry out specific inspections as well as perform battle-damage repairs on aircraft.

Future challenges

Modern Western air forces have enjoyed significant superiority over their opponents in the conflicts of the past twenty-five years, but this superiority will be increasingly contested in the future by agile and capable enemies. Control of the air and space will remain crucial to operational success, but adversaries will challenge modern air forces, particularly in the electro-magnetic spectrum, by exploiting easily accessible commercial off-the-shelf technology, and by applying offensive cyber capability. As a consequence, aircraft and systems will have to be more survivable and more resilient. These challenges in the operational arena and the way air forces respond to them will have implications for the logistics support needed to deliver air power in the future.

Of particular importance will be the unique demands of supporting low-observable or 'stealth' aircraft. Although the USAF has been operating stealth aircraft for more than a quarter of a century, the introduction into service of the F-35 Lightning II will mark the first time other air forces have had to maintain and support a stealth aircraft. Maintaining the stealthy 'signature' of a low-observable aircraft is critical to the aircraft's survival in combat. Damage to the surface finish of these aircraft can have an adverse effect on this signature. Carrying out repairs to maintain the aircraft signature will require specialised equipment and skills and represents a new complication for engineers and logistics planners to consider (Crawford 2010).

The effectiveness of a stealth aircraft is, however, about more than its radar signature. Sensor fusion and the provision and exploitation of data from all sources are fundamental to achieving the maximum combat potential from the air power at a commander's disposal (Harrigian and Marosko 2016). The importance of access to mission-essential data in particular cannot be overstated. The ability to collect data, move it around the battlefield, and exploit it will be critical to operational success in the future. Maintaining resilient networks and the ability to exploit data will become increasingly important considerations for logistics and operational planners alike. As to the aircraft, they operate as a system of systems and maintaining the system's integrity will be crucial to keeping the aircraft operationally effective. Rapid replacement of components will be essential as will the need to develop leaner and more efficient supply chains to keep costs down. These demands will increase the importance of a highly reliable, rapid, and resilient supply chain. This in turn will place even greater emphasis on the need for reliable and effective logistics information and maintenance management systems.

At the same time as these logistics and maintenance management systems are becoming more important to the delivery of air power, they are also set to become increasingly vulnerable to growing threats from enemy cyber operations. If an enemy were able to gain access to the logistics information system, he might be able to ground a fleet of aircraft without ever firing a shot. The most advanced, sophisticated, and largest of these systems is the F-35's Autonomic Logistics Information System (ALIS). ALIS integrates maintenance and supply chain activities across a network of users. Its security relies not just on Lockheed Martin's own cyber security defences but also on the defences of the other nations and contractors that use ALIS. There have been repeated claims that the system is vulnerable to hacking (Shalal-Esa 2012). In 2012, for example, US Navy 'hackers' apparently successfully broke into ALIS, highlighting a vulnerability that the developer, Lockheed Martin, was then able to address. Protecting systems such as ALIS from cyber-attack and enhancing their resilience will be a key consideration for the delivery of air power in the future.

Some leaders, such as Maj. Gen. Harrigian, have also argued that stealthy, 'fifth-generation' aircraft such as the F-35 Lightning II will have to be able to operate from more austere locations, deploying and re-deploying rapidly (Harrigian and Marosko 2016). This sort of lily-pad basing tactic was used successfully following the Normandy landings in the Second World War to keep combat aircraft close to the front line of ground operations. Harrigian and his colleagues assert that in the future deployment and reaction times will have to be fast so that air forces can exploit windows of opportunity to penetrate integrated air defence systems. This will require aircraft to operate with the minimum amount of support and equipment. Given the logistics support requirements of these modern aircraft, advocates acknowledge that it is unlikely that these operations can be mounted from completely unprepared or austere bases. The need for connectivity and for appropriate aircraft operating surfaces will mean that this type of agile deployment will require prior planning and preparation if it is to work effectively.

Future opportunities

Although the future operating environment will present a number of new or enhanced challenges for logisticians and commanders to address, the future also offers opportunities to simplify and improve the logistics support to air operations. One important trend has been a steady reduction in the number of platform types in operation across the world. As the costs of aircraft development have grown, the economic reality has led to joint development of aircraft by allies, and to air forces increasingly buying 'off-the-shelf' technology. This steady consolidation in the aircraft types operated by potential allies provides an opportunity for allied air forces to pool spares and share specialised equipment and potentially skilled people. Air forces that operate the US-built C-17, for example, buy into the global spares pool managed by Boeing and are able to draw on these spares wherever they are in the world. Similarly, the European A400M programme will see at least seven nations operating the same aircraft type. Although not without risk, pooling and sharing of spares offers the opportunity to reduce an individual nation's spares holdings and provide more rapid access to spares during operations.

Similarly, the trend towards basing military aircraft on a commonly available civilian platform also has advantages for the logistics support of military aircraft. The US P-8 Poseidon and the Australian E-7 Wedgetail, for example, are both based on the Boeing 737. In 2011 Boeing reported that more than 5,000 of its 737 aircraft were still operating around the world (Brown 2011). With a fleet that size, flying millions of hours a year, spares can be accessed all over the world, reducing the need to carry spare parts and the time that aircraft are grounded waiting for spares. Damage to a windscreen on an Australian E-7 Wedgetail deployed to the

Middle East, for example, can be repaired using parts made available through a local contractor and fitted by a combination of Royal Australian Air Force technicians and local, approved, Boeing contractors.

Advances in technology also promise some benefits for the logistics support of air power in the future. The airline industry has pioneered great advances in health monitoring and the science of reliability and maintainability on civilian aircraft. Engine manufacturers such as Rolls Royce and General Electric are able to monitor the performance of engines in flight right across the world. As 'big data' analytical techniques develop, the ability to spot trends and predict failure will continue to improve. Health monitoring is designed into modern military aircraft. The vast quantities of data made available by these health and usage monitoring systems promise to improve reliability and predictability and so reduce the amount of time that aircraft must spend in scheduled maintenance or rectification.

Additive manufacturing – or three-dimensional (3D) printing – has also seen significant advances in the past few years and promises benefits to logistic support in the future. Manufacturing spare parts quickly and at the point of use will reduce the need to deploy and hold spares. This could reduce the reliance on the supply chain and lead to more rapid repair of aircraft. There are reports of 3D-printed components being used on Tornado aircraft, and the US Navy has used 3D printing to produce components for drones operated off ships at sea. For the moment these components have been limited to non-critical and simple items such as switch covers or fuselages for simple drones. Although the complexity and high specification of many of the systems and components fitted to modern combat aircraft make it difficult to imagine that 3D printing will replace the need to hold some spare parts, opportunities to improve logistics support for military aircraft are certain to emerge as the technology develops.

Conclusion

It is difficult to envisage successful military operations of the future without air power playing a central role. The nature of air power and its reliance on aircraft and high-tech equipment to deliver it drive specialised logistics requirements that must be in place if commanders are to make the most of the air power at their disposal. Advances in technology have led to remarkable enhancements in capability, but they have also increased the demand for specialised logistics support. The particular logistical requirements of air power are not always well understood, especially in a joint environment, but recognition of them is essential if commanders are to exploit the inherent flexibility, agility, and responsiveness of air power.

To ensure that the right level of logistics support is in place, it is vital that engineers and logisticians be involved from the earliest stages of planning of an operation. Success stems from considering the logistics demands of air power proactively, not simply reacting to the needs as they arise, or, worse, constraining the operation because of a lack of specialised logistics planning. In the future, changes in the threat faced by air forces and the capability offered by new technology will only increase the importance of effective logistics support to the delivery of air power and reinforce the need for specialised air logistics understanding in operational planning.

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Notes

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2 Making comparisons of costs at different points in history is fraught with difficulties, with the different methods providing significantly different results. The economic cost method uses the gross domestic product of a country as the inflationary index. Given the nature of military aircraft and their use, this represents the most sensible cost comparator index and has been used here.

3 Metal fatigue occurs when metal is put under strain. Aircraft, particularly combat aircraft, suffer from fatigue as a consequence of manoeuvring under 'g' loading. An aircraft's fatigue life is a measure of the amount of strain an aircraft structure can withstand and still be considered safe. The fatigue life is based on design calculation and fatigue testing, usually of a full-size early production aircraft. Fatigue life consumption is complex to calculate, but is typically based on the amount of 'g' pulled by an aircraft during its operation.

4 This is the name given to the major components in the avionics system and would include items such as the radar scanner.

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PART III

Cross-domain integration

Applying air power



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13
AIR–LAND INTEGRATION

Harvey Smyth

Throughout its 100 years of existence, the Royal Air Force (RAF) has maintained what many would describe as an 'on–off relationship' with regard to air–land integration (ALI). In truth, the initial *raison d'être* of air power in the military domain was to provide support to land forces: indeed, within ten years of the Montgolfier brothers' hot air balloon ascent in 1783, the French Revolutionary Army had formed a balloon company for reconnaissance purposes. The use of balloons in this manner paved the way for the military's exploitation of powered flight in the early 1900s, with the First World War providing the original stage upon which ALI would play out its first major act. However, in the beginning many remained sceptical of the utility of air power in support of the army, with General Haig allegedly briefing his officers at the outset of the First World War, 'I hope none of you gentlemen is so foolish as to think that aeroplanes will be usefully employed for reconnaissance … there is only one way for commanders to get intelligence … and that is by the cavalry' (Sykes 1942: 105).

As the First World War progressed into trench stalemate dominated by artillery, the cavalry was rendered virtually obsolete and Army commanders became fundamentally reliant on aircraft (and exploitation of the third dimension) as their key reconnaissance tool, and eventually as a vital attack asset. As technology advanced – specifically wireless communications and aerial photography – even Haig, who developed a strong relationship with the Royal Flying Corps' Commander, Major General Hugh Trenchard, became convinced of the critical relationship between air and land assets (AP3003 2004: 12). This critical relationship remains to this day, albeit it has 'conformed to a waveform of highs and lows' throughout its existence (Cox 2008: 1).

In contemporary doctrine, ALI is defined as 'the orchestration and application of air and land capabilities to create desired joint warfighting effects … in accordance with the commander's intent' (DCDC 2013: 4-3). It encompasses 'all of the processes we use to plan, coordinate, control and de-conflict the activities of the air and land components within a given battlespace' (ibid.).

This chapter begins by briefly reviewing the RAF's 100 years of history of operations with land forces, highlighting the key and enduring tenets of successful ALI, before then focusing on two specific case studies: the first, a study of the First World War and the genesis of ALI; and the second, a contemporary study of ALI during Operation Herrick in Afghanistan, using the author's personal experiences of this operational theatre as both pilot and commander. The

chapter concludes with a look to the future, and highlights the challenges expected for ALI during the RAF's second century, specifically as technological advancements present new and different methods of warfighting in the information age. Given that other chapters of this book concentrate on the four core air power roles: intelligence, surveillance, and reconnaissance (ISR), air mobility, and, most important, control of the air, the discussion that follows focuses primarily on the use of fighter-bomber fixed-wing aircraft as a function of ALI. This in no way should be viewed as denigrating the critical roles performed by other types of aircraft in their support to the land component, especially those from the support helicopter world, which have proved absolutely essential to British land formations throughout the breadth of contemporary campaigns.[1]

100 years of air–land integration in a nutshell

Summarising 100 years of complicated ALI highs and lows is no easy feat. Noting the wave-form observation described above, it is fair to say that historians reflect upon ALI's starting point in the First World War as a successful period, especially towards the end of the war in 'The Hundred Days to Victory' between the Battle of Amiens in August 1918 and the Armistice on 11 November, when 'the quality and extent of Air/Land coordination reached perhaps a peak of efficiency which the RAF would not attain again until the middle of the Second World War' (Jordan 2008: 13). However, this was followed by a loss of ALI focus during the inter-war years, when despite much good cooperation happening as part of colonial air policing, the RAF's doctrinal attention focused on strategic bombing, meaning that at the start of the Second World War ALI relationships and capabilities had atrophied, as exposed during the Battle of France in 1940. This said, by the end of the North Africa campaign only a few years later, ALI had been masterfully re-energised by individuals such as Air Marshal 'Mary' Coningham, and rode the crest of a wave until the end of the Second World War. This occurred despite some testing conditions along the way, specifically regarding the eventual breakdown of personal relationships between Field Marshal Montgomery on the one hand and Air Chief Marshal Tedder and Air Marshal Coningham on the other.

Beyond the Second World War, the Cold War period presents an interesting case study in itself, again highlighting the cyclical flow of good and bad ALI. For example, despite a primary focus on strategic nuclear deterrence, the long-term deployments of RAF units to the Middle East helped develop very positive ALI relationships, while in West Germany solid procedures for air support were formed and practised regularly. As an example, the Harrier Force deployed 'into the field' with its Army counterparts to operate from forested 'hide sites', providing close air support (CAS) across the North German Plain in preparation for the anticipated invasion by the Soviet Third Shock Army. Conversely, when the same RAF Harriers were deployed to the Falklands War as part of Operation Corporate in 1982, operating from Royal Navy aircraft carriers, it was apparent that, due to inter-Service friction, they were not integrated effectively into the joint campaign, and despite very notable CAS missions such as those during the battle for Goose Green, overall ALI and the effective use of fast jets for air support were poor (Pook 2007: 63–70).

As the Cold War finished, and the RAF moved through the 1990s towards a new millennium, the focus for fast jets shifted firmly towards air policing, a contemporary version of that practised in the 1920s, again in the Middle East (specifically over Iraq after Operation Granby in 1991, the first Gulf War), and closer to home during the break-up of Yugoslavia. With this competing focus, and the reduction in size of the RAF and concomitant withdrawal of fast jet squadrons from Germany, once again ALI atrophied, especially regarding the coordination and

provision of fast jets for CAS training. These failings were brought into stark focus during Operation Telic in 2003, the second Gulf War, summarised after the operation by the Air Component Commander, Air Vice-Marshal (AVM) Glenn Torpy, in the following terms: 'There is no doubt that we need to do more air–land integration. I believe there are lots of lessons … out of this particular campaign in terms of the core skill that air–land integration should form for all our fast jet aircraft' (Torpy 2003). He concluded by stating, 'we have forgotten some of the things we were quite good at during the Cold War … we have neglected the exercising of those [air–land operations] over the years' (Torpy 2004).

In 2003, Project Coningham-Keyes (PC-K) was initiated as a tri-Service, two-star-led joint venture, with an aim to address the air–land lessons identified from Operation Telic. PC-K continues to the current day – although it too has waxed and waned – and consists of three separate working groups: Concepts and C2; Battlespace and ISR; and Training and Simulation. The initiative has resulted in many positive steps towards a more robust ALI system, including the creation of a Joint Air Land Organisation (JALO) which resides within the RAF's HQ Number 1 Group (present-day owner of all fast jet and ISR assets) and acts as a central body to develop tri-Service ALI. The JALO also attempts to bring together hitherto stovepiped equipment development programmes to produce interoperable technological solutions for future air support. In parallel to PC-K, it should not be overlooked that from 2003 through to the present day, the RAF has been providing British land formations with near-constant air support in combat operations, honing their mutual ALI skills on a daily basis: on Operation Telic and its various iterations from 2003 to 2010; on Operation Herrick in Afghanistan from 2004 through to 2014; and lastly, once more over the deserts of the Middle East (Iraq and Syria) in support of the ongoing Operation Shader. In this latter operation, RAF fast jets and Remotely Piloted Aircraft Systems (RPAS) currently conduct reconnaissance, pre-planned strike, and CAS missions in support of friendly forces. With fifteen recent years of continuous air–land cooperation under its belt, when one examines the waveform of success/failure in the present day, one can attest that the RAF will enter its second century at the absolute zenith of ALI capability.

Enduring tenets of air–land integration

Despite the ebb and flow of ALI success described above, and aviation's vast technological advances during the last 100 years where we have witnessed a transition from 60 mph flying machines made from a 'flimsy spider-work of wood and linen' (Porter 1921: 8), to fifth-generation capabilities such as the stealthy, multi-role air system of the F-35 Lightning, the key tenets of achieving successful ALI remain constant, and are as relevant today as they were over the trenches of the Somme. Air Chief Marshal Sir Clive Loader, a veteran Harrier CAS pilot and former Commander-in-Chief of HQ Air Command, states there are three key elements to successful ALI: first, joint capability development, which includes both people and equipment; second, joint doctrine and training; and third, inter-component coordination and liaison at every level – simply put, human interaction and relationship building (Loader 2009: 50).

Like all complex relationships, even when working in harmony, stresses and strains will exist. As long as ALI remains a people-orientated venture (which it will for the foreseeable future), the most important tenets of its successful implementation, regardless of exponential advances in technological wonders, are those of human interaction, common understanding, and relationship building: history has proven this time and again.

The genesis of air–land integration: the First World War

The men who brought the Royal Flying Corps (RFC) from an initial deployed force of only four squadrons to the RAF's unexpected strength at the end of the First World War had no safe models to copy and no conventions to follow. Regardless, as early as 1915 the importance and primacy of ALI was understood. Part II, Chapter II of the RFC's Training Manual directs that the 'duties of aeroplanes in war may be sub-divided as follows: reconnaissance; direction and observation of artillery fire; fighting against other aircraft; destruction of enemy materiel and communications; and miscellaneous action against troops on the ground' (RFC 2013: 109–113). It then reiterates that the most important role of the aeroplane in war is reconnaissance: 'a well trained and efficient air service will enable a commander to form his plans with a fuller knowledge … than will be possible to one whose air service is inadequate' (ibid.).

In addition, despite this clear direction for the role of the aeroplane, even at this early stage of air warfare development, the vital requirement for control of the air was recognised: 'every effort must be made to attain superiority in the air as early as possible' (ibid.). The primacy of the requirement for control of the air has endured throughout the era of air warfare and will persist. It is perhaps best summed up by General Montgomery's later statement in the Second World War: 'if we lose the war in the air, we lose the war, and we lose it very quickly' (RAF 2000: 5.II.1).

Development of air command and control (Air C2)

While immature, operational Air C2 of air assets was straightforward at the beginning of the First World War due to the relatively small size of the RFC. However, as commanders realised the importance of air power and the RFC grew in strength, conflicting demands for assets necessitated the development of sensible operational-level Air C2 (Stokesbury 1986: 27–37). The RFC in the field was allocated directly to the Army and a scheme was devised whereby squadrons were arranged into Wings. Wings were then allocated to specific Corps and, in practice, remained with the units they were helping instead of returning at night to the landing place at the RFC headquarters (Raleigh 1922: 410–435). This close cooperation was a lesson relearnt in the Second World War and latterly in contemporary operations such as Operation Telic: it allowed for one-to-one personal interaction between airman and soldier, and encouraged an in-depth understanding of the challenges of ALI. As the RFC expanded, it was further organised into brigades, on the basis of one brigade per army. Brigades consisted of two wings: the 'Corps' Wing, which looked after close reconnaissance for corps and divisions, including artillery observation, contact patrols and photography; and the 'Army' Wing, which came under direct army headquarters control and was responsible for more distant reconnaissance and fighter protection (Mead 1983: 61–79). This rudimentary Air C2 framework remained consistent until the formation of the RAF in 1918 and attempted to meld the premise of centralised control with decentralised execution – a fundamental principle of modern Air C2.

At the tactical level, the most critical shortcoming of Air C2 was the lack of robust communications. During early operations, communications were basic: infantry would fire flares or smoke signals to indicate their position, or lay out panel messages to liaise with aircraft, while aircrew would scribble messages and send them overboard (Hallion 1989: 21–23). The development of the airborne wireless was the solution to these problems. However, the ability to miniaturise equipment was lacking, and in many cases if a pilot wanted to fly with a wireless, weight restrictions meant that the observer had to be substituted for it. Nevertheless,

throughout the First World War there is evidence of successful tactical Air C2, as the Counter-Battery Staff Officer would scramble aircraft located on forward airstrips via wireless and direct them to intended targets by cloth arrows laid on the ground by forward infantry. Moreover, the use of aircraft on contact patrols to locate the position of friendly troops established an interconnect between the operational and tactical levels, thereby allowing commanders to make precise decisions that enabled their forces to stay ahead of the enemy's decision cycle, which remains a fundamental role of contemporary air power (Price 2001).

Development of ISR and CAS

As the First World War became a static conflict of attrition, the elevated eyeball was the most sought-after ISR asset on the battlefield. Marshal of the Royal Air Force Sir John Slessor commented that, 'In the great, grim siege that was the Western Front, the RFC['s] … primary job remained reconnaissance and observation for the guns' (Mead 1983: 61–79). Since at this time none of the armies had yet thought of camouflage against aerial spying, ammunition dumps, artillery batteries, and headquarters positions were easy to spot (Stokesbury 1986: 27–37). As invaluable as the airman's eyes were, it was obvious that aerial cameras were needed and, by the time of the British assault at Neuve Chappelle in March 1915, the RFC had developed a system that enabled pilots to photograph the entire German trench line and produce extremely detailed maps that were subsequently distributed to soldiers before the offensive. These photos were also used to determine strategic targets to be destroyed in conjunction with the attack: an early example of indirect support in the form of air interdiction. At this time, it was recognised that aerial reconnaissance allowed a '$10,000 airplane [to] save a billion dollar army' (Kennett 1991: 33–39). This method of tactical reconnaissance endures today and is currently utilised to great effect in Operation Shader over Iraq and Syria with Tornado aircraft operating the RAPTOR (Reconnaissance Airborne Pod TORnado) reconnaissance pod.

As the Western Front solidified into vast earthworks, ISR tasks changed, morphing towards the attack function. Tactical roles increased dramatically, and foremost among these was artillery spotting. In a typical 'shoot', the aircraft observer would locate the enemy, call for artillery fire, adjust fire through use of a clock-code system, and relay damage assessment (Kennett 1991: 33–39). This basic 'call for fire' procedure was identical in principle to that used by the author while conducting CAS in Iraq's Western Desert during Operation Telic in 2003. A further development was that of the armed contact patrol aircraft, which were tasked to work closely with advancing infantry by attacking targets of opportunity. Such offensive capability quickly garnered traction with the land element, as Squadron Leader (later Air Chief Marshal) Keith Park commented regarding the air support provided for the Battle of the Somme (Third Phase): 'The infantryman was loud in praise of contact patrol machines, and ground strafing aeroplanes …The heavy gunners actually admitted that aerial observation was now very important for counter battery work' (Park 2013: 207).

By the start of 1918, both German and British doctrine called for the mass employment of CAS aircraft conducting attacks in direct support of infantry (Hallion 1989: 21–23). By the close of the war, such air support for an offensive operation was sufficiently important for the attack to be postponed if the planes could not fly. In Haig's 1917 Despatches he stated:

> [Air] co-operation with artillery, photography and reconnaissance has been greatly developed … long distance raiding has taken a prominent place, has become a recognised part of the preparations for infantry attack … low-flying aeroplanes not only maintain

> contact with our advancing infantry, reporting their position and signalling the earliest indications of hostile counterattack, but themselves join in the attack by engaging the enemy's infantry …
>
> *(Haig 1917)*

Despite Haig's aforementioned scepticism with regards to the utility of the flying machine, once he witnessed the true power of what in modern parlance is ALI he became a firm proponent of the RFC; in fact, there are multiple examples of Haig protecting the RFC from interference from other senior Army officers, allowing for unhindered development of tactics and capability. Of utmost importance, he completely trusted his air commanders (in particular Trenchard), believing that air matters were best left in the hands of his senior airman. This atmosphere of trust within Haig's headquarters created an environment which allowed air–land cooperation to flourish (Jordan 2008): a perfect original example of how personal, trusting relationships provide the bedrock of good ALI.

By the end of the First World War, the British Expeditionary Force (BEF) and the RAF had developed a battle-proven, highly effective ALI capability, reaching a pinnacle of achievement during 'The Hundred Days to Victory' in 1918. Many salutary lessons can be drawn from the First World War pertaining to ALI development; however, the most important focuses on the need for constant communication and interaction between the air and land components in order to develop an innate understanding of each other's environments and the associated challenges in each. Associated with this lesson is the understanding of the need for effective command and control of air assets via centralised control and decentralised execution. Tactically, air power's role as a reconnaissance asset proved vital, while use of contact patrols and CAS capabilities provided a decisive strike capability, especially towards the end of the war, when development of close cooperation with the Tank Corps proved invaluable, specifically the role that air power played in neutralising the enemy's potent anti-tank guns. Overriding all of the above, attaining and maintaining control of the air remained a critical enabler, thereby affording air assets the freedom of manoeuvre to provide air support to the land component, whose own freedom of manoeuvre was consequently secured.

The experience of the British by the end of 1918 highlighted that winning wars without robust ALI would henceforth be exceptionally difficult, and, more likely, impossible (Jordan 2008). It is from this realisation that we now fast-forward ninety years to Afghanistan and Operation Herrick, where despite the conflict's being an intense counter-insurgency (COIN) campaign rather than the conventional warfare witnessed during the First World War, the British Army's reliance on air power remained fundamental, and the key tenets of ALI endured.

Contemporary air–land integration: Operation Herrick, Afghanistan

As highlighted at the beginning of this chapter, UK Defence relearnt historical air–land cooperation lessons during Operation Telic in 2003: ALI was most definitely at a low point on the success/failure waveform as the UK entered the second Gulf War. Primarily, the dearth of robust air support C2 networks was a fundamental omission while, as highlighted above by AVM Torpy, the lack of joint air-land training prior to combat, accompanied by outdated and misunderstood doctrine, left British forces poorly placed to conduct synergistic joint operations. Most importantly, many of the personal airman–soldier working relationships previously cultivated during the Cold War had withered on the vine throughout the 1990s.

With the above lessons at the forefront of re-energised ALI thinking towards the end of 2003, and constructive initiatives such as PC-K established, British ALI began in Afghanistan a

year later on a firm foundation. This did not mean, however, that it was plain sailing for ALI throughout the Afghanistan campaign, as exposed by the 'utterly, utterly useless' public comments made by a Parachute Regiment officer in 2006 when referring to British Harrier pilots' inability to positively identify targets while conducting CAS (Quinn 2006). No doubt there was some basis to this criticism, as at that point the Harrier was still equipped with the outdated Thermal Imaging and Laser Designation (TIALD) targeting pod, which was designed for conducting pre-planned precision attacks against static targets, and not for the dynamic CAS attacks against small, moving targets experienced in Helmand Province. This capability shortfall was remedied by the summer of 2007 with the introduction of the much higher fidelity SNIPER targeting pod. However, it highlighted one of ALI's key tenets: the need for constant development of equipment capability to meet the changing operational environment. While the opinion of this single soldier was not mirrored by the broader British Army, including the then-Chief of the General Staff, General Sir Richard Dannatt, who responded by saying the RAF had performed 'exceptionally' and that 'irresponsible comments, based on a snapshot, are regrettable' (Quinn 2006), the damage caused to the ALI relationship because of this isolated episode took some time to repair. Unfortunately, history has proven that when ALI is not going well, especially when it creates complications for the land element, there has been a 'regrettable if entirely human tendency to regress into inter-service tribal warfare' (Cox 2008: 1).

Despite such hiccups, the RAF's fast jet support in 2004–2014 to British land force elements and NATO's International Security Assistance Force (ISAF) COIN campaign in Afghanistan was tremendous. Holding true to Air C2's key principle of centralised control with decentralised execution, the Combined Air and Space Operations Centre situated in Qatar tasked the aircraft daily to deliver air support across the whole Afghanistan theatre for ISAF, not just the British troops located in and around the Helmand Valley. Exploiting air power's most obvious strength (its ability to cover vast distances quickly), it was not uncommon for RAF fast jets to receive tasking that took them the length and breadth of Afghanistan in a single sortie. It was also commonplace for a fast jet to get airborne with a plan to conduct a reconnaissance mission, only to be retasked after take-off to support a desperate 'troops-in-contact' situation elsewhere in the country. Exploiting such ubiquity and responsive flexibility became the foundation of ALI in Afghanistan, augmented by provision of assured air support in the form of ground alert close air support (GCAS), whereby aircraft and crew were pre-positioned on the ground, twenty-four hours per day, ready to be scrambled at a moment's notice to support whatever unforeseen scenario may have developed.

From September 2004 to June 2009 the Harrier Force, based at Kandahar Air Field, conducted near-flawless sustained ALI operations, flying 8,557 sorties and amassing a total of 22,771 flying hours conducting CAS and reconnaissance missions. Following a seamless handover in June 2009, the Tornado GR4 Force (TGRF) then took up the reins, continuing in the same vein until the withdrawal of British combat troops in October 2014. Of particular note, in the last six months of UK combat operations in Afghanistan, Tornados catered for almost 50 per cent of all CAS requests from ISAF, 100 per cent of all Ground Alert CAS taskings, and 100 per cent of all fast jet tactical reconnaissance missions. These final air support sorties provided an essential covering force to British and coalition forces, enabling the successful and safe withdrawal from both Camp Bastion in Helmand and Kandahar Air Field in the south of the country. When the Tornados returned to RAF Marham in late November 2014, the TGRF had completed over five continuous years of ALI operations, flying over 33,500 hours in support of Operation Herrick. While this fast jet element is just one aspect of the breadth of air support provided throughout this tough COIN campaign, with the Air Mobility Force, Force Protection Force, ISTAR (Intelligence, Surveillance, Target Acquisition

& Reconnaissance) Force, and Joint Helicopter Force all playing their own noteworthy and critical roles, it was arguably the jets, and the provision of CAS, that enabled UK soldiers to decisively outmatch the determined enemy they faced. Indeed, as stated by Karl Eikenberry, a former US Army Lieutenant General and US Ambassador to Afghanistan from April 2009 to July 2011:

> without air and space power, 500,000 to 600,000 troops would be needed in Afghanistan to achieve the same effects as the 40,000 … we have there today. Air and space power provides the asymmetric advantage over the Taliban such that no matter where they choose to fight, coalition forces can bring to bear overwhelming firepower in a matter of minutes. *(Dalton 2009)*

Despite the overwhelming firepower on offer, the utilisation of fast jets throughout Afghanistan's COIN campaign was not simply limited to the blunt instrument of weapons employment, or what commonly became known as 'kinetic effect'. Very quickly, both soldiers and airmen intimately understood that COIN warfare is both difficult and delicate, whereby a balance must be struck between fighting and defeating a determined and capable enemy, while concomitantly guarding against the potential for civilian casualties or the destruction of domestic infrastructure; such collateral damage would in many instances sway the local populace in favour of the insurgents, thereby undermining the Joint Force Commander's 'hearts and minds' campaign. Against this backdrop, air support adopted an approach of 'graduated response through tuneable effect' in order to remain relevant and productive within such a demanding campaign. This approach highlighted that while fast jets can provide a battle-winning strategic advantage as Eikenberry stated, they can also very quickly become a strategic vulnerability, especially when one considers that a single bombing attack against a target located in the urban environment (the preferred battle ground of an insurgent) could have the potential to cause multiple civilian casualties.

These facts were widely acknowledged within the RAF (especially within its fast jet forces) and, hence, proportionality, requisite restraint, utmost discrimination, and a constant appreciation of the potential for civilian casualties and/or property damage became the fundamental principles when providing air support in Afghanistan. The question every pilot and Joint Terminal Attack Controller (JTAC) asked before releasing ordnance was not 'could I drop this weapon' (am I within the rules of engagement?) but rather, 'should I drop this weapon?'. This appreciation of the operating environment, latterly referred to as 'courageous restraint', coupled with the intimate understanding of the strengths and weaknesses of fast jets, is a testament to the high levels of ALI achieved during Operation Herrick (Wyatt 2010). During the first five years of the campaign, RAF Harriers flew over 8,500 sorties in support of coalition troops in Afghanistan: considering that each sortie supported at least two different ground patrols, this conservatively accounts for over 17,000 foot patrols and vehicle convoys that received dedicated air support. The vast majority of these missions were tasked as 'armed over-watch', where the pilot used the Harrier's advanced SNIPER targeting pod to provide an immediate surveillance capability for the ground commander in order to build situational awareness of his battlespace in real time. On average, only one in ten missions resulted in ordnance being employed, mostly under self-defence rules of engagement. This statistic does not necessarily indicate that 'heavy ordnance' was employed, but rather that some form of kinetic response had occurred, such as a single CRV-7 rocket fired into open ground as a warning shot. In fact, the need to employ ordnance was negated in many instances by use of a low-altitude show of force, whereby the aircraft would leave the sanctity of being flown at or around 20,000 feet, descend

to 100 feet above the ground, and fly directly overhead the enemy at over 500 nautical miles per hour: on many occasions, such tactics would disorientate and scatter the opposition, or draw enemy fire away from friendly forces, affording the ground commander the opportunity to gain the initiative (Woods 2011).

As shown above, ALI doctrine and tactics were adapted and honed throughout the ten years of RAF fast jet support in Afghanistan. Furthermore, the training that preceded each operational deployment was not only relevant but also appropriately coordinated so that, where possible, Army brigades and RAF fast jet squadrons would conduct mission rehearsal exercises (MRXs) together in the UK before then deploying to Afghanistan for overlapping combat tours. This not only allowed the RAF to rehearse realistic scenarios and practise the very latest air support procedures using replica Afghan villages such as those constructed at Stanta Training Range in Norfolk, but also afforded airmen and soldiers the opportunity to meet face to face, build trust, and establish strong professional relationships and friendships (Fairhurst 2014). The foundation of these relationships continued to be built upon once forces deployed to Afghanistan, with many examples of aircrew visiting the British Task Force Helmand headquarters at Lashkar Gah in Helmand Province, or Army commanders and JTACs being hosted at Kandahar Air Field by the resident RAF fast jet squadron. As proven in previous campaigns, such as North Africa in the early 1940s, close working relationships and airman–soldier friendships are vital elements of strong ALI: air support operations during Operation Herrick were proof that this core tenet remains equally valid in the contemporary environment.

In parallel with the continuous development of ALI doctrine and training, the capability of air support equipment also improved exponentially throughout the Afghanistan campaign. From the fast jet perspective, such improvements concentrated mostly on the introduction of more precise and adaptable sensors and weapons. For example, Harrier and Tornado aircraft were fitted with high-fidelity advanced targeting pods, the SNIPER and LITENING respectively: despite routinely operating three to four miles above the battlefield, the detailed imagery from such pods would allow aircrew to observe such details as a man carrying an assault rifle, or a long-barrelled weapon mounted on the rear of a four-by-four vehicle. Such pods were intended primarily for target designation, using laser energy to designate and subsequently direct laser-guided weapons to their target. However, and perhaps more important for the ground commander, the footage from these pods could be streamed to the JTAC on the ground in real time, and viewed on a 'ruggedised' laptop, effectively affording the same bird's-eye view of the battlefield as that of the pilot. Working in unison with the aircrew, the JTAC could scan ahead for enemy activity, 'look over or around' walls or buildings, monitor potential vulnerable points for evidence of enemy ambushes, or simply build a pattern of life picture for certain areas of the battlefield, specifically those areas of particular interest to the land component. Building such pattern of life awareness helped commanders to develop risk-mitigated plans to aid future missions, ranging from deliberate attacks to routine foot patrolling.

For more dedicated reconnaissance, specifically designed reconnaissance pods, in the form of the Joint Reconnaissance Pod (JRP) on the Harrier or the RAPTOR on Tornado, were carried and utilised to great effect. Both pods were used extensively across the whole of Afghanistan to collect a range of intelligence, such as high-fidelity images of land-nominated targets or images to help inform the Afghanistan government where best to situate polling booths in major towns during each election process. Innovatively, the infrared image capability of the RAPTOR was also used to search for temperature changes on the surface of roads and tracks, and could then provide potential indication of buried enemy improvised explosive devices (IEDs) (Hoyle 2010). Designed well before the Afghanistan campaign, the RAPTOR was never intended for such use; however, its contribution to the counter-IED effort during

Operation Herrick proved extremely useful, again demonstrating why ALI doctrine and tactics must be continually reviewed and updated.

With a view to employment of ordnance, each aircraft possessed the ability to deliver a graduated and tuneable kinetic effect. At the low end of the spectrum, this could begin with a short strafing burst from a Tornado's 27 mm Mauser cannon or a 2.75 inch CRV-7 rocket attack delivered from a Harrier, and range up to a 1,000-pound laser-guided bomb in the form of the Paveway 2.

However, two weapons are of particular note, both of which were developed with tuneable effect in mind: the Dual Mode Seeker Brimstone rocket (DMS-B), and the 500-pound Paveway IV laser or Global Positioning System (GPS)-guided bomb. Both weapons had their first operational firings during Operation Herrick, and became synonymous with the COIN campaign in Afghanistan. The DMS-B is a forward-firing rocket, fitted with a small, yet focused, warhead, which dramatically reduces the shrapnel fallout after attack; this therefore makes it remarkably useful where collateral damage is of concern, particularly in the urban environment. It is guided via laser energy (directed from the aircraft's targeting pod); but in its final stages it can also be guided via its on-board radar seeker. Simply put, it provides fast jet operators with a sniper rifle-like capability, which is equally deadly against static or fast-moving targets (up to 70 mph). The Paveway IV, on the other hand, can be guided either by laser designation or GPS, and provides the heavy punch of a 500-pound bomb when required; due to its in-cockpit programmability, this punch can be tailored to each specific attack scenario. Not only can the fuse be set to an airburst mode, it can also be programmed to delay detonation until after impact, therefore burying the bomb deeply in the ground before it explodes. Furthermore, both the impact angle of the bomb, and its line-of-attack heading can be programmed before release, thereby allowing the aircrew to maximise the weapon's effect against the target, while concurrently minimising the possibility of collateral damage. The development of capabilities such as DMS-B and Paveway IV provided RAF aircrew with arguably one of the best suites of tuneable kinetic effects in Afghanistan, and dramatically enhanced their ability to practise proportionality, restraint, discrimination, and, above all, precision.

In summary, during the ten years of RAF fast jet support to Operation Herrick the UK's understanding of ALI and development of air support capability increased dramatically. Specifically, the RAF focused on all three enduring tenets of successful ALI and improved capability development, doctrine and training, and relationship building. By the end of the operation in 2014, it would be fair to suggest that ALI relationships were as firm and trusted as ever witnessed before throughout the RAF's 100-year history. Moreover, the lessons learnt and capability developed paved the way for a seamless ALI transition from the Afghanistan theatre of operations to Iraq (and more recently Syria), where from August 2014 the RAF has engaged in combat operations under the banner of Operation Shader, the British military intervention against the fundamentalist terror organisation of Daesh (otherwise known as the Islamic State of Iraq and the Levant, or ISIL).

Conclusion

The ALI journey throughout the last 100 years has not always been smooth, as both Army and RAF have sometimes focused in other directions, generally attracted by more immediate operational imperatives. However, if air power history has taught us one thing, it is that the art of ALI can quickly perish, and its failures are subsequently exposed during the challenges of joint warfighting. With this in mind, all airmen and soldiers would be best advised to maintain ALI at a constant state of well-being, specifically regarding its three enduring tenets.

Contemporary operations of the last fifteen years have provided the perfect anvil upon which to forge today's exceptional ALI capability. However, such opportunities may not continue to exist in the future. For example, at present in Operation Shader the RAF finds itself based hundreds of miles from the land operation, providing air support to friendly forces which might themselves be geographically dislocated from the fighting on the ground. Networked communications, advanced sensors, and precision weapons have created this change to ALI doctrine, and while at present the change is proving beneficial, it has separated the soldier and airman from one another; history has proven that such separation often undermines ALI. Moreover, since the end of Operation Herrick in 2014, there has not only been a marked reduction in ALI training in UK, but also a tendency to 'gap' liaison appointments within each other's headquarters; again, history has proven that such disinvestment in training and relationships does not bode well for maintenance of the capability. A similar scenario developed throughout the 1990s, which subsequently left UK Defence lacking in regard to ALI during Operation Telic in 2003.

Looking towards the RAF's second century, and the introduction of new capabilities such as the F-35 Lightning – the UK's first fifth-generation, stealthy, multi-role air system – and the RAF's aspiration to double the size of its RPAS forces as part of the PROTECTOR programme, the RAF will dramatically increase the ALI capability it can provide to the land component. Meanwhile, the networked communications associated with such capabilities will mean that airman and soldier can literally be continents apart while conducting ALI operations. Regardless of such technological advances offered as part of warfighting in the information age, ALI will remain a uniquely human endeavour, where airman and soldier must seek opportunities to form bonds of professional trust and intimately understand each other's environment in order for the sum of their joint warfighting efforts to become greater than its constituent parts. Of the three enduring tenets of strong ALI, human relationship building remains most central: cooperation is 'a slow-growing and delicate plant, requiring time, much goodwill, regular human contact and careful training. It is a mood, not to be conjured into existence by decree at a moment's notice' (Orange 1990: 79). Only a consistently joint approach to ALI, from both the RAF and the Army, will allow General Montgomery's most apt statement to be realised; 'If you can knit up the power of the Army on the land and the power of the air in the sky then nothing will stand against you and you will never lose a battle' (Montgomery 1943).

Note

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14
AIR–SEA INTEGRATION

Travis Hallen

Tension between China and the United States has refocused attention on the importance of the effective integration of air and sea power. China's development of a complex air and sea denial capability in its First Island Chain – a line of islands encompassing the Yellow, East China and South China Seas – challenges the maritime primacy America has enjoyed since the end of the Second World War. The apparent vulnerability of America's Carrier Strike Groups, long the embodiment of American maritime power, has raised questions about the ability of the United States to exert influence in East and Southeast Asia. In response, the United States has invested in improving force integration across multiple domains. The original title for the concept guiding this development, *air–sea battle*, indicates the principal focus of these integration efforts. But the apparent novelty of modern integrated air–sea concepts belies an enduring symbiotic relationship between air and sea power that has existed since the earliest days of military aviation. Indeed, the concepts underpinning the new American joint operations represent a fourth stage in the evolution of integrated air and sea power.

The first stage, *experimentation*, began soon after the Wright brothers' first flight. Blériot's 1909 crossing of the English Channel added a new dimension to British vulnerability, against which, British newspapers asserted, 'Dreadnoughts are useless and sea power no shield against attack' (Biddle 2002). The following year, Eugene Ely launched in a biplane from a stage erected on the bow of the USS *Birmingham*. These events afforded an early glimpse of the threat air power posed to naval forces and the potential contribution of aircraft to sea power. The First World War provided navies with the opportunity to develop and test concepts and capabilities that capitalised on air power's maritime potential. Over the course of that conflict, aircraft demonstrated their utility in submarine hunting, fleet defence, and carrier-based strike: roles that were expanded upon during the Second World War as requirements across the war's maritime theatres drove the continued evolution of air–sea integration and the transition to an *operationalisation* stage. Experience gained in the Atlantic and Pacific laid the foundation for the rise of carriers as the cornerstone of naval power during the Cold War. During this next period of integration, carrier air power established its utility by providing mobile and responsive air power to land commanders; however, integration of sea- and land-based aircraft proved problematic. The solution was the *deconfliction* of joint air operations, the third evolution of integration. As the Cold War drew to a close and lessons were learned from Operation Desert Storm, the 1991 liberation of Kuwait, and applied in the Balkans and the

Middle East, focus shifted to *multi-domain* integration, a fourth stage of evolution that continues to unfold.

Progression through these stages of air–sea integration has been rapid. The pace of evolution has been driven by a blend of operational requirements, technological development, and the pragmatism and creativity of sailors and airmen. This chapter explores this evolutionary process and gives the reader an overview of a century of operational air–sea integration.

Experimentation: First World War

Experiments in maritime air power began before the outbreak of war in August 1914. The first operational example took place in February 1913, when Greek aircraft bombed Turkish warships in the Dardanelles, and by 1914 navies from Sweden to Brazil had formed air services and begun experimenting with air power in support of naval operations. Progress was slow and pre-war naval air power remained rudimentary, focused primarily on the reconnaissance role. But the potential for aircraft to be employed offensively to support the fleet's battle for control of the sea was clearly evident, as was demonstrated by the Royal Navy's (RN's) first air-launched torpedo drop in July 1914. Though these tentative first steps left doubt as to the decisiveness of air power in the maritime domain, they laid the foundation for air power's development as an integral component of the fleet.

Anti-submarine warfare

One of the first maritime air roles to receive attention was anti-submarine warfare (ASW). The military potential of submarines was not fully understood in 1914, but as the war progressed submarines emerged as a formidable threat to sea lines of communication. In response, both the Allied and the Central Powers searched for an airborne counter to the submarine menace.

An Austro-Hungarian Naval Service aircraft would establish the utility of aircraft in the anti-submarine role when it claimed the first submarine kill from the air with the sinking of a British submarine in 1916. Around the same time, investment was being directed into the development of specialised anti-submarine aircraft. In Britain, these efforts led to the delivery of the Blackburn Kangaroo to the Royal Air Force (RAF) in April 1918. The Kangaroo, the ancestor of the modern maritime patrol aircraft, was a purpose-built twin-engine anti-submarine aircraft with an eight-hour endurance and a 920-pound bomb load (Polmar and Whitman 2015). By extending the naval commander's horizon beyond the visual range of the ship, and providing the means to damage and destroy hostile submarines with impunity, these early experiences in airborne anti-submarine operations established air power as an integral component in the battle for control of the sea.

Aircraft carriers

As the ability of air power to observe and attack naval targets improved, navies identified the need to protect themselves from aircraft. This posed a significant challenge early in the war, due primarily to the excessive time taken for seaplanes to be lowered into the water from their carrier, launch, and climb to altitude; the time to launch in response to an airborne threat meant that even lumbering German Zeppelins could out-climb the RN's seaplanes launched to intercept them. The solution was to develop a ship that could launch and recover the type of fighter aircraft being employed successfully over the battlefields of the Western Front. This requirement drove the evolution of the seaplane carrier into the aircraft carrier.

The first step in this process was to equip battleships and cruisers with 'fly-off' platforms over their gun turrets, allowing them to launch fighters such as the Sopwith Camel. On return, the aircraft would ditch near a friendly ship to be recovered and reloaded onto the launching platform. It was from such a modified cruiser that the first successful fleet air defence mission by ship-launched aircraft was conducted when, on 1 June 1918, a Sopwith Camel launched from HMAS *Sydney* shot down a German bomber, demonstrating the utility of ship-based aircraft in the contest for control of the air.

As a mobile airfield from which to launch attacks against targets otherwise too remote to be engaged from land bases, ships used as launch platforms for aircraft now allowed the fleet to extend its power projection capability. On 19 July 1918, HMS *Furious*, the world's first true aircraft carrier able to both launch and recover aircraft onto its deck, demonstrated the utility of this capability with an attack on Zeppelin sheds in Tondern, northern Germany. The Tondern attack was the first carrier-based strike against a land target – a capability that has become a defining feature of air–sea integration.

The practice of air–sea integration evolved rapidly during the First World War. By war's end, ASW, fleet air defence, and maritime surveillance and strike, roles now associated with maritime air power, had all been tested in operations. While imagination was still required to conceive, develop, and refine the concepts and technologies to optimise air–sea operations, indications of the strategic and operational potential of air power in the maritime environment were evident by the Armistice of November 1918.

Despite the apparent early success of experiments in integrating across the air and sea domains, domain-centric biases asserted themselves during the interwar period. Airmen embraced the ideal of air power as a decisive war-winning capability in its own right, and their pursuit of independent air power put many of them at loggerheads with their naval counterparts, impeding the development of air power in the maritime domain. Sailors, on the other hand, embraced air power as an integral component of their battle for control of the sea. Their ability to translate this into technological and conceptual innovation was limited, however, by the interwar battle for military funding, and by their service's continued adherence to a battleship-centric view of maritime power. In America and Japan, sailors enjoyed some success in developing naval aviation, and through insight and perseverance, and aided by a degree of support within their respective navies, they were able to successfully create a naval air power capability that was to be employed to dramatic effect in the Pacific during the Second World War. Unfortunately, this foresight did not extend to Europe, where the lessons of First World War maritime air power were largely ignored.

Operationalisation: Second World War

The maritime battles in the Atlantic, Pacific, and Mediterranean theatres of the Second World War were crucial to the Allies' eventual victory. Accordingly, ensuring effective maritime operations was a strategic imperative. In both major theatres of the war, sailors and airmen adapted to the realities of contemporary operations in the maritime domain and optimised the employment of new capabilities as they arrived in theatre.

The European theatre

British air power's contribution to the fight for control of the sea at the start of the Second World War suffered due to interwar neglect of the maritime domain. During the interwar period, the RAF's intellectual focus instead centred on the debate over the relative merits of

air defence and strategic bombing; little consideration was given to support of naval operations, and maritime air power was given the lowest priority for resources. The implications of this neglect became apparent in Britain's struggle during the first three years of the Battle of the Atlantic.

At the start of the war, RAF Coastal Command's fleet of modern aircraft was limited to a single squadron of Hudson bombers and three squadrons of Sunderland flying boats (Hendrie 2010). This was inadequate, both in terms of quantity and quality of aircraft, to assist the RN to protect the convoys critical to the Allied effort. The situation deteriorated as German access to French and Norwegian ports from 1940 on enabled Germany to deploy U-boats deeper into the Atlantic. The challenge was to close a 700-nautical-mile gap in air coverage over the Atlantic during which convoys were exposed to U-boat wolf packs operating between Iceland and Newfoundland. Closing this gap required a long-range aircraft suitably equipped with sensors and weaponry.

The solution was the B-24 Liberator, whose Davis wing provided it with a unique blend of range, speed, and weapons load. When combined with an ASV (Aircraft-to-Surface Vessel) radar set, the Liberator's performance made it ideal for anti-submarine operations in the Atlantic. The problem was the limited number of aircraft assigned to convoy protection. Despite the clear threat to Britain's maritime lifeline, the dominant air power thinking at the time gave Bomber Command priority over Coastal Command for the assignment of long-range bombers. As a result, of the RAF's sixty-five Liberators in December 1941 only sixteen were assigned to the North Atlantic (O'Connell 2012).

The RN leadership understood the importance of air power in the battle for control of the Atlantic and sought an increase in the allocation of land-based aircraft to support naval operations. Yet, even at the height of the U-boat menace in 1942, the RAF leadership and British prime minister Winston Churchill held firm to the belief that the bomber offensive should receive priority, which Air Chief Marshal Charles Portal, Chief of the Air Staff, justified in February 1942 by asserting:

> Bomber Command could best contribute to the weakening of the U-boat offensive by offensive action against the principal industrial areas of Germany … To divert [the RAF's bombers] to an uneconomical defensive role would be unsound at any time.
>
> *(Dimbleby 2016: 365)*

Churchill endorsed Portal's position in October 1942 when he stated that despite the damage being inflicted by U-boats in the Atlantic 'the bomber offensive should have first place in our effort' (Buckley 2002).

The tide turned in the Battle of the Atlantic in 1943: in 1942, 1006 allied ships were sunk for the loss of only eighty-six U-boats; in 1943, 285 allied ships were lost for 237 U-boats (O'Connell 2012). A major contributor to changing Allied fortunes was the closing of the air gap in March, made possible by an increase in the number of Liberators available to cover the Atlantic convoys. Liberators operated by the US Army Air Forces, Royal Canadian Air Force, and RAF from bases on the US East Coast, Newfoundland, and Iceland ensured convoys had airborne protection throughout their transit. Another factor was the arrival in 1943 of RN and USN escort carriers in the North Atlantic.

Sea-based air power also suffered from British interwar neglect. When the RAF handed control of the Fleet Air Arm (FAA) over to the RN in 1937, British sea-based air power was in an anaemic state, comprising a fleet of antiquated biplanes and obsolescent monoplanes operating from two aircraft carriers, one of which was of First World War vintage, and four

converted warships (Kennedy 2006). As a result, the FAA was inadequate to meet the needs of the RN during the early stages of the war.

The RN rapidly addressed the shortfalls in its carrier air power. An interim solution was the introduction into service in 1941 of converted merchant ships, known as Catapult Armed Merchants (CAMs), which carried a single aircraft. By 1943, CAMs were joined by specifically designed escort carriers able to launch and recover up to twenty-five aircraft. These small, fast carriers sailed with convoys, providing organic air cover in addition to that provided by land-based aircraft. By May 1943, British and American carriers were escorting convoys and sinking U-boats in the North Atlantic.

The Pacific theatre

Unlike in the Atlantic, the Pacific theatre saw the clash of two powers that had invested in developing maritime air power during the interwar period. The Imperial Japanese Navy (IJN), in particular, had focused on integrating its air power capability with its naval forces during the interwar period. When war broke out in the Pacific, the IJN possessed a potent air capability comprising 563 land-based and 332 carrier-based aircraft supporting its surface and submarine forces (Peattie 2001). In late 1941, the IJN would reap the benefits of these efforts and demonstrate the effectiveness of expertly coordinated land-based aircraft operating in support of naval forces.

On 8 December 1941, Force Z, a naval task force comprising HMS *Prince of Wales*, HMS *Repulse* and four destroyers, sailed into the South China Sea to interdict a Japanese convoy approaching the Malay peninsula. Force Z relied on the RAF for air cover, but as the fleets closed Admiral Phillips, Force Z's commander, was advised that air support was unlikely as his force would be out of range. Phillips opted to continue in the belief that Japanese air power did not pose a serious threat. The multi-pronged attack by Japanese aircraft on 10 December highlighted Phillips's folly, and unambiguously established the vulnerability of capital ships to air attack.

Force Z's movements were monitored by Japanese submarines operating in the South China Sea and passed to the land-based Twenty-Second Air Flotilla. The Flotilla's tactics reflected the sophistication of IJN air power. High-altitude bombers diverted the attention of Force Z's anti-aircraft gunners, enabling the torpedo bombers to attack the force. Seven torpedo attacks were conducted against *Prince of Wales* and *Repulse*, sinking both ships for a loss of just four Japanese aircraft. In the reviews that followed, Rear Admiral Lyster, the Fifth Sea Lord and member responsible for naval aviation, succinctly captured the significance of the event: 'the lesson now being driven home to us by bitter experience … is that the dominating factor in naval warfare is no longer the big gun but the air striking force whether shore-based or carrier-borne (Gates and Jones 2016).

Six months later, the Battle of the Coral Sea, the first naval engagement in history to be decided without a single naval gun being fired at the opponent's ships, validated Lyster's assertion. The battle occurred in May 1942 as a Japanese amphibious force, including a light carrier and two fleet carriers, sailed from Rabaul through the Coral Sea en route to invade Port Moresby. On 7 May, US carrier-based aircraft located the Japanese transports and their escorting carrier, *Shoho*, which was sunk by dive bomber and torpedo attacks launched from two American carriers. The decisive engagement occurred the following day as both fleets located the opposing force carriers and simultaneously launched their attack aircraft. On the balance of forces lost, the Battle of the Coral Sea was a tactical victory for the Japanese. Strategically, the Japanese decision to withdraw its invasion force made the battle a victory for

the Allies. Beyond its strategic significance, the Battle of the Coral Sea established the carrier's position as the key to a modern navy's offensive and defensive capability.

One month later, the Battle of Midway would solidify the strategic role of carrier air power. The American success in sinking four IJN carriers reduced the Japanese ability to project power into the Pacific, such that the Battle of Midway was not only a turning point in the war but also the 'closest to a decisive battle' in the Second World War (O'Brien 2015). Beyond the implications for the campaign in the Pacific, the Battles of the Coral Sea and Midway heralded a fundamental shift in the character of sea power. Despite the loss of its carriers, Japan maintained a sizeable surface fleet, including the two largest battleships ever built, *Yamato* and *Musashi*. That these forces proved inadequate in the face of overwhelming American carrier air power reinforced Lyster's message: the big guns of the battleship could no longer compete with maritime air power.

The maritime dimension made the Second World War an ideal testing ground for the concepts and technologies that enabled the integration of air and sea power to achieve decisive operational and strategic effects. The experience gained in air–sea operations laid the foundations for modern maritime operations. Formalising these lessons into a coherent integrated air–sea force, however, would present militaries with a number of challenges in the post-war period.

Deconfliction: Cold War

The arrival of the atomic age partially overshadowed the lessons of integration learned during the Second World War, as naval and land-based air power development focused on the delivery of atomic weapons. This trend was most pronounced in the United States, where both the newly established United States Air Force (USAF) and the USN battled for funding to develop a strategic bombing capability: the USAF in the form of the B-36 Peacemaker, and the USN with the development of the atomic bomber-capable *United States*-class supercarrier. The USN lost and the supercarrier was cancelled: a decision that ultimately benefited naval air power. In assigning the nuclear role to the USAF, the US House Armed Services Committee identified carrier aviation as an important complement to strategic air power, and laid the foundation for the development of American carrier air power. The wars in Korea and Vietnam validated the utility of sea-based air power and highlighted the challenge of integrating carrier aircraft into a land-centric approach to air campaign planning.

Wars in Asia

The Korean War tested the flexibility of Western militaries to respond rapidly to an emerging strategic crisis. When North Korea invaded the South on 25 June 1950, the two Western carriers in the region (USS *Valley Forge* and HMS *Terrible*) were quickly enlisted into the United Nations' response. The mobility offered by these carriers was particularly well suited to the geography of the Korean theatre, and by 2 July both were positioned within striking distance of Pyongyang. The following day, aircraft from both carriers attacked targets in the North. The success of the strikes demonstrated the responsiveness provided by aircraft carriers and the versatility and utility of the air power they generated.

Carriers went on to play a major role in Korea; the carriers involved in the war – seventeen American, four British, and one Australian – generated over 280,000 operational sorties, one-third of the total air effort (Polmar 2008). Moreover, carrier aircraft were employed in the full spectrum of mission roles, ranging from close air support to escort duties for B-29s. They even

conducted 'strategic' missions, such as the torpedo strikes by USN Skyraiders against North Korean dams in April 1951 (ibid.).

The versatility of carriers to support a diverse range of missions complicated the command and control of air power. At issue were organisational barriers between the Air Force and Navy over the control of air power. To achieve a modicum of integration of disparate air assets, in July 1950 General MacArthur, Commander-in-Chief Far East, delegated 'coordination control' of naval air missions to the Commander of Far East Air Forces (FEAF) when the naval missions were flown in conjunction with FEAF assets. Unfortunately, 'coordination control' was too vague a concept to be effective, proving too cumbersome for the commander of the FEAF to execute. Therefore, geographic deconfliction was adopted as the basis for integrating land- and sea-based air power (Crane 2000).

While the employment of carrier aircraft during the Korean War had demonstrated the effectiveness of integrated air and sea power, it had also highlighted the complexities of integrating aircraft from multiple services to deliver joint effects. These issues remained unresolved and reappeared during the Vietnam War. During that conflict, Air Force and Navy air operations were deconflicted by dividing Vietnam into seven geographic areas called 'route packages', with responsibility for operations in each area being assigned to either the Air Force or the Navy. While this deconfliction approach to integration avoided task duplication and eased coordination pressure, the partitioning of the theatre reduced the overall effectiveness of American air power.

The British experience

Cold War carrier development was not limited to the United States: eleven navies acquired aircraft carriers during the Cold War, though the level of capability between them differed significantly. The carrier experience of smaller navies, such as the RN, provides an alternative perspective on the operational integration of air and sea power. With British interests spanning the globe, the carriers' mobility and power projection capabilities made them useful foreign policy tools. Early in the post-war period, RN carriers ranged the globe, supporting British foreign policy in the Korean War, the Suez Crisis, and the blockade of Rhodesia. But by the 1960s, British attitudes to sea-based air power began to change.

In 1966, the British government decided that there was only one role for carrier-based air power, 'the landing, or withdrawal, of troops against sophisticated opposition outside the range of land-based air power' – a role the government could not foresee Britain undertaking without the aid of more powerful, carrier-equipped, allies (Polmar 2008). Instead, the British opted for long-range land-based strike aircraft as their principal power projection capability. Carriers continued in the RN in a more limited role as ASW platforms, whose principal armament was their complement of ASW helicopters and a small number of Harrier fighters to provide fleet air defence. This mix of long-range land-based bombers and an ASW-centric carrier force spearheaded the British response to Argentina's 1982 invasion of the Falkland Islands.

The British were unprepared for the Falklands War, and retaking the Islands without allied support required an innovative approach to integrating diverse capabilities. The eventual British success rested on integrating two capabilities in particular: carrier-based air power operating near the Falkland Islands, and long-range bomber aircraft operating from Ascension Island.

British carriers provided a sustained air power presence in the vicinity of the islands. The RN Sea Harriers and RAF GR.3 Harriers assigned to the RN provided fleet air defence, strikes against land targets, and close air support to troops retaking the islands. Helicopters

provided anti-submarine protection and troop mobility. But the carriers were vulnerable. Defending them against Argentinian air strikes placed heavy demands on the Harriers, limiting their availability for other roles. The solution was to integrate long-range Vulcan bombers into the campaign.

The Vulcans were vital to British success. Five Vulcan missions were flown from Ascension Island against targets designed to support the British fight for local control of the air. The attacks on Port Stanley made the airfield unsuitable for use by the Argentinian Skyhawks and Super Étendards, requiring them to operate at maximum range and thereby reducing their on-station time to attack the British ships. The strikes also highlighted the potential for British attacks against mainland Argentinian bases, leading to the withdrawal of the Argentinian Mirages, and thus alleviating the fleet's air defence problem.

Success in the Falklands rested on the combined effect of carrier air power and long-range Vulcans. Without either capability, Britain could not have hoped to retake the Islands (Freedman 2010). On a small scale, the Falklands campaign hinted at the synergies possible through the integration, not just deconfliction, of sea- and land-based air power.

Land-based anti-submarine warfare

Another success story in the integration of air and sea power during the Cold War was the development and employment of land-based ASW aircraft, commonly referred to as maritime patrol aircraft (MPA). MPA development was driven by the Soviet prioritisation of submarines as a bulwark against Western naval power; by the end of the Cold War the Soviet Navy had 315 submarines in its order of battle, of which 137 were ballistic or cruise missile submarines (Polmar and Whitman 2015). The threat posed by Soviet submarines was twofold: ballistic missile submarines provided a formidable second strike capability, and hunter-killer submarines threatened the West's own missile boats. Balancing this threat gave rise to a cat-and-mouse game played out across the world's oceans in which MPA performed a vital role.

To counter the submarine threat, Western forces developed a layered approach to ASW which integrated ships, submarines, and specialised sea- and land-based aircraft. Like their B-24 predecessors, Cold War-era MPA provided a fleet commander a blend of range, sensors, and weapons load far in excess of that possible from their ship-based counterparts. This made MPA ideally suited to operate in direct support of a force, as 'pouncers' to respond to submarine detections from other sources, or independently surveilling large areas of open ocean. Regardless of how the MPA were employed, their effectiveness rested on their ability to integrate seamlessly with the naval units they supported. In many respects, Cold War MPA operations provided the benchmark for effective air–sea integration.

The MPA example is notable because of the variation in command arrangements that militaries used to manage these aircraft. In some militaries – for example the United States, India, Netherlands, Japan and Korea – the Navy operated MPA, whereas in others – such as the United Kingdom, Australia, Norway and Brazil – air forces operated the aircraft. These organisational arrangements reflect a philosophical difference as to which service should command air power employed in support of naval operations. That these philosophical differences had no significant impact on the effective integration of land-based MPA into naval operations indicates that organisational arrangements are not an insurmountable barrier to integration.

Despite the notable, though not often discussed, success of MPA integration, the organisational issues that beset the Korean and Vietnam wars defined air–sea integration during the Cold War period. Deconfliction was used as a simple mechanism to reduce inter-service rivalry and to minimise mission overlap, but achieved this at the cost of overall effectiveness. Against

non-peer competitors, these costs may be acceptable. In the modern strategic environment, this is unlikely to be the case.

Multi-domain integration: twenty-first century

The carrier-centric approach to air–sea integration reached its zenith in the first two decades after the Cold War. The collapse of the Soviet Union removed any credible threat to Western maritime power, allowing naval forces to focus on support to operations ashore. Commencing with Operation Desert Storm and continuing through operations in the Balkans, Iraq and Afghanistan, carrier air power became an integral component of the air campaign. Indeed, during Operation Enduring Freedom, the US-led war in Afghanistan, 72 per cent of all combat air sorties were flown from the decks of US carriers, an impressive achievement for operations in a land-locked country (Lambeth 2005).

A more subtle, but no less significant, indication of progress in the integration of naval and land-based air power was the appointment of an Admiral as the Deputy Combined Forces Air Component Commander (CFACC) during Operation Enduring Freedom and Operation Iraqi Freedom. The elevation of a naval officer to be second in charge of the air campaign reflects the importance of maritime power in modern air operations and is the culmination of a growing naval presence in the Air and Space Operations Centre (AOC), the primary command and control organ of Western air power. No longer restricted to a small Naval and Amphibious Liaison Element, sailors now fill key roles across AOC divisions. Indeed, following the experience gained in Enduring Freedom and Iraqi Freedom, USN aviators have routinely filled AOC staff positions prior to assuming senior aviation command positions (Lambeth 2008). Initiatives such as these improve mutual understanding and trust, necessary prerequisites to move beyond coordination to truly integrated air and sea power.

One area where naval involvement in the AOC has been very successful is in the employment of sea-based cruise missiles, in particular the Tomahawk Land Attack Missile (TLAM). First used operationally during Desert Storm, TLAMs have become an integral component of US-led air campaigns, with the United States employing over 1,600 TLAMs operationally since 1991 (McCarthy 2017). The strategic utility of TLAMs derives from the ability of TLAM-equipped destroyers, cruisers, and submarines to provide a sustained presence in areas of operational or strategic interest. The rapid response this allows makes them an ideal complement to, and sometimes substitute for, conventional air power. Although operational control of the weapons remains with the naval commander, TLAM employment is coordinated and integrated into the broader air campaign through a targeting process managed by the CFACC on behalf of the Joint Force Commander. The near-seamless integration of sea-based cruise missiles into modern air operations would not be possible without having sailors with TLAM expertise embedded into the AOC targeting process.

Despite the success in integrating carrier air power and TLAMs into the air campaign, gaps in integration remain that must be addressed. The improvements in strike coordination that have been observed since the end of the Cold War have occurred in the absence of a credible air or sea threat. This can no longer be taken for granted. China, Russia, and Iran have adapted to America's power projection capabilities by implementing multi-domain anti-access/area denial (A2/AD) strategies, capable of denying freedom of manoeuvre across all the domains. Long-range land-based and air-launched anti-ship and land attack cruise missiles threaten US carriers and regional forward operating bases. Meanwhile, sophisticated cyber and electronic warfare capabilities undermine the network-centricity that has become the foundation of the Western way of war. Further, a growing ability to deny the use of

space-based assets poses challenges to American intelligence collection as well as to the ability to conduct precision navigation in times of conflict, another cornerstone of modern Western warfare.

One area of particular concern is the integration of sea-based air and missile defence into a theatre air and missile defence capability. Crucial to effective missile defence is the integration of capabilities across multiple domains and forces. *The US Joint Integrated Air and Missile Defence: Vision 2020* captures this requirement succinctly, stating: 'Commanders must understand and embrace every weapon and tool available to them' (US Department of Defense 2013). The mobility and sustained presence of ship-based systems in particular makes them key components of any missile defence system, particularly in a maritime theatre such as the Western Pacific.

Though making effective use of all available tools is easy in theory, the path to fully integrating naval air and missile defence systems into a theatre missile defence capability poses a number of integration challenges that are yet to be resolved, not least of which is balancing the fleet defence role with broader theatre defence requirements. Determining where tasking priority lies for ship-based contributions to theatre missile defence will be one of the defining challenges of air–sea integration in the contested and denied operating environment of the future.

Alert to the challenge that faces its operations in the Western Pacific, the US military has embarked on a new approach to joint operations. In 2009, the USAF and USN began developing the concept of air–sea battle, which aimed to deepen the level of integration of their respective capabilities in maritime theatres, and described a force that is integrated by design. The concept has evolved since 2009. No longer is the answer to the A2/AD challenge seen primarily through an air and sea power lens; rather, the solution to a multi-domain threat is a multi-domain response. In October 2016, air–sea battle was replaced by the more expansive Joint Concept for Access and Maneuver in the Global Commons (JAM-GC), which seeks to integrate capabilities across all domains. The idea of air–sea integration as the basis of maritime power projection has, in effect, been subsumed into a new concept of *multi-domain operations.*

The shift towards a multi-domain focus is apparent in the future concepts being developed by the US military. One such concept is the idea of replacing the AOC with a Multi-Domain Operations Centre (MDOC), which will provide 'Air Force with the ability to plan, conduct, and assess *integrated multi-domain operations*' (US Department of the Air Force 2015). Though the terminology appears progressive, the MDOC concept as described in USAF publications is, in effect, an enhanced AOC that more effectively integrates cyber and space with air operations. In essence, the MDOC will integrate the multiple domains of USAF operations. Improving the integration of air and maritime operations may be an incidental benefit, but is not the stated aim.

The service-centric focus of the MDOC concept reinforces that effective multi-domain integration cannot be achieved through the efforts of a single service. The examples of successful integration that have developed during the Cold War have occurred as the result of cross-service cooperation and the integration of both personnel and capabilities. This cooperation must continue to expand if the benefits of integrating the increasingly sophisticated capabilities of modern air and naval forces are to be realised. Integrating carrier air power and cruise missiles into an air campaign is a relatively simple undertaking when compared with the challenge of effectively integrating cyber, space, and electro-magnetic spectrum operations into a modern campaign. But future success rests on achieving such multi-domain integration. Concepts such as the MDOC are not necessarily the solution to this challenge, but they are a necessary first step. Over time concepts such as these will undoubtedly

evolve and new ones will emerge, and these will lay the foundations for the continued progress of air–sea integration into the future.

Conclusion

The key to the future of air–sea integration lies in developing sailors and airmen who see beyond domain- and service-centric biases, and understand the synergies that can be achieved by combining the unique characteristics of air and sea power. Developing such individuals is not a difficult process. The history of air–sea integration is replete with examples of effective cooperation and integration across service and domain lines. Though there are clearly a number of examples where failures to see the bigger picture have yielded less than ideal results – with British struggles in the Atlantic and the 'coordination control' and 'route package' systems of the Cold War being the most notable examples – overall the operational integration of air and sea power has been a success story. In contrast to the parochialism and service-centricity that characterised interwar Britain and US operations in Asia during the Cold War, the success of MPA development and the integration of sea-based cruise missiles into the modern air campaign demonstrate that organisational dynamics do not present insurmountable obstacles to effective integration. As Western forces continue to develop their next generation of air and sea capabilities, they must ensure these forces are integrated by design. This approach will be a prerequisite for success in the maritime operating environment of the future. Accordingly, the pursuit of concepts such as *Air–Sea Battle* and JAM-GC bodes well for the future of integrated air and sea power as part of a multi-domain force.

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15

AIR–SPECIAL OPERATIONS INTEGRATION

James D. Kiras

The history of air–special operations integration is a long one, with many associated challenges. Indeed, depending on one's definition of what constitutes 'special operations', attempts to integrate them have existed since mankind harnessed powered flight as a means to exploit the third dimension in war.

This chapter surveys the history of air and special operations integration from its genesis during the First World War to the present. It explores the evolution of air and special operations during the Second World War, which featured a range of experiments in different forms of integration. The war in Vietnam saw the development and growth of air and special operations, driven by the nature of the enemy and the scope of the war. Next, the chapter outlines the changes brought on by the Goldwater–Nichols Act and Nunn–Cohen Amendments and examines their organisational impact on integration. The chapter then switches from a chronological narrative to a thematic one to evaluate the honing and refining of air and special operations since 2001. It concludes with a brief summary of the future implications of the current model of air and special operations integration.

A chapter on the integration of air and special operations must necessarily begin with definitions of two core terms. For the purpose of this discussion, special operations:

> are built on individuals and small units who apply special skills with adaptability, improvisation, and innovation. Special operations normally require precise tactical-level planning, detailed intelligence, and knowledge of the cultures and languages of the operational areas. Rigorous training and mission rehearsals are integral to the success of most special operations. Special operations conducted by small SOF units, with unique capabilities and self-sufficiency (for short periods of time), provide the USG with a wide array of military options.
>
> *(Joint Staff 2001: I-2)*

By contrast, no doctrinal definition of integration exists. An initial challenge is defining the scope and scale of integration. At its most basic level, integration consists of combining two elements into a whole. Often other meanings associated with the term confuse matters; two in particular are relevant here. The first connotation is military and suggests enhanced efficiency to achieve economy of force, or being able to achieve more with existing resources but often with less or

fewer. The second connotation is more elusive and ambitious: to achieve greater effectiveness by fusing together elements in a partnership. Such a partnership will reach synergy – the ability of both elements to leverage their unique strengths while at the same time offsetting each other's limitations or vulnerabilities. The two definitions are not mutually exclusive, but the former tends to be more readily observable and mistaken for the latter. While the history of air and special operations integration is a rich one, comprising experiences of several nations, the exploration here focuses primarily on the US experience for two reasons: access to far more source material, and the emulation of its organisation, doctrine and operations by a number of countries.

Genesis: the First World War

Initial attempts to link the special operators of their day – secret agents and saboteurs – with aircraft met with mixed results. The British conducted experiments and operations that delivered personnel to their destinations using modified aerostats, which proved too slow and cumbersome. To overcome the associated problems individuals within services either experimented with or were ordered to explore the possibility of using aircraft instead. The first documented dropping of an agent, by the French, occurred in November 1914 and over the next ten months the French conducted twenty-seven more successful landings (Maclaren 1998). Following the French lead, the British soon delivered agents and saboteurs of their own, with their first drop taking place on 28 September 1915. One of the most successful special mission pilots was Lieutenant (later Group Captain) J. W. Woodhouse of No. 4 Squadron, who not only delivered agents and flew resupply missions but was selected to form and command the first specific unit for 'special duties' in 1916: the 9th Wing Special Duty Flight, which had the capability to deliver agents by parachute (Woodhouse 1971).

Delivering agents was a relatively simple matter compared to recovering or sustaining them. Given the difficulties in coordinating information and actions among the GHQ, Secret Intelligence Service (SIS) Intelligence section, flying squadrons and agents, few if any plans were made to recover agents from behind enemy lines using aircraft. In addition, the RFC response to requests for support to drop or recover agents was lukewarm at best, particularly when they involved distances longer than fifteen miles behind enemy lines and in dubious weather and moonlight conditions (Andrew 1986). Nevertheless, by war's end agents had been delivered in almost every theatre of war, including the Western and Eastern fronts, Salonika, Palestine and Egypt and the Italian–Austrian Front.

The collaboration between aircraft and secret agents remained rudimentary throughout the First World War largely because of the embryonic stage of aircraft and of the methods to coordinate technically and technologically between aircraft and agents. Nevertheless the First World War established a pattern still discernible to this day: the preferred aerial means of supporting special operations through integration was through the creation and use of special operations aviation units.

Evolution: the Second World War

The integration of air and special operations made a number of strides during the Second World War for three reasons. The first reason was the quantum leap in aircraft design, construction material and processes, and engine power. The second and third reasons for the integration of air and special operations were intertwined. The Second World War saw the development of modern special operations forces (SOF). Modern SOF possess a number of qualities and characteristics that differentiate them from 'elite' forces. These characteristics

include the formation and special designation of standing units, as opposed to ad hoc ones disbanded after a mission is completed; a selection process designed to screen candidates and pick those with physical and psychological qualities necessary for special operations work, including unorthodox problem solving; a training regimen that focuses, in particular, on honing particular combat skills and enhancing self-reliance and team building; and, technologically advanced equipment that is highly modified or non-standard issue in the conventional force for its time. SOF, while highly trained and unique, often require direct support to succeed given their relatively small size, highly risky missions and need to tackle challenging problems in compressed or extended time frames.

The largest strides in integration during the war by Great Britain and the United States resulted from strategic necessity. Beginning the war on the strategic defensive, the leaders of both countries turned to special operations as a way to bolster the morale of populations in Nazi-occupied Europe and as a method of taking the offensive while preserving strength for the main efforts: the invasion of Germany and Japan and the liberation of occupied countries.

For Allied SOF, aircraft were first and foremost a means of delivery into occupied Europe and later Asia. Most conventional air commanders, including Arthur 'Bomber' Harris, were loath to divert aircraft for delivery or resupply and dilute the strength of raiding strategic bomber forces. In consequence, commanders grudgingly allowed the formation of specialised aviation units to support the unique requirements of SOF. The dangers associated with delivering agents at night were substantial. The two special duties flight squadrons suffered between them the loss of 163 small, medium and large aircraft in a forty-four-month period through accidents, mechanical failure, or enemy action (Clark 1999). Comparable American special aviation missions, flown by the 801st Bomb Group (P)/492nd Bomb Group (Heavy), better known as the 'Carpetbaggers', flew 3,000 sorties and delivered 556 special operators at a cost of twenty-six aircraft and 208 aircrew.

Beyond providing a means of transportation and resupply, aircraft were used for other missions that continue to this day. Special operations forces proved valuable identifying or tracking targets in the field that had otherwise escaped detection from the air by conventional air forces. Great strides were made throughout the war to provide airstrikes in a timely and accurate fashion in response to urgent or developing situations identified by special operators or resistance forces. Improvements in methods of radio communication, combined with the streamlining of procedures and approval authorities, meant that fighters, fighter-bombers, or bombers could strike high-priority targets identified in France in a relatively short period of time, measured in hours. In the assessment of one author, 'It took Special Air Service and Maquis teams on the ground to recognise what was happening, and the intelligence they provided finally closed this targeting loophole and brought barge traffic under attack', depriving German forces of replacement troops and fuel (Ehlers 2009). Mobility, resupply and air-delivered firepower, for example provided by a single special mission air unit in the form of 1st Air Commando Group in Burma, demonstrated the integration of air and special operations at the rudimentary level of direct support.

During the course of the Second World War the Allies experimented on a small scale, with integration between air and special operations to achieve a high level of synergy between them. Activities conducted as part of the so-called 'Blackmail' scheme sought to achieve such synergy. Blackmail involved close cooperation between the British Special Operations Executive (SOE), the special operations organisation responsible for sabotage and subversion in occupied Europe, and the RAF's Bomber Command. The two worked together from December 1943 to July 1944 to plan and coordinate their actions to achieve a common goal: denying Nazi Germany the output of a number of large and small factories in occupied France.

Destruction of the factories by aerial bombing could achieve this goal, but its price was high. Bombing industrial targets in France introduced political considerations into planning calculations, including limiting the amount of damage caused to French industry as well as avoiding needless French civilian casualties. The genesis of the idea for Blackmail began with first-hand observation, by a British covert agent on the ground, of just how destructive and inaccurate one such raid was. The Blackmail scheme involved, as the name suggests, a level of coercion. Special operators or the agents would approach French factory management and present them with a choice: conduct or allow sabotage in their works or face raids from RAF bombers. From its initial conception, modest roots and early promising results Blackmail grew to cover more than thirty targets, including the major manufacturing facilities of some French firms whose names are instantly recognisable: Peugeot, Michelin and Renault. The timing of Blackmail, however, was anything but favourable. In the words of official historians, 'it was too late in the war to catch on properly' (Foot 1966: 287) and '1944 was rather late for an experiment which must be cut short by D-day' (Mackenzie 2000: 601).

Development and growth spurt: Vietnam

Following the Korean War (1950–1953), the integration of air and special operations remained relatively static for a number of reasons. Colonial powers such as Great Britain and France used conventional air units to support their SOF with mobility, sustainment, and psychological operations. The support air provided to SOF was restricted for a variety of reasons, most of which reflected the limited nature of colonial counter-insurgency campaigns in Malaya (1948–1960), French Indochina (1945–1954) and Algeria (1954–1962). While there were a number of innovations in air and special operations integration, including insertion and extraction methods, they were largely limited to modest improvements of tactics, techniques and procedures. In the United States, integration was stymied for another, more significant reason: the dearth of military SOF. Paramilitary SOF of the Central Intelligence Agency (CIA) were active and supported by air through contract air forces of Civil Air Transport, Air America and others, but on an unassuming scale to keep the nature of such activities clandestine. A range of motives, some malicious and others practical, including budget constraints, organisational memories of past rivalries, and a mistrust or misunderstanding of what was now termed 'unconventional warfare' contributed to the disbandment of US Army special operations units (Paddock 2002).

American interest in unconventional warfare and special operations revived as a result of Nikita Khrushchev's declaration of 'wars of national liberation' and the perceived instigation of Communist-inspired insurrections in former colonial countries, including French Indochina (Vietnam). The details of the American involvement in Vietnam, from initial advising efforts to the conventional expansion of the war, are well known and do not bear repeating here. US Army Special Forces, more commonly known as 'Green Berets', began advising and assisting South Vietnamese forces, including local defence militias, in 1961.

Special Forces teams were committed in force to base camps situated near Viet Cong and North Vietnamese Army infiltration routes into South Vietnam. Base camps relied for their security and advance warning of attack on a defensive perimeter, mobile patrols, and good relationships with the local villagers or tribesmen. The US Air Force developed a range of 'bizarre improvizations [*sic*]' in equipment and techniques, including ground-based radar, to ensure that base camps, even under fire or in remote locations, could be resupplied (Sams and Aton 1969: 63). Special Forces camps were dependent on air-delivered supplies. As one contemporary account notes, 'During the last half of 1968 … the Special Forces received more than 84 per cent of their logistical support by air', primarily from C-7s and C-123s (ibid.: 54).

Integration in terms of firepower in Vietnam fell into the pattern it followed previously. Air power supported firebases under attack on an emergency basis, but given the cover and concealment available to Viet Cong insurgents, airborne forward air controllers (FACs) directed close air support (CAS) strikes. FACs could strafe Viet Cong forces but more often marked targets using smoke rockets for 'fast movers', or jet fighters, to drop their ordnance. Rather than using jet aircraft, two captains suggested fixing side-firing guns on older, propeller-driven transport aircraft to provide longer on-station times over targets and overwhelming firepower. The concept for the proposed 'gunship', the AC-47, was innovative for a number of reasons, but was opposed by the Tactical Air Command commander, General Walter C. Sweeney, Jr., as a technological step backward for the Air Force, among other reasons (Schlight 2003). Largely for institutional reasons, the AC-47s were relegated to special operations squadrons, where they conducted a wide range of missions, including night-time overwatch, hamlet defence and interdiction.

The integration of air with special operations was also influenced by other developments in the war beyond the insurgency in South Vietnam. The air war, as well as special operations, expanded into North Vietnam as well as Laos and Cambodia, which created different challenges to integration. In the case of North Vietnam, the conduct of special operations was shaped by three factors: the geography and terrain of North Vietnam, including the distances to potential targets of value; the capability of North Vietnamese internal security forces that put any SOF remaining on the ground at considerable risk; and ground-to-air defences that ranged from large numbers of basic anti-aircraft artillery (AAA) up to integrated air defence systems around Hanoi and elsewhere. As a result, special operations were limited in scale and intensity in North Vietnam and comprised small-scale coastal raids, border incursions and agent drops and resupply, none of which had lasting strategic effects.

Given the air defences, special operations supported air in North Vietnam in attempts to rescue downed pilots before their capture. Special operations provided the means to identify and confirm the location of the pilots and then rescue and recover them. Such recovery missions required substantial integration and coordination; in the case of Captain Roger Locher, almost 120 aircraft, including special operations aircraft, were dedicated to his recovery (Ethell and Price 1989). Integration, in the face of defences, was necessary for survival and mission completion. To meet the unique demands and operating conditions of special operations in a high-threat environment, the US Air Force experimented with heavily modified C-123 Provider aircraft (Projects Duck Hook and Heavy Hook) and later C-130 aircraft (Project Combat Spear) to penetrate enemy airspace and avoid radar (Thigpen 2001).

The expansion of the war into Laos and Cambodia challenged air and special operations in different ways. The use of air and special operations in both countries was designed to address a primary problem: the flow of men and material from North Vietnam into South Vietnam through the Ho Chi Minh Trail. While ostensibly an interdiction mission against a logistics supply line, monitoring the 'Trail' was anything but simple. It comprised thousands of roads that constantly evolved and varied, depending on the location and geography, from dirt tracks to paved roads. It later also contained a pipeline that moved hundreds of tons of supplies into South Vietnam daily. The intelligence estimates of supply traffic diverged widely due to a lack of accurate data.

Special operators from the Military Assistance Command, Vietnam Studies and Observation Group (MACV-SOG) were tasked with missions against the Ho Chi Minh Trail, including road watch and photography missions, placement of sensors, and prisoner snatches. In addition, SOG operators conducted cross-border raids. SOG initial attempts to integrate with air assets foundered on the squabbles over which service – the Army or the Air Force – controlled *armed*

rotary-wing aviation and whether the use of Air Force helicopters constituted a breach of a previous agreement. Air Force 20th Special Operations Squadron (SOS), flying armed UH-1F Hueys, supported SOG operations and during one three-month period in 1967 'transported more than 63 tons of cargo and 5,314 passengers, and expended 389,000 rounds of ammunition' (Abbey 1976: 92). Such support, however, came at the cost of shared risks with losses leading to the squadron's being partially 'stood down' in early 1969 (ibid.).

Other air assets conducting special operations contributed to the 'War against the Trucks' or interdiction missions along the Ho Chi Minh Trail and experienced losses. Efforts to replace the increasingly vulnerable AC-47 took various forms, including the AC-117 (Stinger) and AC-123K. Arguments for a C-130-based replacement won out given that the plane could fly higher and faster while carrying a larger payload. The greater payload translated into a bigger crew, heavier weapons (from rifle-calibre mini-guns to a 105 mm howitzer), and a range of sensors including infrared and low-light television. The net effect of this combination of crew, sensor operators and shooters was a dramatic increase in special operations capability. The AC-130 could not only find its own targets but also destroy them and conduct battle damage assessment (BDA) at the same time.

An increase in capability did not translate, however, into special operations independence or invulnerability. Special operations AC-130s required airborne command and control centre (ABCCC) support, as well as F-4 Phantom escorts, to conduct their 'truck hunting' missions in Laos (Ballard 1982). While accounting for 12,741 trucks destroyed, six AC-130s were lost during 'Commando Hunt' campaigns along the Ho Chi Minh Trail (Nalty 2005).

The integration of air and special operations during the Vietnam War was complicated by several factors. The first was the differences of opinion within the Air Force itself noted above. Such opinions led to the general consensus that SOF were best supported by other 'specialised' aerial assets. The second factor was inter-service bureaucratic politics over who controlled specific air assets. The third was the interagency politics associated with clandestine cross-border operations into Laos and Cambodia. Keeping cross-border special operations clandestine led MACV-SOG to simultaneously integrate with other components while at the same time thwarting them. As one historian notes:

> Conduct of UW [unconventional warfare] activities, due to political sensitivities, required considerable coordination with agencies normally peripheral to the military chain of command. Political sensitivities also included deliberate efforts to disguise lines of authority.
> *(Abbey 1976: 118)*

The fourth and final barrier to integration of air and special operations was the war's scale, complexity and increasingly conventional nature. Special operations, and their related air operations, were subsumed during the war: 'At their 1969 peak, however, the gunships totalled only 53 of over 1,800 US aircraft in the war theatre' (Ballard 1982: 256).

Despite the preceding discussion, the Vietnam War saw the emergence and growth spurt of air and special operations integration in one important respect. The demands of the complex operating environment revealed shortcomings in capabilities and integration, including integration of air and special operations. Such capabilities included the need for long-loiter surveillance and reconnaissance, clandestine infiltration and exfiltration, and delivery of precision firepower. Such integration, however, never rose above the tactical level in Vietnam for two primary reasons: the nature of war itself and the way in which it was prosecuted. The lessons of tactical integration, however, remained transitory and limited so long as the services perceived special operations as a necessary evil in an anomalous war such as Vietnam.

The great leap forward: from Operation Desert One to US Special Operations Command

After Vietnam SOF were substantially reduced given the defence budget cuts that followed. While these reductions affected all of the services, they hit the special operations community especially hard given its smaller size. The mood and attitude among the special operators during this era is best captured by William Ohl II, who wrote 'SOF have a history of languishing as the second class citizens of all the services' (Ohl 1993: 1). Among the conventional forces, there was a perception that 'special operations forces, in general, were out of control or at least not under the control of US military leadership' (Marquis 1997: 20). The era of the 'hollow force' military after 1975, and competition for budget dollars, made service infighting bitter and pronounced and special operations, with few exceptions, saw their budgets and manpower significantly reduced.

Two US military actions led directly to the organisational change necessary to make air and special operations integration at the operational level a reality. The failed attempt to rescue Americans held hostage in Iran in April 1980, Operation Eagle Claw, highlighted the strategic impact of the inability to integrate air and special operations tactically. More specifically, unnecessary compartmentalisation between organisations during planning, opaque command and control, and failure to conduct full mission rehearsals to coordinate air and special operations contributed to the disaster. In October 1983, US conventional and special operations forces conducted Operation Urgent Fury to rescue Americans held hostage in Grenada. While the operation ultimately succeeded, anecdotes highlighting the lack of integration between the different services, as well as between special operations and conventional forces, made headlines. Results of these shortcomings included costly raids which struggled due to 'minimal coordination, little cooperation, and inadequate [intelligence preparation of the battlespace]' (Isby 2004: 203).

The net effect of both actions was Congressional action to solve the problem after a series of testimony and committee hearings. The passage of the Goldwater–Nichols Act in 1986 forced the armed services to integrate by the pursuit of 'jointness'. Although the Goldwater–Nichols Act mandated jointness among conventional forces, it did nothing to guarantee the long-term health of SOF, much less the integration of SOF with conventional forces. The Nunn–Cohen Amendment to the 1987 National Defense Authorization Act, named for the two senators spearheading the legislative effort to ensure the stability of the SOF community, accomplished its primary goals. First, the Nunn–Cohen Amendment forced the armed services to support special operations while creating a separate unified command, United States Special Operations Command (USSOCOM), to manage the acquisition of SOF-unique equipment. Second, the Amendment stressed the requirement for the creation of a policy interface with the armed services and Congress within the Pentagon, the Assistant Secretary of Defense for Special Operations and Low Intensity Conflict (ASD SO/LIC). The two organisational changes – mandating a degree of integration between the services and creating a special operations organisation within the Department of Defense that still relied upon the services, but had its own unique budget authority and access to policy-makers – represented a great leap forward in the integration of air and special operations.

Integration honed and refined: Operation Enduring Freedom to today

The creation of USSOCOM in 1987 did not immediately produce full integration of US air and special operations. That has resulted instead from the convergence of several factors and the

processes of experimenting, testing and validating new concepts and equipment. Rather than present chronologically the significant events that have shaped current air and special operations, this section groups them thematically and offers illustrations and examples. This treatment reflects the sensitive nature of contemporary air and special operations as well as a paucity of reliable, rigorous, publicly available studies or treatments. The section covers the refinement of the air force and special operations interface; the twin revolution within air from precision-guided munitions and intelligence, surveillance and reconnaissance (ISR); and the creation and expansion of joint doctrine and training exercises. The net effect of the convergence of special operations with air is the realisation of what Soviet Marshal Nikolai Ogarkov described in 1984 as a 'reconnaissance-strike complex' (Watts 2011: 1–2).

Refining the interface

The refinement of the air and special operations interface has evolved due to two approaches. The first followed the historical pattern of creating and using special mission aviation. The establishment and growth of the 160th Special Operations Aviation Regiment, matched by the creation of 23rd Air Force (1983) and its expansion into Air Force Special Operations Command (1990), were contemporary answers. Special mission aviation has a specific value in terms of integration. The continuous interaction of special mission aviators and platforms with ground special operators develops habitual relationships, which in turn foster trust. Through sharing danger, as well as demonstrating competence and reliability through consistent performance and a willingness to attempt the unorthodox, special mission aviators build trust and allow ground force operators to assume greater personal risk while at the same time lowering the overall risk to mission completion.

Integration for special mission aviators starts at the earliest phase of their career. The competence and reliability of special mission aviators in the most challenging conditions results, in large part, from the taxing training they undergo. In the words of one special mission aviator, 'But using the systems and integrating the crew is where it really becomes something special. It enhances the capability beyond the machine. It's the men in the machine who give it the capability' (Whitcomb 2012: 544–545). Functional integration within the airframe during training permits broader integration with the operators they support tactically throughout their career.

The second approach to addressing the air and special operations interface has centred on solving the related problems of the air–ground interface and CAS. Most contemporary special operations are conducted against insurgents or terrorists who attempt to hide among or blend in with the local population. Where insurgents or terrorists can gain the initiative against special operators and pin them down, fires are necessary to suppress or destroy the threat.

One criticism of the US Air Force's responsiveness to CAS requests in irregular warfare has historically focused on limitations in the number of individuals from across the armed forces who have mastered the technical skills necessary to call in airstrikes. Even in an accelerated training scheme, potential Joint Tactical Air Controllers (JTACs) must complete four phases of training and must pass written tests and live and simulated control exercises. The phased training is incremental: a candidate who fails one phase cannot progress to the next. Although the requirements differ somewhat between JTACs, Tactical Air Control Parties (TAC-Ps) and Forward Air Controllers (FACs), the basic skills and training required to achieve certification are the same.

The CAS process can be thought of as a 'kill chain' that links the aircraft and its support structures through to the target of the attack. From the aircraft base of operations, the CAS kill

chain progresses through the following sequence: airbase ➡ CAS stack ➡ Air Support Operations Center (ASOC)/TAC-P ➡ aircraft ➡ JTAC ➡ weapon ➡ target (Jacobs et al. 2008). This method of depicting the process illustrates the infrastructure, command and control, and other technical requirements for CAS. In addition to personnel skilled and trained in the necessary tasks to put the right munitions on target, suitable numbers of platforms capable of conducting CAS missions must be available. Further, there should be some form of higher command function, exemplified above by the ASOC, responsible for apportioning and allocating aircraft across its span of control and deconflicting airspace to prevent collisions between friendly aircraft.

To facilitate the integration of air and special operations, and much as happened with special mission air, the response took the form of creating specialised units of CAS controllers. The units of Special Tactics combat controllers were first created in 1977 under the innocuous label 'Brand X'. Its operators quickly developed a reputation for capability, competence and reliability and were initially attached to Army Ranger units (Carney 2002). Special Tactics 'battlefield airmen' are trained and qualified to conduct a range of air integration activities, including airfield surveying, air traffic control and JTAC certification. Through their integration into other special operations units, as well as with special operations and conventional air units in the course of training and combat missions, Special Tactics combat controllers have developed habitual working relationships and trust with all three. The level of tactical integration within the special operations units results from complementary, as opposed to competing, skills:

> what the [Special Forces] guys bring is a cultural sensitivity and a sense of how to integrate with other land forces in an appropriate way … I don't need [Special Tactics] to be SOF experts – they're airpower experts – and I need to integrate them into this fight.
>
> *(Call 2007: 28)*

The 'Afghan model'

The second theme of this section is the twin revolutions in air power that have occurred through precision-guided munitions and ISR. Their potential was first demonstrated in Afghanistan in 2002 when SOF, air power and local militias combined to overthrow the Taliban and scatter al-Qaeda forces in twenty-one days. While much debate has surrounded the uniqueness or universality of the so-called Afghan model, the reality is that it has been used to effect in a number of recent conflicts, including Iraq and Syria (Andres et al. 2006). Special operations forces, as well as air power, had few problems historically destroying targets once they found them. The level of precision obtained through current air power, using satellite coordinates or laser-designation systems, now allows low-yield or inert warheads to kill individuals with little or no risk of collateral civilian casualties.

The challenge for special operations and air power historically has been 'finding' and 'fixing' mobile and fleeting targets, including insurgents and terrorists. The use of manned and unmanned ISR platforms, ranging from the U-2 and U-28 to the MQ-9 Reaper, enables the location and tracking of individuals. The fusion of intelligence information, combined with other source reporting, allows special operators to develop 'pattern of life' profiles for their targets. The net effect has been a shift from dynamic targeting, and its need for CAS, towards more deliberate targeting at a time and place that will limit civilian casualties. The integration of air and special operations tactically has expanded the targeting methodologically to F3EAD: find, fix, finish, exploit, analyse and disseminate. The net effect of the integration of air and

special operations, enabled by the 'unblinking eye' of ISR and precision strike, has been the creation of 'industrial counterterrorism': each terrorist or insurgent takedown develops new intelligence that feeds into target packages that, once refined through ISR, lead to further takedowns (Urban 2010).

Training, exercises and joint doctrine

Takedowns in combat actions, much less the degree of integration currently observed, would not be possible without the creation and refinement of joint doctrine and procedures as well as joint training exercises. The Goldwater–Nichols Act laid the foundation for the development of joint doctrine and procedures. Doctrine and procedures, while the least exciting of the themes, are necessary nevertheless for the important function they perform. Integration can and has occurred in past, sometimes out of necessity and at other times through operational experimentation. Such integration and the lessons learned as a result of it, however, have rarely been captured and codified.

Codified lessons form the basis of standardised behaviour between the services and special operations. Standardisation ensures a common frame of reference between different organisations. This common frame of reference, in turn, promotes greater integration through constructive clashes over the substance of an issue, and not its definition or boundaries. Consider Joint Publication 3-09.3, *Close Air Support*, which outlines fundamentals, command and control, planning and requesting CAS, preparation for a strike, and its execution (Joint Staff 2014). While the issue of CAS remains an emotional one organisationally and bureaucratically, the discussions of how to perform it focus on the limitations of current systems and processes. Information on special operations tactics, techniques and procedures remains restricted but the point remains: through joint doctrinal publications, SOF have a common frome of reference for CAS, what constitutes special operations, and how they are commanded and controlled. The ability of doctrine to keep pace with technological change, however, remains a constant challenge.

At the tactical level joint exercises prove invaluable in facilitating integration between air and special operations prior to combat deployments. Such exercises allow the identification of gaps and seams in planning, mission execution, techniques and procedures, and command and control. One set, Jaded Thunder, is a 'joint combined arms fires exercise with the purpose of validating and exercising current Air C2 and Joint Terminal Attack Control (JTAC) & fire support architecture while simulating current and future operational scenarios' (Walden 2016: 1). This exercise is designed specifically to test force integration and interoperability. The series has been successful enough to warrant the creation of another series, Jaded Edge, which incorporates remotely piloted aircraft (RPA) into the scenarios.

The return on investment in time and resources into existing and ad hoc training exercises may not be readily apparent. The ability to anticipate and train to future scenarios, however, may pay unexpected dividends. For example, in 2002, in the 'Early Victor' series of exercises,

> SOF teams and aircrews had the opportunity to test both the [concepts of operation] and the practical details of air-ground coordination … Early Victor provided SOF operators and Air Force pilots the chance to view the operations from each other's very different tactical perspectives.
>
> *(Kiras 2013: 418)*

A year later in combat, the SOF teams and aircrews put the lessons learned to good use in the western desert of Iraq, conducting an integrated air and special operations line of effort that

seized considerable territory at little cost. In short, over the past decade the 'reconnaissance-strike complex' envisioned by Ogarkov has become a reality due to the integration of air and special operations.

Conclusion

While military services have made great strides at integrating air and special operations tactically, in terms of combining the two, achieving operational and strategic integration nevertheless remains elusive. Integration remains problematic as it continues to be interpreted as 'support the special operator' in the direct functional sense of the term, as opposed to meaningfully integrating the qualities and capabilities of air early in the mission planning process. Meaningful synergy characteristic of integration in its other definition requires a full and equal partnership between air and special operations. As a result, meaningful synergy between conventional air and special operations will remain problematic, despite doctrine, training and exercises, given their different frames of reference. Synergy is possible, however, but most likely to occur within the most integrated air–special operations team organisationally: specialised mission air or Special Tactics battlefield airmen.

There are two identifiable challenges to future air–special operations integration, both tied to the current approach. This approach places heavy emphasis on integration as a means to guarantee tactical superiority at the point of enemy contact. Air is useful for a number of reasons, but primarily to limit risk to mission and to forces. Sizeable air packages are necessary to support SOF in order to mitigate risk. Such support makes considerable demands on conventional air forces already stretched to meet global requirements, including ISR and airlift. It is also worth recalling that the effort to rescue Captain Locher from North Vietnam, in the face of air opposition, required the 7th Air Force commander to suspend all other air activity to support the rescue mission. More problematic is the opportunity cost of such support. In racing to meet demand after demand in a seemingly unending set of requirements, what may be lost are the time and space necessary to think through how to use the speed, reach, precision and ability to mass effects of air in ways of its own as a substitution force to relieve some of the pressure on operationally stretched SOF.

The second challenge associated with the current approach is complacency. The high degree of tactical integration characteristic of current operations results from air superiority or air dominance. Should command of the air be contested or denied in the future, the current approach to integration is untenable. Dedicating overwhelming air resources to overpower enemy defences and ensure special operations success is unlikely if conventional forces face credible enemy anti-access or area denial systems.

Integration has followed the path of least resistance out of necessity, with air providing direct support to special operations. Such support has been contingent on air having sufficient resources to achieve and exploit air superiority. In the future, special operations may be tasked with directly supporting air to accomplish this task. Integration in terms of synergy, however, has proven more elusive but should be anticipated. Doing so requires assessing the strengths and vulnerabilities of air and SOF. One approach should explore what air campaigning looks like against current and future terrorist threats. Another might examine the use of SOF as an operational manoeuvre and targeting force in denied access areas and work through the command and control as well as deliberate and dynamic targeting implications of this approach. While requiring energy and effort, working through such problems of synergy in advance is infinitely preferable to improvising should air superiority be contested or lost.

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16
AIR–SPACE INTEGRATION

Everett Carl Dolman

According to the US Department of Defense's authoritative Joint Publication, *Space Operations*, 'Military, civil, and commercial sectors of the US are *increasingly dependent* on space capabilities, and this dependence is a *potential vulnerability as space becomes increasingly congested, contested, and competitive*' (JP 3-14 2013: I-2, emphasis in the original). Integrating space capabilities into military operations, particularly air power operations but also essential to all services today, is thus of the highest importance. It should also be routine, at least by now.

Unfortunately, efficient integration, which should have had a relatively straightforward practical trajectory, has been marred by shifting theoretical perspectives. Accordingly, this chapter functions as a brief overview of military space capabilities and missions and of the historical progression of integrating space power into military operations, from its earliest prophets to its current position as the backbone of modern military capabilities, highlighting several of the obstacles that have slowed what should have been a much quicker process. The theoretical perspectives that have caused significant inefficiencies in the process are based on notions of proper strategy and domain control. Is space a separate warfighting domain or is it subservient to the air domain, and – if it is a warfighting domain – what differentiates space strategy from air or aerospace strategy? The chapter concludes with a brief summary of prominent trends in space applications today.

Space operational capabilities and mission areas

Space capabilities have proven powerful force multipliers when integrated into military operations. Around the world today military space assets provide global communications; positioning, navigation and timing (PNT); weather and environmental monitoring; space-based intelligence, surveillance and reconnaissance (ISR); and early warning of hostile actions. Several nations have the potential to conduct offensive and defensive space operations, though no state has yet deployed a robust enough capacity to fight in and from space sufficient to warrant an independent military space force. Despite the importance of space to modern military operations, achieving the full potential of space support has been slowed by a lack of clear understanding of just what space does for the military, and much more so by a lack of common knowledge of what space assets could do if fully utilised.

Integrating and synchronising space capabilities into routine operational planning has proven arduous. Arthur C. Clarke once said that a sufficiently advanced technology, even to the most technologically savvy population, can be made so difficult to understand or so transparent to daily life that it simply appears as magic (Clarke 1973: 36). Much that happens in space is invisible to the user. Satellites operate out of sight. The only time it seems they are noticed is when they are not working, despite the increasing realisation that almost all of modern routine military interactions depend on space support working flawlessly. From secure Internet access to properly operating cell phones, life without space support today would be almost as traumatic as life without electricity.

More than just being out of sight, out of mind, space capabilities, especially military space capabilities, are often highly classified. The benefits provided and the potential harm from loss of space capabilities are thus unknowable to most people. Moreover, the highly technical nature of space operations requires a certain minimum level of training to understand the unique operating characteristics of both spacecraft and the space environment. For planning and integration, these factors mean that extensive coordination and early identification of requirements and capabilities are vital to optimally functional space support. It is easier simply to accept the benefits and not look deeply into how they are generated or worry too much if they one day disappear. The first step to full integration, then, is a basic understanding of space characteristics, missions and capabilities.

Orbital space characteristics

The environment of outer space is harsh. Radiation tears apart sensitive components. Extremes of heat and cold stress the most durable components. The extremely fast relative velocities of even the smallest dust particles make collisions spectacularly destructive. And all of this takes place in an orbital geography in which gravity and fuel consumption are the factors that most determine factors of success and operational lifetime.

One of the unique artificial constraints on space potential is that international law has not established where airspace ends and outer space begins, though it must be in the ambiguous region above the highest altitude sustainable through aerodynamic flight (at about 53–54 miles above the Earth), where the atmosphere is insufficient to produce any noticeable aerodynamic lift. This is known as the von Kármán primary jurisdiction line, named for physicist Theodor von Kármán who identified the upper limit in 1957, and the lowest altitude at which an unpowered orbit can be sustained – a little over 90 miles (Goedhart 1996: 63). This is not an oversight. International diplomats have not been able to determine who might benefit from too high or too low a defining line because state sovereignty exists from the ground to the highest level an aircraft can attain but does *not* extend into Earth orbit. As such, states can legally overfly other states in space, but not in the air (without prior consent). States have further agreed that no terrestrial political entity can lay claim to the Moon or other celestial objects, though they may build and station whatever satellites, bases, stations and even weapons platforms anywhere in orbit, so long as they do not include weapons of mass destruction: specifically nuclear, chemical, biological, or radiological weapons (United Nations 1967: §IV). Conventional and other weapons not specified are legitimate.

On the physical side of environmental limitations is the complete dependence of operational manoeuvre on orbital mechanics. Satellite orbits must follow specified parameters due to the laws of physics. Orbits can be optimised by terrestrial launch site selection, but are essentially limited to initial injection plus on-board fuel capacity for changing and maintaining useful orbits. When satellite operators choose to change a spacecraft's orbital parameters, they deplete

available fuel and shorten the satellite's useful life. If the satellite moves to a non-optimised orbit, mission capability may be severely degraded. While it is often overlooked, the high cost of getting mass into orbit on a rocket has remained steady at about $20,000 per kilogram (NASA 2008). That means launches of large, highly capable satellites are extremely expensive. The size, weight and power of a satellite are constrained not only by the harsh environment, technology restrictions, political considerations and orbital parameters, but also by the trade-off considerations of where military planners allocate their limited budgets.

Of critical importance is satellite dependency on the electromagnetic spectrum for all command and control operations. Due to the high cost of maintaining human life in space, stationing humans in space currently confers no military advantage (though this will change as human activity moves deeper into space and as commercial enterprises, to include space tourism, become operational). The brief time lag for communication from Earth-based controller to satellites up to 70,000 km above the Earth is an acceptable trade-off, and so all military satellites are remotely piloted. Even the current astronaut shuttles from the Earth to the International Space Station are remotely piloted, with humans serving as manual operators in the event of a catastrophic control failure. What all this implies is that satellite systems are vulnerable to natural interference, most noticeably high solar activity, as well as human interference (hacking). In a modern military, robust and secure communications to all components are vital for fully integrated joint operations. This is especially true for space systems.

Space mission areas

The process of categorisation highlights the complicating aspects of space integration. The following paragraphs outline a sample scheme mostly drawn from US military doctrine, but that scheme does not attempt to be all-encompassing or universally accepted (AU-18 2009).

Space operations support

Space operations support encompasses all those functions, today terrestrial, involved in acquiring and maintaining an on-orbit presence. This spans research and development (R&D), to include partnerships with universities and private corporations; manufacture of systems and components, both in house and outsourced, for design and testing as well as production; space lift capabilities, generally rockets and launch pads/facilities but also recovery capabilities and the control and management of operational ground stations; and the storage and preparation of additional assets necessary to reconstitute space forces in times of crisis or depletion.

Space situational awareness

Space situational awareness (SSA) involves characterising the space environment as completely as necessary, to include cataloguing and tracking all observable objects in Earth or near-Earth orbit, determining the operational capabilities of functioning satellites, and determining threats to space systems or – in the case of large meteoroids, asteroids or comets – to Earth itself. SSA is vital for ensuring cooperative use of space, detecting threats, avoiding collisions, and perhaps someday cleaning up the orbital space between the Earth and the Moon. It can also provide warnings to friendly terrestrial forces when opposing reconnaissance satellites are in view, allowing those forces to take appropriate cover or deception operations. Currently, the most comprehensive SSA system is the US Air Force's Earth-based over-the-horizon radar system, which tracks more than 20,000 objects in orbit around the Earth and publishes the location

and element sets of each on the Internet. Other nations supplement their SSA by various means. The best SSA would come from space-based detection systems, as the atmosphere reflects light and obscures ground-based detection, and some efforts to build this capability have been initiated. SSA is the initial integrating task for processing and coordinating space activities, performing long-term effective environmental monitoring, processing and analysing intelligence data, determining the status of national and cooperative satellite systems, and making efficient use of intelligence sources to provide insight into adversary intent and capabilities through continuous monitoring of the use of their space assets.

Space force enhancement

Space force enhancement encompasses any space-based support to joint land, sea and air forces that increases the combat potential of those forces. There are five force enhancement functions:

- ISR;
- integrated tactical warning and attack assessment (ITW/AA);
- environmental monitoring;
- communications; and
- PNT.

These functions enhance the situational awareness of the terrestrial combatants, covering both adversary and friendly locations and dispositions; increase the depth and reliability of command and control; add unique and corroborating intelligence, persistent surveillance and extended reconnaissance; improve missile warning; expand weather forecasting; deliver global secure communications; and provide precise position and targeting data.

Space control

Space control is intended to ensure that access to space for all nations is not unnecessarily impeded in time of peace, and to provide access and freedom of action in space for friendly forces in times of conflict or war while denying that access to adversaries – and, when necessary, defeat adversary efforts that interfere with or attack friendly or allied space systems and negate adversary space capabilities. In the US, space control has two components: offensive space control (OSC) and defensive space control (DSC). OSC includes measures taken to prevent an adversary's hostile use of controlled or friendly space capabilities, generally via the electromagnetic spectrum, and offensive operations to negate an adversary's space capabilities, to include direct attack anti-satellite (ASAT) measures. DSC includes active and passive countermeasures against adversary OSC measures such as armouring or hardening satellites, distributing capabilities through networked systems, incorporating planned redundancies, and quickly reconstituting on-orbit satellites. An important point is that today most of the known preparations to enact space control are terrestrially based, and can only affect space from another domain. As is discussed below, true space control can only be effected from inside the domain.

Space force application

Space force application consists of combat operations *in*, *through* and *from* space to influence the course and outcome of conflict by holding space and terrestrial targets at risk. The space force application mission area includes ballistic missile defence and, in the US, where space and cyber

commands are combined under the nuclear delivery mission of US Strategic Command (USSTRATCOM), force projection capabilities such as intercontinental ballistic missiles. There are no known weapons systems based in space today.

Current functions of military space power

The mission areas summarised above are categorisation schemes intended to capture the full range of military operations in space. This section briefly describes the types of spacecraft that perform these missions.

Space-based ISR

These systems monitor Earth from space to reveal location, disposition, movement and intention of opposing forces at the tactical, operational and strategic levels of war. They provide – among many other enhanced capacities – warning of approaching forces, operational combat assessments both friendly and adversary, and tactical battle damage assessment (BDA).

Integrated tactical warning

Although ISR provides warning of conventional attack, ITW focuses on detecting attacks from ballistic missiles and identifying nuclear detonations. Whether at the tactical/operational level, such as warning forces of incoming SCUD medium-range ballistic missiles so the forces can take defensive measures, or at the strategic level, such as warning the national command authorities of an incoming intercontinental- or submarine-based ballistic missile attack with nuclear warheads, ITW provides decision-makers with launch location, type of missile, likely payload, likely target and time to detonation.

Global communications

Once the only means to transmit secure communications across long distances wherever telephone or telegraph wires were not available or practical, satellite communications (SATCOM) provides a unique military capability today. When operating behind enemy lines, as is typical of many Special Forces missions, other means such as radio and cell phones are at best unreliable, at worst open to enemy interception and exploitation. Using dedicated military satellites and leased transponders from commercial or allied systems, SATCOM has the bandwidth to allow massive two-way data transmission of plans, orders and force status, increasing the effectiveness of joint operations. Using encrypted burst transmission of tightly focused or even laser transmissions, satellites in low Earth orbit can collect data from and relay instructions to clandestine or hidden assets. An emerging critical capacity is the ability to operate so-called drone aircraft (properly termed remotely piloted aircraft, or RPAs) flying anywhere on the Earth from control stations located in the home country.

Positioning, navigation and timing

Provided to most of the world now as a public good, the US Air Force Global Positioning System (GPS) has done more than revolutionise the process of precision bombing – for example, enabling close air support (CAS) to forces in contact by dropping GPS-guided bombs from B-52s flying at more than 10,000 feet; it has changed global economics and culture as

well. Indeed, while the US Air Force now uses precision strikes almost exclusively, and the ramifications of that are still unfolding, these satellites have changed the world's economy. Just-in-time supply, a concept that would have been unimaginable before the Internet and PNT satellites combined to give up-to-the-minute location data of global business, allows companies such as Hyundai to produce more than a thousand cars per day from its Alabama plant while eliminating the need for warehouse space – without ever having more than twenty-four hours' supply of parts and materials on hand at any given time. Precise timing signals from GPS allow real-time encryption for secure Internet commercial transactions, allowing for the explosion in online commerce. It is hard to believe that GPS was proposed in the early 1960s as a useful military capability, but was not fully funded for twenty years because cost–benefit analysis could not predict the enormous economic benefit this once military-only system would have on the world's economy.

Weather and environmental monitoring

Weather has always been a crucial factor in war, and effective weather monitoring and prediction give the side with the best information the initiative in determining when and where to strike. Weather information also includes space weather, such as solar radiation monitoring that can alert satellite owners when particularly harsh space conditions may affect performance. In addition, environmental monitoring provides terrain information useful to planners, including soil saturation and vegetation density for movement, road traffic capacity, and beach conditions for amphibious landings. Environmental monitoring over time can isolate enemy staging areas and lines of heaviest communication.

Future

Efforts, especially by the US, are under way to vastly expand the commercial exploitation of space. A completely green, neo-industrial age is possible as the massive resources of space are harnessed and used to provide benefits on Earth. Imagine solar power collected in space and transmitted to the Earth free of charge. Consider that the world's nations spend $100 million annually on storage of radioactive and toxic waste – in containers and underground caves that will leak long before the ill-effects of the waste material dissipate naturally (World Nuclear Association 2017). Now imagine safely removing those waste items from Earth and sending them into the sun – a giant incinerator – for permanent disposal. Envision large factories in orbit around the Earth, creating perfect metal alloys and strong plastics in a gravity-free environment with all heat and waste from the manufacturing process off-planet. This is the grand vision of space enthusiasts, but at least three changes must occur to prepare the way.

Massive networks

One large, long-life satellite per massive rocket is obsolete. A $100 billion satellite with state-of-the-art components can take years to design, produce and field. With a design life of fifteen to twenty years, some of these satellites stay operational for as much as a decade longer. In the year 2017, imagine a satellite still operating that was launched in 1987. The top-of-the-line computer chip was the Intel 8086. Not only was the satellite behind the technology wave by the time of launch, but within a few years it was hopelessly outdated – not to mention a single point of failure should it fail or suffer operational degradation before its planned lifetime was complete.

The alternative was developed when planners stopped asking how to perfect an existing satellite and instead starting asking what the best way is to get a persistent *capability* into orbit. One option is to have smaller rockets place several small satellites in orbit at the same time. Larger rockets can place hundreds of such satellites in orbit in a single launch. These microsatellites are cheap, have one- or two-year lifespans, and interact with each other. Some envisioned networks have thousands of satellites – in essence the latest cell phone technology with solar panels for power – all collecting and transmitting data in real time to ground stations. Google, Amazon, Boeing and Space-X have recently proposed networks with more than 3,000 satellites to provide global Internet services or real-time imaging worldwide (Boyle 2016; Masanuga 2016; Palermo 2014). As networking expertise develops, these small satellite constellations will revolutionise the amount and consistency of cutting-edge information operations, much as the GPS PNT network has done for location and tracking services. For the military, this could be the route to distribution of capabilities for defensive survivability as well as the capacity to rapidly replenish space-based support in crisis and in war. Getting there requires another breakthrough in launch capacity.

Transport

As technology billionaires focus on personal dreams of space travel, and are building several human-rated Earth-to-orbit capabilities for space tourism as well as making long-range plans for mining asteroids and colonising solar system planets and moons, commercial launch transport is undergoing a revolution. If the technology matures, and is cost effective, military forces may develop rapid-deployment special operations teams that can reach any place on Earth in ninety minutes or less. Supplies and reinforcements could be delivered to especially critical locations in otherwise denied areas. But the real revolution appears to be in developing ultra-low cost access to space (ULCATS) rockets to make the cost per pound of payload to orbit radically cheaper. Dozens of companies are producing rockets that use innovative techniques such as reusable boosters, horizontal take-off and landing, and new fuels to get payloads to orbit, with the ultimate goal of making space transportation as routine as air travel. When thousands of rockets head to space every month, transportation costs will plummet.

Weapons

As business goes into space so do the national interests of those states whose business interests are predicated on the infrastructure of space. At that point a need to protect assets there and to police the heavens will become more evident. Space is not the Wild West. Some laws and rules extend into space, and many more will be promulgated as space becomes more crowded, congested and contested. Then major spacefaring states will be called upon to defend national interests *in* and *from* space – not just *into* and *through* it. This is because *space is a war-fighting domain*. What these arms will look like is hard to say, but they will include a mix of kinetic projectiles and directed energy (laser, microwave, plasma and electro-magnetic pulse) weapons at least.

Domain theory and service integration

Separating domains is too often an exercise in semantics. Unless a *meaningful* reason exists for doing so, it is simply academic. But when done correctly, domain differentiation offers organisational and strategic benefits that make it vital to national strategy.

Since this chapter concerns domain integration, it may be surprising that analysis centres around domain differentiation, but that is the surest path. *All* domains become evident only when access to the domain becomes possible. Although humans are at their core land animals, once the capacity to build boats made travel far into the seas and oceans feasible, thinking of water as a warfighting domain became possible. Only once ships are crafted specifically for fighting on the water, and this type of fighting develops differently than land engagements, does a separate force or service become reasonable. The same happened with the air domain. Only when powered flight was proven in 1903 did the possibility of a domain in the third or vertical dimension become conceivable.

For air power, the First World War was the catalyst for a quick recognition and proof of the air domain as airplanes shifted from being artillery spotters and couriers to becoming full combat participants. Space has not come full circle to having the equivalent of fighters, bombers and mobility assets, and until it does it may not be a fully recognised warfighting domain – but that it someday will be so seems obvious to most forecasters.

Thus, and despite the low number of cases, a four-stage pattern has emerged. New technology is first incorporated as a *replacement* for a current function that is no longer available or overtaken by events. When artillery could go beyond the horizon, aircraft were used to replace balloon or hilltop spotters. Eventually the new technology demonstrates advantages over the old and is seen as an *enhancement* over the original. For example, using airplanes to replace cavalry reconnaissance in rough or mountainous territory also allowed for longer distance and faster returns of reconnaissance – a significant improvement. The third step is *enablement*, when the new technology or emerging domain permits new missions not previously achievable or a way of completing the mission that is so superior to the old method that the old is obsolete. Air power, perhaps more than the combustion engine on terrestrial automobiles and motorcycles, ushered out horse cavalry as anything more than a ceremonial force. Finally, a domain is indisputable when meaningful military missions can be carried out independently in the domain: when there is an *independent* strategic value that allows for the concept of useful, single-domain campaigns.

Seeing how domains emerge, differentiate and mature does not explain why they do so. Domain differentiation begins with a simple question: 'Is the domain *unique*?' In other words, does fully effective use of the domain require a separate strategy and operational practice than that used in other domains? Or do all simply reflect a general military strategy that operates the same way regardless of the domain, just with different equipment? It is possible to argue that there is no real difference between land and sea services, for example, and that a good strategist or flag officer in the navy could adequately plan and oversee land operations just as an army general could fully plan and execute sound sea campaigns. But given the long-standing practice, at least for armies and navies, the separation seems to have been historically settled. Of course, every organisation has specialists within it. Land forces today are divided into armour, infantry, artillery and support components. Air forces generally cohere around fighters, bombers, transport and reconnaissance missions. This allows focused training and maximises the capabilities of platforms, and efficiency- or effectiveness-prompted reorganisations are common. But at the helm is a strategist who puts all sub-specialties together into a coherent campaign, nestled within the broader military or grand strategy.

Proper domain differentiation thus provides two critical functions for warfighting. First, by distinguishing the meaningful boundaries of the domain, effective allocation of limited resources can be determined; the platforms or missions that should go with which service. Second, missions can be properly assigned. This includes primary service oversight of a joint campaign given the relative levels of effort or goal achievement anticipated – in other words,

what service should take the lead in a joint effort? The two functions allow for proper service control that should eliminate infighting when all services are jointly engaged in war. Unfortunately, the boundaries traditionally drawn are flawed – selected for service advantage and not necessarily for warfighting prowess.

The most common approach is to define domains by physical or operating characteristics. This is akin to dividing up service responsibilities according to the physical states of matter: solid, liquid, gas and vacuum. The army is given a solid, earthen domain; the navy a liquid one; air forces the gaseous atmosphere; and space forces the vacuum. To be sure, fluid dynamics and aerodynamics are quite different, and the orbital dictates of outer space require knowledge of gravitational mechanics for operations, but these may not be enough to meaningfully separate them. All air and spacecraft (today) are manufactured and launched from the ground or from a floating platform. Are these land and then air and space power until they are operating in the medium that differentiates them? Where should the proper span of control start and end for a ballistic missile that is constructed on land, launched from a submarine, passes through the air on its way to space, returns through the air, and detonates on a land target? It would be absurd to hand over operational control as the missile passes through all four domains and back.

The second common differentiation, often combined with the operational characteristics of the medium, is according to platform. If it flies it is air power. If it orbits it is space power. One supposes that if it floats it is sea power and if it rolls or crawls (or makes contact with land) it is ground power. The reason for selecting such a differentiation is first protectionist and then expansionist. By asserting, for example, that if it flies it is air power, a logical case can be made that anything that flies should be under the control of the air force, to include aircraft aboard ships (naval and marine air), helicopters (army aviation), and even commercial air assets (Federal Express and Delta, for example). Should the army have control of naval or air bases because they are on the land (and use armed guards with rifles, armoured vehicles and the like for defence)? Should the navy give up all its air assets to the air force?

This illustrates that differentiation based on medium or platform is fraught with ambiguity. Ad hoc arrangements that violate the criteria for differentiation become the norm, and each service competes inefficiently for equipment, support and span of control.

This chapter offers a meaningful alternative for separating warfighting domains: *purpose* (Dolman 2005: ch. 2). It is the purpose of the state, for example, to enhance the security and economic well-being of its citizens. This is the essence of grand strategy. States that fail to do so do not tend to last very long. Accordingly, states have a variety of means to fulfil their purpose. Diplomatic, information, military and economic (DIME) means are available and have been differentiated according to function. Each has a methodology and strategy that uses specified resources to create an unlimited span of effects. Note that it is not the effect that determines the proper span of control, but the means. In other words, diplomatic actions can have DIME effects: they are all diplomacy. A military bombardment that destroys a factory is not an economic operation (though it has economic effects) and should not be controlled by private enterprise, just as the bombing of a school is not educational warfare (Baldwin 1985: 36–42). Counterfeiting foreign currency to destabilise an enemy state is economic warfare that could have lasting economic, informational and even military effects. Each area has a meaningful definition of purpose and function that separates its span of control.

This chapter focuses on the military means that support state objectives, which is always a better state of peace (Clausewitz 1976: 73–78). When one places the *purpose* of military power within the context of grand strategy, as defined above, a separate and quite different definition results: to be prepared for, and when called upon by the legitimate governing authority, to maximise violence within the limits and constraints specified by that authority.

This is a harsh definition, but it does a number of useful things. Being prepared to go to war is as much the military's purpose as successfully prosecuting (or 'winning') war. Otherwise, any time the military is not engaged in war it does not serve its purpose. Indeed, as the ancient Romans stated so well, *si vis pacem, para bellum*: if one is prepared to go to war, one may not have to fight. A strong military can be a deterrent – at least to an opportunistic opponent. It also highlights that interstate violence is legitimate under international law only when undertaken by a state's military force. It does not mean that violence must be used in every military operation, but it does mean the potential for violence (latent violence) is or should be evident in every military operation. When delivering humanitarian aid, for example, the constraints placed on the use of force may be significant – and ideally violence will not have to be applied – but there is a difference between when a military unit goes into a hostile area to provide relief and when a civilian or commercial entity does so. Attacking Doctors without Borders or the Red Cross/Red Crescent is a reprehensible act, but the risk in doing so is that these organisations may deny future services (they will not return). Attacking the US military while it is distributing food or supplies to impoverished people means that a violent response is highly likely.

Within the broader mandate of military means for achieving state objectives the differentiation into separate services is commonplace. No major power has a single military service to cover all its land, sea, air and space endeavours, though all will eschew a service for a domain not accessed. Land-locked states often find they do not need a navy, and non-spacefaring states would not be likely to develop a separate space force. For those that *can* operate in space, the issue of differentiating between two services, one for air and one for space, or a single aerospace (or air *and* space) force must be placed into proper context.

Now the purpose of ground, sea, air and space forces becomes clearer. Each must be nested within the military purpose (itself nested within the grand strategy of the state) but unique relative to the other services. Thus the purpose of land power is to gain and maintain control of ground. Control here means the ability to operate within the domain with little or no interference. A contested domain is one in which the ability to operate is moderately to severely restricted by enemy activity, making successful actions there unsure. A closed domain is one to which neither side has access. Accordingly, if control cannot be gained, it is imperative that the state's armed forces contest the ability of another state to control the ground. Sea power requires the ability to maintain and control sea lanes of communication, and if that is not possible to ensure that no other state can gain control. The same applies to air power: to gain and control command of the air when needed and to deny that command to others. If space is a usefully separable military domain, then a military capability to seize and control space – at least near-Earth space – is paramount, though failing that the ability to contest another state's control of space is vital.

With this, span of control becomes a simple issue. Whatever assets are necessary to secure domain control belong to the service that owns the domain. If the air force needs trucks to fuel its aircraft, very well. If the navy needs airplanes to patrol sea lanes and participate in naval combat in its efforts to control the domain, it should acquire them. If the army needs RPAs to scout ahead of patrols, or its own CAS aircraft to support troops in contact, then it should by all means obtain them. To the extent that air power can rely on ground power to protect its terrestrial support locations, or that the navy can bring floating airbases near enough to participate in an air campaign against a target state, the essence of joint operations is highlighted.

In addition, in order to prevent effective contestation of the domain by an opponent, each domain-service must be able to contest the domains on its littorals. Ground forces, for example, properly have surface-to-air missiles (SAMs) assigned to them. It would be foolish to allow an

enemy air force to fly freely over ground forces without contesting that capability. Though the effect of preventing such overflights likely is an increase in the friendly air force's ability to control or command the domain, the purpose is to contest a littoral, not to take over command. Ground-based air defences can be considered a proper asset of ground forces. So, too, are aircraft – be they helicopters, jets, or RPAs – if they are used primarily to engage or support ground forces pursuing ground *control*.

Similarly, air forces have the capacity to attack ground and sea forces, but can only do so if the air has been locally or broadly commanded first. For the air force, command of the air is job number one. The navy can and should use aircraft for surveillance and attacking enemy combatants, but the aircraft it uses may not directly confer sea control. They can only contest it. Imagine that a freighter has been spotted that is suspected of human trafficking. Unless the navy has a capability to stop and board the freighter at sea; to inspect its contents; and, if it is acting illegally, to remove its cargo (taking the victims to safety) and then commandeer the vessel, its only options are to sink the ship (from the air or perhaps via coastal artillery – a dreadful result) or alert authorities in the port to which the freighter appears to be heading.

It is also quite apparent that control of a domain can only be attained from *within* the domain. While a domain may be contested from an adjacent domain, it cannot be commanded from there. A ground force may be able to scour the skies of any opposing aircraft, but this does not mean that friendly aircraft can operate with impunity there. The opponent's ground forces may be able to do the same – no one has command. This is obvious in the 'boots on the ground' argument for seizing and holding territory. Air forces may be able to prevent anyone from controlling a specific tract of ground, but air power alone can never *use* the ground efficiently. Land forces may be able to prevent any navy from operating near a nation's coast, but only ships can control (and therefore guarantee proper and efficient use of) the seas. This can be termed the 'oars in the water' hypothesis, and another could apply to air power ('wings in the air'?). If space is a meaningful military domain, then space can only be controlled in and from space.

With purpose at the fore, assigning the lead service for joint operations becomes easier and more effective. If the conflict requires taking and holding territory, then it is a land campaign supported by the other services. An army officer should be in charge, and for the most part has been. The same goes for a campaign to control or command sea lanes; clearly, this is the realm of naval expertise. But if it is an air campaign, especially one in which committing land forces has been precluded, should not an airman be in overall charge? Yet historically this has not been the case. In the campaign to stop Serbia's ethnic cleansing of Kosovars and remove Slobodan Milošević from power, air force air power supported by naval air was the force selected, and yet an admiral was in charge. Currently in Syria, where the US Air Force is attacking the Islamic State (IS) relentlessly, an army general is in charge. Clearly the Afghan and Iraqi campaigns in the twenty-first century were land campaigns, and the army should have been in charge. But the 1983 Grenada and 1989 Panama operations could (and should) have been handled entirely by the US Navy and Marines – and one of these forces should at least have had overall command. Again, with purpose at the fore, service rivalry and costly equipment and deployment concerns can be allayed if not eliminated, and truly cooperative and efficient joint operations can follow.

The space warfighting domain is characterised as encompassing an area that it must control to allow friendly forces to operate there with minimal interference, project power into adjacent domains, and prevent enemy forces from operating there effectively. To do this, military space forces must be able to enter outer space with weaponry, defend assets and target and destroy enemy capabilities in and from space. If politically it is determined that no weapons in space are acceptable, then governments should not put the military in charge of protecting space and guaranteeing continued access to it.

Conclusion

Integrating the space domain into military operations has taken longer than it should have but has still proven an absolutely vital component of modern military operations. Integration has been slowed by inter-service competition for budget shares and spans of responsibility, and the failure of space advocates to determine if air and space are separate or inseparable domains. If space is a warfighting domain, regardless of the decision to set up a separate space service or to create a cadre or space corps within the air force component, until warfighting becomes a practical space mission – not just an asserted one – complete with the ability to conduct independent space campaigns, full integration will be suboptimal. Nonetheless, space capabilities are now so ingrained into America's and the West's warfighting plans and doctrine that full integration is a necessity. Paradoxically, full integration may require an independent military service for the space domain, complete with independent space campaign planning and execution. The optimal joint fight is not one in which everyone participates equally, but one in which everyone participates efficiently. Government officials and military leaders must envision a future in which a space-heavy force is led by a space service, and planning is optimised from there.

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17
AIR POWER AND CYBER

Richard B. Andres

One of the most pressing problem military planners face when a new technology enters military service involves how to assimilate the new capabilities into existing operational constructs and concepts. In rare cases, however, the new technology is so radical that it cannot easily be integrated into existing concepts of operation or even strategic notions about how to employ force as an instrument of national policy. In these cases, attempting to assimilate the technology into existing systems may lead to suboptimal or even counterproductive results. Early notions that airplanes' main contribution to war would be as agile substitutes for reconnaissance balloons is an example of trying to fit a radical new technology into an existing operational construct; the idea that nuclear weapons would merely serve as more powerful artillery is an example of misunderstanding how to best employ a new capability as an instrument of national policy.

In the current era, one school of thought conceives of cyber weapons as little more than adjuncts to conventional operations. At its most extreme, this school relies on a series of analogies taken from conventional concepts of operations: it envisions cyber warriors as a force in being that springs into action to rain down devastating effects when war is declared. This school of thought fits well with existing paradigms about war and offers a familiar route to organising, training and equipping cyber forces for future military missions. Unfortunately, its main tenets are deeply flawed and nations that use it as a guide to building cyber forces are destined to go badly astray.

This chapter provides readers with a rough idea about how cyber conflict works – rough because the world currently lacks examples of first-rate cyber powers fighting each other and at times theory and approximation must substitute for experience and history. The basic argument made here is that states that intend to use their military-related cyber capabilities must rethink key operational and strategic issues. Cyber technology represents a radical new capability, and states that attempt to force their cyber capabilities into existing operational and strategic constructs will find themselves unable to take full advantage of their potential.

Predicting the character of future wars

There are few tasks more fraught than attempting to predict how radical new technologies will affect future military conflict. Perhaps above all other human endeavours, war and its precursors

are characterised by fog, friction, and uncertainty. Even if they were not, when a technology is mutating rapidly, what is true about the connection between the technology and war one year may not be true the next. A staple lesson for air power historians is that the 1930s-era assumption that bombers always get through lasted only until real-world experience in the 17 August 1943 Schweinfurt bombing raid showed that sometimes they do not. Too much confidence in the assumption that bombers would not require fighter escorts led to costly mistakes in procurement and operations. Thus, it is usually a good idea for those seeking to predict how a new technology will affect future wars to pursue their goal with a flexible mindset.

That said, there are two particular ways to develop informed opinions about how a new technology is likely to affect future military operations: deductive and inductive. The first, the deductive approach, involves examining what is known about the character of the technology and then logically deducing from that how it is likely to affect future wars. The main problem with this approach involves an ecological fallacy: what is true of the individual technology acting on its own may not be true of the technology performing in the complex interactive context of a war. For instance, even if Douhet's unalloyed theory about bomber technology and war had been correct, his argument did not stand up well in the context of the world as it was in 1943. The second, the inductive approach, involves looking at how the technology influenced previous wars and using observations gained from those cases to speculate about how it is likely to influence future wars. In the case of cyber operations, the problem with this second approach is that so far cyber capabilities have only been used in small, peripheral wars. Just as Italy's use of aerial bombing against Libya in 1911 provided a spotty guide to the use of air power in the First and Second World Wars, cyber operations in Iraq, Georgia, and Ukraine are unlikely to provide wholly reliable lessons about the role cyber capabilities will play in future wars. Nevertheless, for the past two decades, major powers have been experimenting with using cyber tools in small wars and it would be foolish to ignore these lessons. The remainder of this chapter discusses both the deductive and inductive approaches.

Attacking through cyberspace

The argument for the importance of cyber operations in war is based on the notion that most infrastructures related to national security are attached to and controlled by computer networks. Over the last two decades, mainly in pursuit of economic and military efficiency, nations have connected virtually everything affiliated with security to digital networks. A list of such vulnerabilities reads like the targeting list in a strategic bombing campaign. It includes, for instance, energy grids, communications infrastructure, financial institutions, transportation facilities, mechanised weapons systems, logistics, command and control, intelligence organisations, private industry, and population groups that receive their news and political opinions from online sources.

Theoretically, anything attached to a computer network is vulnerable to attack via cyber weapons. Over the last decade, in laboratory experiments and larger test beds, various organisations have demonstrated the ability to degrade, destroy, or take control of a wide variety of vital systems via cyber means. In 2007, for instance, the US Department of Homeland Security publicly demonstrated that it could cause a large generator to explode by hacking into the computer that controlled it (Swearingen et al. 2013). White hat hackers have subsequently demonstrated their ability to take control of airliners in flight (Zetter 2015a) and cars in motion (Greenberg 2016). In controlled experiments, researchers have demonstrated that when they could subtly control the results from Internet search engines and social media they could alter test subjects' political beliefs and actions (Epstein and Robertson 2014).

When transported from the laboratory to the battlefield, capabilities such as those described above and many others have the potential to exert a significant impact on a target's military capabilities and political will. Given this sort of experimental evidence, it seems reasonable to conclude that a state that left its networks entirely undefended would be at the mercy of an adversary with a robust ability to conduct offensive cyber operations. In a hypothetical war between a capable cyber power and a state with undefended computer networks, civilian critical infrastructure might stop working, military hardware might be manipulated, attackers might take and control of the defender's perceptions and communications, and populations might be manipulated into joining insurgencies. In short, in such a situation, an attacker with strong network attack ability would likely gain considerable military advantage from its cyber weapons.

The problem with the scenario described above is that modern states employ cyber defences. It is one thing to hack an undefended civilian jetliner or automobile; it is another to hack a bomber or tank that has secured digital systems. Militaries generally spend significant sums on cyber defences (Matthews 2016). Even when they do not, however, the private firms that build the hardware and software that connect critical systems to the Internet generally build security into their systems. These defences can make even small hacks difficult. Thus, while it is theoretically possible for a military to use offensive cyber capabilities to generate nation-crippling effect, the reality is that doing so is extraordinarily difficult.

That states defend their critical computer networks and that cyberspace is a contested domain should not be surprising. What is likely to be surprising to those not versed in cyber conflict is how states vie for control of cyberspace: how they defend their own networks and gain access to their opponents' networks. In popular literature and film, hackers are generally portrayed as computer experts acting alone or in small teams and able to penetrate enemy defences within hours or days. In fact, this popular conception of cyber conflict distorts how cyber conflict works in ways likely to undermine clear thinking about military strategy, concepts of operations, and what is needed to organise, train, and equip forces capable of contesting control of cyberspace.

The subsections that follow describe the three basic ways militaries use their cyber capabilities. The first of these involves fighting to access enemy computer networks and deny enemies access to friendly networks. The second involves generating effects against an adversary that aid the attacker but do not provoke an escalatory response from the defender – so-called phase 0 actions. The third involves using the access and effects developed earlier to assist military operations during a kinetic war. As should become apparent, the nature of cyber technology requires a mindset that is sometimes at odds with traditional approaches to war and, like the proxy-guerrilla wars of the twentieth century, may require redefining what constitutes interstate war in the cyber age.

Access and denial

The first type of cyber conflict involves gaining access to adversaries' computer networks while denying adversaries access to friendly networks. In some ways this process is similar to contests for control of other domains. One of the keys to success in this battle involves training and equipping skilled teams of computer specialists to penetrate and defeat enemy defences and to detect and intercept incoming attacks. But the analogy is imperfect in a number of ways.

The first main way the battle for access in cyberspace differs from that in other domains is that most of the specialists involved in offence and defence do not wear uniforms. The key government actors in access missions are usually intelligence organisations. While the law of

armed conflict may dictate that some missions be carried out by military units, the bulk of cyber missions require organisations dedicated to interpreting foreign languages, understanding complex physical systems, and mapping networks and social networks. These missions often require skills, mindsets, and career progressions at odds with military culture and methods. Consequently, building first-rate cyber forces generally requires alliances with business and intelligence organisations in which the military plays a comparatively minor role. The relationship between US Cyber Command and the National Security Agency offers one such example (Keffer 2017).

A second difference between the way states vie for control of traditional domains and cyberspace involves timing and sequencing of operations and the line between peace and war. The problem is that gaining access to the networks that control enemy critical systems generally requires months or years. This delay means that countries that intend to use their cyber weapons during a future war must fight for access in the years preceding the war. However, since it is seldom possible to predict specifically which nations a country will fight in the future, militaries that mean to use cyberspace in war have an incentive to contest access with numerous prospective opponents during peacetime. This contest can range from benign attempts to map adversaries' networks, to destructive attempts to sabotage servers, to warlike actions such as planting city-killing malware on critical infrastructure.

From a military perspective, the problem is that if a state chooses not to fight to gain access to potential enemies' networks during peacetime, it risks losing control of key elements of the cyber terrain in wartime. On the other hand, if it does work to gain access, it finds itself walking a fine line between reconnaissance and pre-emption, with imperfect agreement between actors about which actions fall within which definition. What appears to one state to be reconnaissance may look like a *casus belli* to another. In recent years, for instance, policy-makers in both the United States and Russia have routinely described actions in cyberspace as warlike and have even argued that their country was involved in a war based on their adversaries' actions in cyberspace (Schleifer and Walsh 2016). Understanding the nuances of these dynamics requires thinking in ways that do not always merge well with traditional notions about military contests in physical domains.

Beyond questions about pre-emption and the blurred line between peace and war, a third difference between fighting for control in traditional domains and cyberspace involves the fact that cyberspace is the only military domain entirely manufactured and owned by human beings. When a company builds a device or software platform, it often has the opportunity to build in backdoors or simply to allow friendly militaries to use its equipment. Such devices or platforms include microchips, computers, cellphones, servers, routers, cables, microwave transmitters, operating systems, software, phone apps, and virtually every other device or piece of computer code that makes up cyberspace.

In countries too small to play a major role in constructing cyberspace and in democratic countries in which business firms are free from government control, the ability of militaries to benefit from domestic construction of cyberspace is limited. However, autocratic countries with robust cyber industries that are able to force domestic companies to build software and hardware in ways that enhance their militaries' ability to gain access may gain a great deal from this dynamic. Thus, for instance, China's massive state-owned enterprises are regularly accused of building and selling various types of cyber infrastructure abroad with the goal of providing China's military with greater control of the domain (Rogers and Ruppersberger 2012).

The overall effect of the above dynamic is that the competition for control of cyberspace is not restricted to militaries and intelligence organisations. If states aspire to control cyberspace, they must also consider which private manufacturers are selling which products in which

markets. They must carefully monitor and control foreign mergers and acquisitions, trade policy, and regulations related to how cyber infrastructure is constructed. States unable or unwilling to fight in these commercial spaces are at a significant comparative disadvantage.

These characteristics of the technology and contest for control of cyberspace have led different actors to use different methods. In the broadest terms, the United States has attempted to gain access to foreign networks by using advanced technology and building allied coalitions constrained by the rule of law. Russia has similarly employed advanced technology but is generally unconstrained by legal considerations. China, by contrast, has often adopted what Federal Bureau of Investigation (FBI) Director James Comey has described as a 'kick down the door' approach. That approach involves, among other things, a barrage of unrelenting massed low-technology exploits, using state resources to purchase the private Western companies that build and maintain key elements of cyberspace, and selling equipment and services at a loss in global markets with the goal of purchasing control of the domain (Roberts 2014; Johnson 2017).

Together, the dynamics described above make the contest for access in cyberspace significantly different from the fight for control in other domains.

Generate sub-war effects

Once a nation gains access to its adversaries' networks, a second type of conflict in cyberspace involves attempts to gain economic or military benefits without provoking retaliation. The benefits nations seek from their accesses differ considerably between nations, as do the methods they employ to stay below the thresholds that are likely to stimulate an aggressive response. In general, however, states seek to take three things from each other through cyberspace operations that fall below the threshold of kinetic war.

The first use for which most states employ their cyber accesses involves espionage. Cyber espionage, like other forms of espionage, aims to provide the exploiting state with information it can use to its advantage. The main differences between cyber and older forms of espionage lie in efficiency and quantity. Using cyber methods it is often possible to pilfer a given volume of information from an adversary at a tiny fraction of the cost of getting the same information by other means. For instance, in 2014 China allegedly stole more than 20 million personnel records from the US Office of Personnel Management (OPM), including security background information. If the operation had been performed using non-cyber methods, simply having minimum wage workers carry the tons of paper out of the building would most likely have cost more than the entire real-world cyber-enabled operation. Similarly, a number of analysts have stated that cyber spies have accessed the plans of every major US weapon system. It is difficult to evaluate the military value of the exquisitely detailed information states receive from cyber espionage, but it is likely to be high.

While virtually all states employ cyberspace for state-on-state espionage, a smaller subset of nations use their military intelligence apparatus to engage in industrial espionage. Among states that use their intelligence agencies for this purpose, China stands out as a particular offender, as the amount of intellectual property (IP) it pirates and its ability to convert stolen IP into products and market share is vastly larger than that of any other state or even combination of other states. The scope of China's programme is so large that the US FBI assesses that it has accessed every major business in the United States, and the National Security Agency estimated the cost to the global economy and benefit to China's economy in the hundreds of billions of dollars per year (AFP 2014). Military power is closely linked with economic power and over the last decade China's industrial espionage programme has substantially changed the balance of military power between China and the West.

The second use for which states employ their cyber accesses involves penetrating civilian and military infrastructure. States utilise their cyber access to critical infrastructure for two main purposes. The first is to gain passive military advantage that they can employ as needed at a later date, either as a coercive threat or as a weapon in war. The second purpose is to actively attack an adversary. Commander of US Cyber Command Admiral Michael Rogers described an example of the first in Congressional testimony in 2014, when he explained that a number of countries have gained access to the US electric grid and have the ability to severely damage it, although they are not currently employing that capability for harm (Crawford 2014). It is likely that states are attempting to use similar methods against each other's military hardware, logistics, and command and control. Examples of active attacks include the Stuxnet malware (generally presumed to have been launched by the United States and Israel) to destroy nuclear centrifuges in Iran, and the Shamoon malware (generally presumed to have been launched by Iran) to destroy tens of thousands of computers in Saudi Arabia's Aramco oil company (Zetter 2015b; Bronk and Tikk-Ringas 2013).

The third use for which states employ their cyber accesses involves social and political manipulation. The goal here is to use cyber capabilities to gain some social or political advantage. The methods that democracies and autocracies use for this purpose vary significantly. In the late 2000s, democracies began to use telecommunications networks to help dissident groups in autocratic nations bypass state censorship apparatus on networks and to use cyber means to coordinate their actions. The goal behind these campaigns, as described by then-Secretary of State Hillary Clinton, was to spread democracy and succour oppressed populations (Marks 2015). Autocratic regimes, however, generally saw these campaigns as existential threats to their survival and pointed to the revolutions connected to the Arab Spring as evidence that the West was actively pursuing regime change. More recently, autocratic regimes, Russia in particular, have begun to use cyber means to create dissent and instability in democratic nations. To do this they have used a variety of methods such as 'troll factories' to disseminate online propaganda and disseminating email messages hacked from US politicians and parties to expose potentially compromising information (Sanger 2017).

All of these methods – espionage, exploiting civilian and military infrastructure, and social-political manipulation – depend on the attacker's being able to reap some reward without provoking the target to escalate. The central problem is that the rewards attackers are stealing often have strategic value so great that in previous eras they could only have been obtained by war or threat of war. China's IP piracy campaign, for instance, has cost Western companies trillions of dollars over the last decade (far more than any historical state-sponsored naval piracy campaign) and social and political manipulation campaigns may have resulted in regime change in a number of nations (something that is generally considered an act of war against the affected regime). Thus, some observers, and particularly victims, have attempted to label specific types of cyber campaigns as a form of war, while the perpetrators of these campaigns have been at pains to ensure that they are not characterised as war. Whether or not these campaigns are warlike, however, the effects they achieve in terms of lost resources and political and military advantage are at times indistinguishable from the prizes states achieve through coercive diplomacy and battle.

The dynamics described above suggest another significant difference between conventional and cyber weapons. While conventional weapons tend to produce their greatest strategic benefit either in coercive diplomacy or when used in war, cyber weapons often benefit their owners most when they are used below the threshold of kinetic war to take goods from opponents without diplomatic warning or demands.

Kinetic war

A third way militaries use cyber weapons involves kinetic wars. Despite almost two decades of experience, little is currently known about how much impact cyber operations have on conventional operations and outcomes. There is, however, some agreement about several dynamics that cyber capabilities create within the context of a kinetic war that are likely to affect its onset and execution.

One of the potential dynamics created by the existence of cyber capabilities is a 'use it or lose it' incentive. The basic problem is that states sensing an imminent attack can quickly and drastically decrease their vulnerability through such means as disconnecting vital systems. Knowing this, potential attackers have an incentive to strike first and without warning. Chinese cyber-military theorists, for instance, regularly describe surprise attacks as a necessary element of cyber conflict (Fritz 2017). These pre-emptive attacks could be digital or could involve kinetic strikes on the physical infrastructure connected to an opponent's cyber capabilities. Such incentives have the potential to lead to crisis or instability.

Another dynamic likely to influence states' calculations about the use of cyber weapons involves uncertainty. Once states begin to use their cyber capabilities, they may find that their pre-war estimates about the efficacy of their weapons are wildly off the mark. As described earlier, cyber accesses tend to be fragile and fleeting; small changes in network defences can destroy accesses even when the defender does not know the access exists. Worse yet, from the perspective of prediction, when a defender finds an adversary has gained access to its systems, it generally attempts to close off the access without alerting the attacker to the discovery. Thus, it is possible, even likely, that attackers that believe they have exquisite access to critical systems will learn in combat that their access was illusory.

Beyond access problems, uncertainty also has implications for the effects that militaries hope to achieve through cyberspace. This is particularly the case in regard to the effects militaries attempt to generate against critical infrastructure and social systems, since these are generally based on guesswork and assumptions rather than empirical testing, and thus are vulnerable to the usual problems involved with employing untested theory against large, complex and often unique systems. In this situation, Murphy's Law applies both ways. In some cases attackers may find that large cyber actions result in small real-world effects. In this context the meagre effects achieved by Iran's massive distributed denial-of-service attack on US banks in 2012 comes to mind (Perlroth and Hardy 2013). In other cases, however, defenders may find that an apparently small cause has a large effect. In this context it is worth recalling the 1998 power outage in Auckland, New Zealand, in which a broken power cable took the city's downtown area off the electric grid for five weeks, displacing 60,000 workers and 6,000 residents.

At the strategic level, cyber-related uncertainty also affects escalation dynamics. Throughout the thermonuclear age, states with nuclear weapons have worked to develop commonly understood thresholds for escalation in order to avoid general war. Where cyber weapons are concerned, it is entirely unclear where these thresholds might lie. Experience suggests that most states view attacks through cyberspace as less escalatory than kinetic attacks that achieve the same military effect. This could lead to new types of escalation patterns. It is possible to imagine two major powers fighting a limited kinetic war in a small third country while using their cyber weapons against each other's homelands. No one is likely to have much ability to predict whether such cyber-attacks could achieve the millions of deaths, economic disruption, or regime change some envision until it is tried; nor can anyone predict with much certainty whether states affected by such operations will retaliate kinetically or even, as the US Department of Defense's Defense Science Board suggests, with nuclear weapons (DSB 2013).

How likely, for instance, is a NATO-led information operation to result in regime change in Russia and how would Russia react if its regime began to crumble as a result of such a cyber operation? Even if such strategic attacks are impossible or can be deterred, however, attacks on a major power's military bases, command and control systems, satellites, and related military targets are likely to pose tricky escalatory dilemmas that states will interpret in unique ways.

Trial runs

The above discussion is based mainly on logical deduction from what is known about cyber technology. This approach has the drawback that it often proves an unreliable guide to future war when it is not checked against real-world operations. The obvious problem (in this context) is that no cases exist of first-rate cyber powers facing off against each other in physical battle. There are, however, numerous cases of first-rate cyber powers using their cyber capabilities against weaker opponents. The subsections below briefly describe six cases in which a state with significant cyber capabilities used them during kinetic military operations. These descriptions provide some hints about how states might attempt to employ cyber capabilities in kinetic wars in general.

Operation Allied Force (1999)

Perhaps the first use of cyber capabilities in war occurred during the war between NATO and Serbia in 1999. In that war, NATO overtly declared its intention to conduct the war through a bombing campaign without recourse to ground troops. While the original campaign focused mainly on military targets, over time the Coalition's strategy expanded to focus specifically on infrastructure owned by key Serbian decision-makers – Serbian President Slobodan Milošević's so-called cronies. As part of this campaign, the Coalition used telephones, fax messages, and email to inform political leaders that their private assets were being targeted and would continue to be destroyed until they persuaded Milošević to agree to the Coalition's terms. Stephen Hosmer argues that, while Serbia's elite were willing to see the country bombed, seeing their personal assets destroyed, in conjunction with personalised messages from the Coalition, helped convince them to pressure Milošević to seek terms. While the cyber and analogue methods used in the campaign are primitive by modern standards, the campaign provided evidence that oligarchical political structures, such as Serbia's, are potentially vulnerable to psychological operations that can communicate personal threats directly to leaders (Hosmer 2001; Tolbert 2006).

US-led coalition–Iraq: Operation Iraqi Freedom (2003)

The second case of cyber capabilities being used in war follows a pattern similar to the first. In the years leading up to the 2003 US-led invasion of Iraq, the Coalition spent considerable time probing Iraq's analogue and digital networks to locate and communicate with individual Iraqi civilian and military leaders. The point of these communications was to subvert Iraq's political and military command and control structure and to sow distrust among the Iraqi leadership. The campaign included various instructions, threats, and promises aimed at individual Iraqi leaders. The campaign was effective in achieving both its goals. In order to disrupt the effort, Iraqi President Saddam Hussein was forced to take measures that cut communications networks, thus crippling the military's command and control systems. Even so, a large number of Iraqi civilian and military leaders followed the Coalition's instructions, deserting their

commands and instructing their soldiers to desert. In total, around 85 per cent of Iraqi soldiers deserted before their units encountered coalition ground troops (Andres 2007; Gray 2009).

Israel–Lebanon War (2006)

A third case that provides some hints about the effectiveness of cyber operations in war involves the Israel–Lebanon War of 2006. Apparently following the example set by the US-led coalition in Iraq three years earlier, Israel employed a campaign to locate and communicate with members of its opponent's forces using their cellular telephones. According to William Arkin's account, the campaign met with mixed results but accomplished nothing resembling the success achieved in the Iraq War (Arkin 2006: ch. 6). The reasons for the limited effectiveness of the campaign most likely lie in the different organisational structures employed by Iraq and Hezbollah (Hezbollah did not employ a brittle hierarchical C2 structure), and the differences in the ability of the US-led Coalition and Israeli military to back messages with credible threats and promises.

Israel–Syria: Operation Orchard (2007)

While the previous cases described ways states used cyber methods for psychological purposes, Israel's 2007 execution of Operation Orchard involved a cyber-attack on physical military infrastructure. In the operation, Israel used digital means to disable Syrian air defences while it bombed a Syrian nuclear reactor. While there is debate about the specific means Israel used to disable Syrian defences, the notion that Syria's Russian-made integrated air defence system was vulnerable to cyber-attack carries with it warnings about the vulnerability of military infrastructure in general (Clarke and Knake 2011: ch. 1; Fulghum and Wall 2007).

Russia–Georgia War (2007)

In 2008, Russia took use of cyber operations to a new level during its invasion of Georgia. In the weeks preceding the invasion, Russia appears to have orchestrated groups of civilian patriotic hackers to launch various types of attacks on Georgian computer networks. These pre-invasion operations were most likely intended to map network vulnerabilities, degrade the government's ability to communicate internally and externally, support Russia's public affairs and psychological operations, and obscure Russian government cyber operations. In the hours preceding the physical invasion, operations accelerated to the point that they significantly degraded Georgia's ability to act at both strategic and operational levels. At the time of the invasion, Georgia had virtually no domestic cyber capability, which made access to its networks easier for the attacker but limited what it could accomplish with the networks it accessed. Although the cyber portion of the invasion appears to have aided Russia, Russia's physical overmatch was so great that it would be difficult to draw lessons about how large a role cyber operations played in the success of the invasion.

Russia–Ukraine (2014)

Russia's 2014 military operations against Ukraine represented an evolution and expansion of those used seven years earlier against Georgia. In the years leading up to the operations, Russia gained what appears to be exquisite access to Ukraine's networks, mainly because it had built the commercial infrastructure. In the months preceding military operations it conducted cyber

psychological operations using troll armies and disinformation aimed at populations within Ukraine. In Ukraine's August 2014 election a proxy, CyberBerkut, hacked election infrastructure but the hack was detected and the results ignored (Coker and Sonne 2015). In military operations in Crimea and Donbass, Russia used its access to Ukrainian networks to hinder military and police communications during Ukrainian operations and as a source of intelligence for Russian operations. In ensuing years, Russia conducted cyber-supported psychological–political operations against the United States and Europe that included disinformation and election tampering. Overall, although Russia's actions in cyberspace are shrouded, they appear to have significantly assisted Russia's non-cyber operations.

Assessing the empirical record

The above cases provide some examples of ways first-rate cyber powers have used their capabilities in kinetic war and some tantalising hints about the role of cyber capabilities in future wars. States have used their cyber capabilities to aid coercive operations, to persuade soldiers to desert, to track enemy operations, to deactivate enemy air defences, to attack critical infrastructure, and to cut off opponents from potential allies. At times these operations have clearly had major effects, but more often their effects on operational and strategic outcomes have proven difficult to assess.

These cases have generally involved attackers with substantial cyber capabilities going against defenders with few defences. Moreover, in most or all of these encounters, it is likely that the attacking states kept a portion of their capabilities in reserve, being unwilling to expose them to their major power opponents. Thus, the empirical record as it exists today provides clues about what cyber operations might look like in wars between capable adversaries. On the one hand, it fosters the illusion that access will be relatively easy and, on the other, may not really show what cyber weapons can accomplish when used without restrictions. Thus, the empirical record should be read with caution.

Conclusion

This chapter has provided readers with a rough idea about how cyber conflict works and, in particular, suggested key differences between cyber and conventional conflict. To utilise cyber capabilities effectively, national decision-makers must understand the unique character of cyber conflict. They must understand that access operations often require years, that cyber operations often yield their greatest political and economic results in operations short of kinetic war, and that the use of cyber weapons in war is characterised by uniquely high levels of uncertainty.

These characteristics of cyber operations have significant implications for how states should think about organising, training, and equipping their cyber forces. For a military to be effective in this domain, it must build robust partnerships between intelligence organisations and industry in which the military will often be required to take a back seat. It must create capabilities that are technically and legally capable of operating within adversaries' national borders when war has not been declared. Further, it must develop a culture that encourages not only technical acumen, but also the type of flexible mindset capable of dealing responsibly with deep-seated tactical, operational, and strategic ambiguity.

Over the last two decades, cyber operations have proven capable of creating significant military and geopolitical effects. As the world continues to attach national security infrastructure to computer networks, the military's role in the domain is likely to increase. As states work to develop capable cyber forces they would do well to understand the unique and radical

nature of cyber technology as a military capability and build their new forces to meet the unique nature of the challenge.

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18

AIR POWER IN INTERAGENCY OPERATIONS

James S. Corum

Interagency operations have become a major feature of modern conflict. Throughout the Cold War, and especially since the terror attacks of 9/11, the United States and other Western nations have faced an array of unconventional threats and enemies that cannot be effectively countered and defeated by conventional military organisations and methods.

Air power has played a key role in fighting unconventional enemies and in supporting Western nations' own unconventional forces. However, non-conventional conflicts require organisations and doctrines that include personnel and resources outside the military forces and organisations that have evolved over the last sixty years. Interagency organisations contain a mix of civilian and military personnel who focus on a specific mission. A true interagency organisations is not just a military organisation with civilian employees, but is organised into groups and teams based on function and expertise in which personnel from military and civilian agencies are fully integrated, with civilians routinely supervising military personnel and vice versa.

Over time Western nations have developed integrated civilian–military organisations for unconventional conflict, such as the British committee system developed during the Malaya counterinsurgency effort (1948–1957), in which military and civilian personnel working together coordinated the counter-insurgency effort with great success. However, a long evolution was required to reach an interagency system and the United States, with its large forces and resources, has been the major Western power to employ the interagency concept as a major tool on conflict. In recent years the best example of using the interagency approach has been the United States' development of the Interagency Task Force, an organisation that plays a central role in current conflicts.

This chapter examines the evolution of the interagency concept in modern conflict and the role that air power has played in interagency operations. It examines the beginnings of air power operations in partnership with civilian agencies in the Cold War that set an early model for the US Air Force (USAF). The interagency concept evolved during the Vietnam War, which saw the first true interagency operations, and was revived to deal with irregular threats to the United States in the war on drugs in the 1990s. Finally, the interagency construct has become an indispensable organisation for waging modern conflict and in each step of the evolution of the concept the role of air power has expanded.

Cold War: air power support to intelligence agencies

Air Force support to intelligence operations conducting clandestine operations was the foundation of the early interagency operations. In 1943 General Eisenhower, then Supreme Commander of the Allied Forces in the Mediterranean, directed the US Army Air Forces (USAAF) to allocate a small number of bombers and transports to support the resistance forces inside occupied Europe. The Office of Strategic Services (OSS), which directed support to anti-Nazi partisans mainly in France, Italy and Yugoslavia, required aircraft that could penetrate German-controlled airspace at night and parachute agents and commando teams to work with partisan forces. At times, transport planes would land on rough, clandestine airfields behind the lines to deliver personnel, arms and supplies. These secret operations required specially trained aircrew as well as modifications to aircraft. To fly alone and at night, and to find drop zones and clandestine airfields (usually, farm fields marked with lights and small fires) required exceptional piloting and navigational skills (Moore 1992).

From these small beginnings, the USAAF in Europe eventually fielded a specialist wing of one hundred aircraft to support OSS operations behind enemy lines throughout southern and western Europe. The greatest success of the 'Carpetbagger' operations in support of the resistance forces was in supplying and supporting the French resistance in the summer of 1944. The resistance fighters were assisted by small teams of Allied officers and non-commissioned officers (NCOs) who trained the resistance fighters and provided vital liaison. As the Allies fought in Normandy, thousands of German troops, including whole divisions, were tied up in fighting the well-supplied French resistance forces in the highlands of south central and eastern France. Resistance units also caused havoc with German road and rail communications (Moore 1992). Across the world in the Burma Theatre the USAAF created a similar organisation, the 1st Air Commando Wing, that supported the anti-Japanese Burmese guerrillas deep behind enemy lines.

During the 1944–45 Allied campaign in Burma the air-supplied and -supported guerrilla forces disrupted enemy operations and tied down thousands of Japanese who would otherwise have been deployed against the Allied forces fighting their way into Burma (Y'Blood 2014). In neither case were the air-supported irregular forces a decisive factor in the campaigns, but in both cases these forces made a significant contribution to the Allied victories by disrupting enemy logistics and diverting enemy forces. Despite their success, at the end of the Second World War these highly specialised air units were disbanded. However, they were soon revived with the onset of the Korean War and the rise of the Soviet threat in Europe, which demonstrated a clear need for the Air Force to assist the civilian intelligence agencies to carry out their clandestine operations.

The United States created the Central Intelligence Agency (CIA) out of the intelligence agencies formed in the Second World War in the grand reorganisation of the American national security system in 1947. The Air Force, which was established as an independent service in 1947, already had a history of providing specialised air support to the OSS, the forerunner to the CIA, during the Second World War. In the early Cold War period of the 1950s, the USAF and CIA developed a close partnership in order to conduct unconventional operations against Communist states. While not a true interagency model in the current sense, the work of the Air Force in partnering with a civilian agency was an important and essential step in the development of the interagency system used today.

During the Korean War the USAF's special operations force, modelled on the special operations groups formed in the Second World War, was substantially increased. In the aftermath of the Korean War the US military again reduced the special operations forces, but still main -

tained a few small and highly secret Air Force units organised to conduct special operations missions for the CIA. At a time when the USAF was oriented around nuclear-capable bombers such as the B-52 and was rapidly developing an intercontinental nuclear missile force, at the other end of the spectrum in the 1950s and 1960s the US Air Force special operations units operated some highly specialised but low-technology equipment such as the SA-16 Albatross flying boat, a simple radial-engine aircraft that cruised at 140 knots, but also had an endurance of sixteen hours and was capable of landing on small bodies of water.

With the waters and airspace of the Warsaw Pact countries closely guarded and the land borders heavily mined and patrolled the Albatross flying boat, painted black for night operations and with the exhaust shielded to reduce engine flame, offered the best means of infiltrating agents and exfiltrating defectors and agents from behind the Iron Curtain. One account of these Cold War operations describes a typical operation of the 1950s in which an SA-16 Albatross flew in low under Soviet radar in order to land at night on an isolated lake in the Balkans to pick up and drop off agents. Such operations continued into the 1960s with the Soviets not suspecting that their airspace was being invaded by the CIA/USAF (Haas 1997: 119–120). The success of the special operations airmen in penetrating Soviet-controlled airspace is a testament to the exceptional piloting and navigation training of the small special operations forces.

During the Cold War one of the most difficult of the USAF special operations with the CIA was the campaign to support the Tibetan guerrilla army that waged a decade-long war to oppose the Chinse invasion of their country which began in 1950. This operation was highly sensitive in that the CIA and US Air Force had to use bases in allied nations such as Thailand and the mission required overflying neutral countries such as Burma and Nepal. Supporting the Tibetan guerrilla army, which grew to an 80,000-man force, required exceptionally long-range flights over some of the worst terrain in the world. The region between Thailand and Tibet was largely unmapped jungle and mountains. The area was also beset by sudden storms that hit with terrific force. Because the operation was so sensitive and secret there could be no network of emergency airfields, nor could the USAF mount a search and rescue effort if a plane went down. Of course, there were no navigation aids to help the American airmen navigate over endless jungle and then over some of the highest mountains in the world.

The Tibetan operation revolved around flying arms and supplies to the guerrillas as well as flying back to Tibet guerrillas who had undergone training in secret US military facilities outside Tibet. The initial missions to supply the Tibetans used the C-118 transport: a good plane for the time but with a relatively small payload, which limited the supplies and arms that could be flown into Tibet. In 1957 the USAF assigned some C-124 Globemaster transports to fly to Tibet and fly out Tibetans for guerrilla training. The USAF dramatically improved its ability to support the Tibetans when some of the first models of the C-130 transport were assigned to the special operations forces for the Tibetan mission. With the C-130 the special operations units supporting the CIA-led effort had an aircraft with the performance and payload to be truly effective.

The year 1959 saw one of the most dramatic episodes of the CIA/USAF operation when the US-trained Tibetan guerrillas (who had been flown back to Tibet after training outside the country) helped the legitimate spiritual and state leader of Tibet, the Dalai Lama, to escape the careful watch of the Chinese Army and make his way for hundreds of miles through tortuous mountain passes to the Indian border. The Dalai Lama was guarded by the US-trained and equipped guerrillas and he and his escort were sustained by supply drops by the C-130s that enabled his successful escape from the Communists (Haas 1994: 28–31).

The Tibetan operation ended in May 1960 when a large force of the Chinese Army was deployed to Tibet to crush the insurgency. The Chinese pressure against the Tibetans became

so overwhelming that continuing the resistance against the Chinese invaders was considered hopeless (ibid.: 31). Still, for a decade the CIA/ USAF partnership played a key role in enabling the Tibetan resistance. The Tibet operation, more than any other Cold War operation, demonstrated the ability of the USAF to support the clandestine operations of the intelligence service, even under incredibly difficult conditions. Remarkably, the USAF lost no transport aircraft during the Tibetan operation. The loss of any transport would have resulted in a diplomatic incident with several countries. This amazing record is testimony to the exceptional planning and training of the small USAF special operations units.

Vietnam: the first true interagency operations

The Vietnam War pushed the concept of interagency operations to a new level. In Vietnam, the United States found itself fighting two wars, both of which it had to win. The first war was against the conventional forces of North Vietnam, and required the military services to fight the kind of battles for which they were trained and equipped. The second war was broader, and harder to define. This was the war against the Viet Cong guerrillas, who lived and operated among the mainly rural population of South Vietnam. While the Viet Cong had a cadre of full-time leaders and some regular forces, many of the Viet Cong were part-time guerrillas who carried on their lives as peasants, but were also ready to conduct small-scale operations: setting ambushes, deploying booby traps, assassinating government officials, and harassing the government troops. The Viet Cong operated in a largely friendly environment with many South Vietnamese willing to provide the Viet Cong with information, food and shelter. Other South Vietnamese were coerced into paying taxes and providing supplies to the Viet Cong.

While the conventional war against the North Vietnamese was the main focus of the US military, defeating the Viet Cong required a host of non-military resources focused on supporting the South Vietnamese civil government in the rural areas. The US campaign in the countryside included executing aid programmes to improve farming and small business, advising and supporting the South Vietnamese civil agencies that provided basic services and medical care, improving the local infrastructure, and conducting a pro-government propaganda campaign. The US aid programmes required civilian expertise and leadership, which they found in civilian agencies such as the US State Department, the CIA and the US Information Agency. At the same time, the civilians had to work closely with the corps of military advisers who were responsible for standing up and training the South Vietnamese local security forces.

By 1967, with the conventional military effort in South Vietnam expanding, the war against the Viet Cong was going poorly. The Viet Cong, who had created a very effective shadow government, was rapidly expanding its recruitment and influence. The weakness of the South Vietnamese government and its police and local self-defence forces allowed the Viet Cong to effectively control large parts of the countryside (Hunt 1995: 6–7).

The US military leadership under command of General Westmoreland (Commander, Military Assistance Command Vietnam, or MACV) understood that the military was unsuited to coordinating a mainly civilian-focused effort in the countryside. The answer to the problem was provided by a senior CIA officer, Robert W. Komer, who proposed a single agency combining military and civilian personnel to manage the American support of the South Vietnamese in the countryside.

In 1967 the United States created CORDS (Civil Operations and Revolutionary Development Support), with Komer as director. At every level the rural pacification effort would be under one person, with civilian and military personnel intermixed. CORDS developed into a highly effective interagency organisation to support the South Vietnamese effort in the

countryside. The agency came to oversee the South Vietnamese regional forces, psychological operations, public administration and rural health care. The CORDS programme, through effective coordination of effort, played a central role in breaking the power of the Viet Cong in the countryside. Viet Cong membership declined between 1968 and 1972, and the Viet Cong in guerrilla units declined from 77,000 in January 1968 to 25,000 in May 1972 (Hunt 1995: 252–253). As the Viet Cong declined, the government presence in the countryside improved, as did the security and living standards of the rural population.

Creating CORDS was no easy process, and the CORDS organisation exhibited problems that would bedevil all interagency organisations that came after. In essence, CORDS was more of a coordination system than an independent agency, since it did not have its own resources. The State Department provided personnel and funding via its aid budget, and the military provided personnel, equipment and funding for programmes to develop the local South Vietnamese security forces. The CIA provided personnel as well. Considerable friction occurred at first in an organisation where many State Department and CIA civilians came under the direct command of military officers, while many military personnel ended up being commanded by civilians. However, Robert Komer proved an effective leader and made the new organisation work.

During the critical period after the Tet Offensive, CORDS took over the entire effort to develop and train the South Vietnamese regional and part-time forces tasked with local security in the rural effort. This included managing the advisory effort and working with South Vietnamese officials at every level. It was a difficult task in that the CORDS personnel could influence the South Vietnamese, yet not directly command them. Still, the effectiveness of CORDS in carrying out its mission cannot be denied. In the years 1968 until the American departure from Vietnam in 1973, the security situation in the countryside dramatically improved. In the spring of 1972, when the North Vietnamese Army (NVA) mounted a major offensive, the South Vietnamese regional forces, trained and advised by CORDS personnel, performed far better than they had during the 1968 Tet Offensive. Whereas the Viet Cong irregular forces had been a centrepiece of the 1968 campaign, in the 1972 offensive the Viet Cong played only a minor role. In contrast to 1968, in 1972–1973 the rural areas of South Vietnam were mostly under clear control of the South Vietnamese government.

Air power is part of the CORDS story in that CORDS, while a mixed military and civilian agency, reported to MACV and ultimately came under the command of the military theatre commander. This meant that CORDS received air transport support from the USAF, a necessity for maintaining small CORDS teams in isolated areas of South Vietnam. Being tied into the MACV chain of command and communications net meant that CORDS provincial advisers, both civilians and military, could call in American and South Vietnamese air strikes in case of an NVA or Viet Cong attack.

The ability of the CORDS personnel to call for air strikes played a key role in the defeat of the 1972 North Vietnamese Spring Offensive. Since nearly all the American combat ground troops had been withdrawn from Vietnam by 1972, the NVA believed that the time was right for a major ground offensive. Instead of fighting the American forces that had decimated the Viet Cong and North Vietnamese forces during the 1968 Offensive, the NVA would now face only the South Vietnamese Army and the regional forces – forces they had easily beaten in the past. However, thanks to CORDS, the South Vietnamese forces were better trained and prepared than in the past, and CORDS personnel could still call on the very considerable American air power still available in the theatre. The combination of effective South Vietnamese forces, backed up by US air power and often coordinated through CORDS provincial advisers, proved deadly to the North Vietnamese. Despite conducting a massive effort that included tanks

and heavy artillery, the NVA managed to overrun only one South Vietnamese provincial capital – and this was later retaken (Wilbanks 2004: ch. 6).

With the NVA's bloody setback in 1972 and the improvement of South Vietnam's security situation, the US could negotiate a withdrawal of its forces from Vietnam in early 1973, turning the war effort over to the South Vietnamese. Unfortunately, in early 1975 the North Vietnamese initiated a massive conventional invasion of South Vietnam, spearheaded by large armoured and mechanised forces backed up with heavy artillery and a mobile layered air defence system. Unable to cope with a true blitzkrieg by regular forces, the South Vietnamese military collapsed – and with it, the entire country.

Ironically, despite the myth that the United States is not effective in counterinsurgency operations, the Americans and South Vietnamese had actually crushed the guerrilla insurgents of the Viet Cong and secured the countryside for the government by 1972 – and CORDS deserves a great deal of the credit. Yet, in the aftermath of Vietnam, few in the US government wanted to look at the positive lessons that came from the war – and the CORDS interagency model was one of the real successes of the Vietnam War. It would be two decades before the interagency concept would be revived to fight a new kind of war.

The Joint Interagency Task Force and the war on drugs

With a crime epidemic at home that was fuelled by drugs and the drug trade, and with nations such as Colombia and Peru becoming destabilised by the drug trade, it was clear by the early 1990s that something different from the traditional law enforcement model was needed to face a crime problem with major international implications. This does not mean that no effort was being devoted to the war on drugs. The Drug Enforcement Agency (DEA), Border Patrol, Federal Bureau of Investigation (FBI) and Coast Guard were all involved in countering the drug trade.

The CIA and military provided intelligence, while the State Department oversaw aid to Latin American police forces. Yet despite a major effort by US law enforcement agencies the problems continued. Congress, concerned about the continuing rise of the drug trade and its destructive cartels, held hearings to see if a better use could be made of the efforts by the federal law enforcement agencies. One obvious problem was the lack of coordinated effort by the many agencies involved. As explained by Coast Guard Rear Admiral Andrew Granzuno and echoed by a host of senior officers in US Congressional hearings, 'There is no one in charge' of the drug interdiction campaign, and this was a key factor to drive some radical changes (Presidential Decision Directive PDD14 1996). Another factor encouraging a more concerted effort was the change made by the US government in looking at the drug trade as an international security issue. Indeed, by the early 1990s, the focus in the war on drugs turned to interdiction (reducing the supply), and this meant going after the production and distribution of the drugs at their source and not just dealing with the drugs later as a law enforcement or border protection issue (ibid.).

With this new national security focus, the US government turned to the interagency concept that would become the key tool in fighting international drug trafficking. In 1994 President Clinton signed Presidential Decision Directive 14, National Drug Policy, that set up three US Joint Interagency Task Forces (JIATFs) responsible for the Latin American, Caribbean and Pacific regions that would serve as organisations specifically designed to coordinate the counterdrug and interdiction operations. In 1997, as the US pulled forces out of Panama to comply with the turnover of the Panama Canal, the then-JIATF South (headquartered in Panama) was combined with the JIATF East (headquarters in Key West,

Florida) and became the new JIATF-South. The JIATF was an entirely new organisation for the United States and was designed to formally integrate personnel and capabilities of the US military, the US Coast Guard (Department of Transportation), the Customs Service (Department of the Treasury, the DEA (Justice Department), the FBI (Justice Department), and intelligence agencies such as the CIA, National Security Agency (NSA) and Defense Intelligence Agency (DIA). Because the Caribbean region also included the overseas territories of America's NATO allies France, the UK and the Netherlands, those countries also became involved with the JIATF South.

The JIATFs have for the counter-drug campaign had a carefully designed command and organisational structure that required the full integration of the civilian agencies and military. For example, the largest of the JIATFs, JIATF South (responsible for the Caribbean region), is commanded by a Coast Guard rear admiral. This makes sense, as the US Coast Guard itself is a hybrid organisation, serving not only as a US military force but also having civilian duties in regulating and policing shipping. While the Navy, as a military force, is not normally tasked with law enforcement duties the Coast Guard is, and Coast Guard personnel, unlike Navy personnel, have arrest authority and are well trained in the duties of enforcing the law at sea. Other sections of the headquarters are allotted to other services and agencies.

The deputy commander is a US Navy rear admiral, the vice director is a senior Customs agency officer, another vice director is a senior FBI agent, and the chief of staff of the JIATF South is a US Air Force colonel. The headquarters looks much like a military command with a J-2 Intelligence section, a J-3 Operations section, a J-4 Logistics section, and a J-5 Plans section. However, the JIATF also has sections not found in a normal military organisation, to include a J-9 International Affairs section. Because of the nature of its mission the JIATF South contains specialist liaison officers from the military and intelligence services and also from foreign allies – namely the Dutch, British and French, who provided naval and air units to support the task force.

The heart of the JIATF is the operations command centre where the intelligence and operations are fully integrated. The Task Force is able to access and analyse intelligence from every source: human intelligence, signals intelligence, imagery intelligence, and air and space surveillance. Intelligence is provided through the Task Force's own assets, but mainly through direct liaison with law enforcement agencies and military commands. The Air Force liaison officer, for example, can request Air Force Space Command's support for imagery and surveillance. In the intelligence centre of the Task Force civilians and military personnel are fully integrated into functional teams. Monitoring shipping and air traffic, for instance, one might find a Marine sitting next to an Air Force NCO with a DIA civilian serving as the section leader. JIATF South has its own resources to mount operations, with naval and Coast Guard vessels, and military aircraft, military and law enforcement personnel organised into three task groups to operate in sectors of the Caribbean. Allied nations are full partners in the mission, with a flag officer from the Netherlands commanding one of the task force groups involved in patrol and drug interdiction. French and British air and naval and police forces also participate in the task groups (Marine Nationale 2011). However, if the situation requires more assets and assistance the JIATF can, as a military organisation, access available military units to support specific operations.

Air power plays a central role in the work of the JIATF, mainly in the form of air and space reconnaissance and surveillance of the vast region. Once a likely drug shipment by sea or air is identified, air assets track the suspicious vessel or aircraft and often helicopter units are employed in the interdiction and seizure of drug shipments. For this reason the chief of staff slot is filled by an Air Force colonel, and Air Force liaison and intelligence personnel are

assigned to the command centre. Other Air Force assets are integrated into the Task Force's three groups.

In the more than two decades since the JIATF South and West were developed, they have demonstrated their value in integrating military and civilian agency assets, as well as foreign forces, into one highly efficient organisation. The JIATF South and West did not end the drug trade, but their work did noticeably increase the amount of drugs interdicted and the number of drug smugglers arrested. They have forced drug cartels to move to new, less efficient transport routes and have put pressure on the insurgent forces that used the drug trade as their means of finance and support. Colombia and Peru are far more stable nations since the more effective counterdrug strategy of the 1990s, and the JIATFs can take some of the credit.

Air power and the JIATF in the war on terror

The international interventions of the 1990s highlighted the need for military and civilian agencies to work together more effectively. The end of the Cold War did not bring the expected era of peace, but instead unleashed a high level of international disorder. The implosion of various countries required international intervention led by military forces. These types of operations had been conducted before, but usually on a limited scale. However, the 1990s saw a series of crises erupt from Africa to Latin America to Europe and each crisis required a strong military response initially, with a strong follow-on response from civilian agencies to stabilise the country affected and assist it to restore services and government functions. In most cases these interventions required first dealing with large numbers of refugees and whole communities in dire need of medical aid and food. In the 1990s both the US-led interventions in Panama (1990) and Haiti (1995) and the NATO-led interventions in Bosnia (1995) and Kosovo (1999) required the deployment of significant numbers of military personnel, accompanied by aid workers and civilian agencies from supporting governments, or put under contract by the United States and NATO. The interventions in Haiti, Bosnia and Kosovo required long periods to control the chaotic and lawless conditions and to assist the local populations to return to a stable civilian life.

Neither the United States nor the European nations had an effective interagency doctrine or organisation to provide the command and control for military and civilian government agencies to operate together. The lack of a military/civilian command and control system meant that various ad hoc systems were thrown together that, frankly, did not work effectively. In the case of the US interventions in Panama and Haiti the US State Department, which oversees aid to foreign nations as well as law enforcement training missions, was completely unprepared to support the oversight and training of local law enforcement, and was unready to assist in the rebuilding of government and other nation-building measures. The immediate distribution of food and provision of emergency health care was successful, but the long-term stability operations remained a problem (Pope 2014: 79–81). Part of the problem was rivalry and competition between agencies, exacerbated by insufficient planning and resources for sustained aid to government.

As in the early years of the war on drugs, it was often unclear who was actually in charge. The National Security Council, charged with ensuring that military and civilian agencies are coordinated at the strategic level, failed to work out any effective command and control for military and civilian agencies (ibid.: 57). Unfortunately, the later military/civilian stability operations in Iraq and Afghanistan were still carried out with an ad hoc command and control system as multiple agencies led separate efforts with little overall coordination (ibid.: 84, 90). Another study of the problems in military/civilian agency coordination in the 1990s and into

the 2003 Iraq War pointed out the friction over the roles of the agencies in stability operations as these were not clearly defined. Without clear direction from the top (National Security Council) the agencies were left without clear lines of command and authority in conducting vital missions (Rast 2004: 247–248). In short, the US military and civilian leadership were still struggling with a model of how to coordinate military and civilian efforts.

Fighting the global terrorist network of al-Qaeda after 2001 became a top priority of the United States. With al-Qaeda and allied radical Islamist factions the Americans were dealing with a new kind of enemy. Not only were America and Coalition partners facing local insurgents in Afghanistan and Iraq, but in Iraq the Coalition forces also faced well-trained and financed foreign fighters who had flocked to Iraq to join the local factions fighting the Coalition forces trying to stabilise the country in the aftermath of the 2003 conventional war that toppled Saddam Hussein's regime. Many of the foreign fighters joined a force called al-Qaeda in Iraq under the leadership of a Jordanian jihadist, Abu Musab al-Zarqawi. The professional jihadists took advantage of the chaotic situation in Iraq to increase the level of violence and to push Iraq into a full scale Sunni–Shia civil war that would have ended any hope for a stable nation.

Al-Qaeda in Iraq could call on the global network of al-Qaeda for support and legitimacy. Early in the conflict the United States responded by setting up a Special Operations task force, Task Force 714, directed to conduct operations against al-Qaeda and its leadership throughout the area of responsibility of Central Command (CENTCOM). However, it was soon clear that far more than special operations and the military intelligence assets would be needed to fight a sophisticated international enemy that operated underground and worked through a network of small groups.

In 2004 Task Force 714 was reorganised as a JIATF that would include not only military personnel from all the services, but also civilian personnel from the CIA and DIA. As with the JIATFs conducting the drug interdiction campaign, the civilian and military intelligence personnel were fully intermixed in functional teams and CIA paramilitary and support personnel were integrated into the operational and support forces. Again, as with the anti-drug interagency task forces, the intelligence and operations centres were combined into one large operations centre. This meant that priority intelligence information developed by the collection and analysis teams could be passed on to operations immediately. While often missions were conducted after a careful planning process, in war conditions the intelligence acquired sometimes demanded immediate action; otherwise opportunities to capture or kill terrorist leaders and groups might be lost.

The United States set up two interagency task forces to focus on different parts of the war on terrorism. JIATF East was based at Bagram Air Base in Afghanistan and focused on al-Qaeda leadership in Central Asia. JIATF West was based at the huge Balad Air Base forty miles north of Baghdad and focused on fighting the al-Qaeda forces in Iraq. Both were under the direction of General Stanley McChrystal, a highly experienced special operations officer who had a knack for unusual missions. In his memoirs General McChrystal described the long process of building the JIATFs into effective teams that could process large amounts of intelligence and act quickly upon it. Like the counter-drug interagency task forces, the JIATF in Iraq had its own Special Forces units assigned to it, but the effective liaison with the other services also meant that air and ground units in the theatre could be immediately tasked for missions. Air power provided an essential capability to the JIATF West in the form of surveillance through aircraft and mostly unmanned aerial vehicles, whose long endurance provided the capability to observe and follow targets for twelve or more hours at a time. When raids were required helicopter-borne special operations teams were at hand and aircraft could be tasked at a

moment's notice. Starting with a very limited intelligence picture of Iraq and the al-Qaeda threat, by 2005 the JIATF West was becoming effective in developing focused analysis that gave the Coalition Forces an accurate view of the terrorist networks. This intelligence enabled the strike forces to take down key parts of the al-Qaeda organisation (McChrystal 2013).

A key event in June 2006 demonstrated the importance of air power in the surveillance and strike roles. The leader of al-Qaeda in Iraq had long been the main target of JIATF West. One mullah known to be a close adviser of al-Zarqawi and to meet with him regularly was put under surveillance by an unmanned aerial system (UAS). A young civilian analyst working on the surveillance team noticed the mullah moving out with several associates. Immediately the other surveillance teams were alerted and strike forces put on standby. Other surveillance aircraft were diverted immediately to support this high-priority mission. Al-Zarqawi's mullah drove some distance from Baghdad and met al-Zarqawi in a small restaurant.

Two groups emerged and climbed into two vehicles, which took off in different directions. Helicopter-borne Special Forces teams intercepted one vehicle and captured the drivers, but they were low-level operatives. The other vehicle with the mullah/adviser took a side road to an isolated farm compound. Knowing that this was al-Zarqawi's headquarters and as it was nearing dusk, and would have required a large force to properly surround the compound at night, the decision was made to call in an F-16 air strike, which pulverised the farm house with two 500-lb precision bombs. A Special Forces team arrived minutes later to find al-Zarqawi dying, as well as a trove of documents in the compound. The loss of al-Qaeda's charismatic leader was a major blow to the foreign jihadi forces operating in Iraq. The strike on al-Zarqawi showed how the JIATF, which fully integrated intelligence with operations and had the right mix of air assets available, could put a complex operation together with no notice and rapidly adjust the mission to achieve full success (McChrystal 2015: 130–131, 235–242). No other kind of organisation can employ this kind of flexibility and integrate air power so efficiently into operations.

Conclusion

Interagency operations have become one of the major tools in modern conflicts with irregular enemies. The interagency organisation has proven its worth as means of effective command and control for air, ground and sea assets. Western nations will see extensive use of interagency operations in the future and air power will be a major part of these operations. However, in the years since the Cold War some key lessons have been learned about interagency operations. First of all, civilian and military agencies do not naturally work well with each other and one can expect considerable organisational friction in any interagency operation. Secondly, building an effective interagency organisation requires leaders who can understand civilian and military cultures and who are willing to work well outside their comfort zone to integrate different agencies into one well-running organisation. Third, ad hoc interagency organisations have not been effective. To use all the military and civilian assets well and to ensure full cooperation from the participating agencies, the joint interagency task force needs to be clearly focused and have a clearly defined mission. The tasks of all the participating agencies have to be carefully spelled out to ensure clarity of the mission as well as ensure that the participating agencies fully support the task force.

True interagency operations are difficult to conduct as they require the permanent allocation of significant resources and personnel from both military and civilian agencies who must then learn to operate as members of one team. As military and civilian agencies are not used to working together under one chain of command, creating and training an effective

organisation requires a unique kind of leadership as well as a commitment from the participating agencies to overcome their own institutional cultures. This chapter focused on the American use of air power and interagency operations because, to date, only the United States has had the will to commit the necessary resources and personnel to build effective interagency task forces. Allied nations, however, have participated in the interagency process in organisations such as JIATF South, where British, French and Dutch forces have been part of, and even led, the task groups working for JIATF South. So even if allied nations do not set up their own interagency task forces, they need to fully understand the interagency task force organisation and system. Interagency organisations have proven to be a highly effective answer to meeting many of the challenges of modern irregular conflicts and air power has played, and will continue to play, a key role in interagency organisations.

However, one lesson is clear from the history of interagency organisations and that is the importance of full commitment of both military and civilian agencies and the importance of a clearly focused mission. Ad hoc and temporary interagency organisations created from diverse civilian and military assets and without clear command lines and mission focus will not perform effectively.

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PART IV

Political–social–economic environment

Air power in its strategic context



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19

COMBAT AIR POWER AND POLITICAL EFFECT

Michael Clarke

Warfare is inherently political and the use of air power in any military conflict, in whatever way it is applied, carries more political overtones and sensitivities than most other military instruments. Since the end of the Cold War many different types of conflicts have occurred across the world. In the most overt conflicts of the last thirty years nations have used air power to shape the battlespace before a ground campaign; to supply the battlespace; to offer close air support (CAS) to forces on the ground plus battlefield and deep air interdiction; to provide the bulk of intelligence, surveillance, target acquisition and reconnaissance (ISTAR) assets for all forces engaged in operations; to exert coercive effects; and to symbolise the nation's depth of commitment to a campaign.[1] In the more indirect and proxy conflicts over the same period the use of air power has served to back up proxy forces through both strategic bombing and CAS; to maximise a military commitment that in operational terms is relatively minimal; to convince a domestic audience that a government is committed to a campaign where it is not prepared to take too many risks or sustain casualties in significant numbers; and to demonstrate deterrence, both within a conflict zone or to other external actors, as a symbol of a willingness to escalate should a provocation occur. Meanwhile, in the same thirty-year period, air power has also delivered emergency aid, provided intelligence for humanitarian actions, rescued hostages and extracted civilians from danger zones.

In short, nations have used air power across the full spectrum of operations within the full spectrum of conflicts that have occurred since the end of the Cold War. Like any other military instrument, it has intrinsic strengths and weaknesses, and the successes and failures of air power are entirely context specific. Air operations are as prone to ineffectiveness and unintended consequences as any other types of operations if they are mounted without due regard to the prevailing political context. Yet leaders, and public opinion, have habitually assumed that air power has the capacity to change the political context around and within which a conflict is fought (Gray 2012).

The ambiguous past of air power

The underlying air power story of the years since the end of the Cold War is the consistency with which political and military leaders have viewed the inherent capabilities of air power – the enduring symbolism that puts air power high on the agenda of policy-makers in both

positive and negative ways. The geopolitical contexts in which air power is now used, however, have evolved out of all recognition from the years when air power was set in its Cold War context. If professional military doctrines have made constant attempts to refashion their thinking to new circumstances (RAF 2009), the same cannot always be said of defence policy-makers, political leaders, or the domestic public in Western societies.

Politicians are easily tempted to employ air power to achieve their military objectives, and are just as easily outraged when they see air power employed against their interests. The ability of air power to deliver military effects in a high-tech manner, far away from one's homeland, or to engage in explicit coercion of an adversary, to be highly discriminating in targeting, or to be an agent of extra-judicial killing in precision strikes and with the ubiquitous use of drones and so on, all create an aura around air power that leads policy-makers both to revere it and fear it, and often to expect too much of it as a military asset. The highly potent air forces of the leading military powers in the world foster a perception that they provide an instrument that can somehow be both detached from local political risks and yet also kept under tight political control, making it, as Gray (2002: 17) comments, 'the weapon of first political choice'.

Table 19.1 presents a list of twenty-five discrete cases of significant post-Cold War military conflicts. Air power has played a combat role in eighteen of them. In seven other cases air power played a supportive or humanitarian role or no significant combat role at all. The eighteen cases where air power was openly employed in combat offer a basic typology of the primary role that policy-makers have assumed for air power. Of course, the use of air power frequently shifts from one role to another in any operation and is often justified on the basis of more than one military rationale. Sometimes, too, the rationale for its employment is simply ambiguous or is misunderstood by policy-makers. But policy-makers, whether political leaders or military chiefs, have in their minds some assumption about what air power should be able to achieve.

What is most notable about this typology is the difference between categories I and II as opposed to categories III and IV. Using air power to prepare a battlefield, or for CAS and air interdiction, has an underlying military logic, driven by events, that political leaders and publics generally understand. But using air power to create a primary strategic effect or to exercise political coercion directly is far more difficult to calculate or measure and more dependent on the political context in which it is used – an altogether more uncertain and politically risky undertaking. Yet twelve of the eighteen cases fall into one of these two categories. As the geo-political wheels have continued to turn in the last thirty years, all the indications are that nations will continue to employ air power in such ways, despite the inherent political risks.

The first two categories in Table 19.1 refer to air operations that have generally been least contentious politically and most clearly understood by both policy-makers and their domestic publics. All air operations have tended to attract criticism from sections of public opinion that may oppose an operation on principle, but in these cases air power was used in ways naturally dictated by battlefield logic: for shaping the battle area, preparing for ground operations, supporting ground operations and facilitating the vital ISTAR elements of campaigns.

Paradoxically, some of these campaigns have applied air power with the greatest kinetic force. This could be seen in Western air operations against Iraq in 1991, where air power was used to shape the battlespace in a vigorous four-week campaign before the ground offensive began, and again in the Gulf War of 2003, which involved a 'shock and awe' air campaign that was all but simultaneous with the beginning of a ground offensive. In both cases, extensive air operations were a necessary precondition of decisive ground operations (Ullman and Wade 1996: xxiv). In 1991 and again in 2003 Western air operations then moved to a CAS and air interdiction role as they supported their own ground forces moving forward (Osinga 2012: 446–448, 452–453).

Table 19.1 Modern air warfare – five categories.

I *Preparation of the battlefield*	*II* *Close air support/ air interdiction to ongoing operations*	*III* *Primary strategic effect*	*IV* *Political coercion*	*V* *Other operations (in which air power played no significant combat role, or a humanitarian role)*
First Gulf War 1990–1991	Somalia Intervention by US 1992–1995	Afghanistan War (Phase 1) 2001–2002	US-led no-fly zones campaign in Iraq 1991–2003	Rwanda civil war 1994
Second Gulf War 2003	Bosnia campaign (end of UN Protection Force (UNPROFOR) phase) 1995	Libya operation 2011	Bosnia campaign (end of UNPROFOR phase) 1995	US intervention in Haiti 1994
	Sierra Leone operation 2000	Israeli air strikes inside Syria 2013–ongoing	Russian anti-separatist campaigns in Chechnya, 1994–1996, 1999–2000	Italian-led intervention in Albania 1997
	Second Gulf War 2003	Anti-Islamic State coalition in Iraq and Syria 2014–2018	Russian anti-separatist campaigns in Chechnya, 1994–1996, 1999–2000	Australian-led intervention in East Timor 1999–2000
	Afghanistan War (Phase 2) 2006–2014	Saudi-led air operations in Yemen 2015–ongoing	Kosovo campaign 1999	NATO intervention in Macedonia 2001
	French-led intervention in Mali 2012–2014	US-led counter-terrorist drone operations, South Asia, Somalia, Levant, Yemen, Libya 2010–ongoing	Russian war against Georgia 2008	French intervention in Côte d'Ivoire 2004
	Anti-Islamic State coalition in Iraq and Syria 2014–2018	Russian operations to support Syrian government 2015–ongoing	Russian operations in eastern Ukraine 2014–ongoing	

In 2003 the ISTAR assets were particularly relevant, marking a real technical maturity in this aspect of air power operations since the previous Gulf War twelve years earlier.

The CAS/interdiction roles were also demonstrated in the second phase of the Afghan campaign, from 2006 to 2014, and are still relevant as US air power seeks to support government forces against ongoing and new insurgencies in Afghanistan. Similarly, a brief CAS role was evident in US operations in Somalia in the 1992–1995 period and in the later stages of the Bosnia campaign in 1995, where air operations supported British, French and Dutch ground

forces as they enforced UN resolutions to help bring a three-way civil war in Bosnia and Croatia to a negotiated end (Ripley 1999: 279). A small CAS role was also seen again briefly in Sierra Leone in 2000, when British ground forces received combat support from the air (Richards 2012: 349–352; Evoe 2008: 65–66). CAS and air interdiction have also, more controversially, been offered to proxy forces fighting on the ground in Iraq and Syria since 2013 in the US-led coalition against the Islamic State, and since 2015 in Russian (and since 2016 also Turkish) operations, partly against Islamic State and Kurdish militias, but also in favour of President Assad's forces fighting opposition groups on a number of different fronts.

Though all of these campaigns have been politically controversial in their own ways, such uses of air power within them generally were not. The onset of the Syrian civil war and the emergence of the Islamic State across the Levant since 2014, however, have added very mixed politico-military rationales for all the external countries involved, and created political controversy around all military instruments employed in these conflicts.

In contrast, the third and fourth categories in Table 19.1 have presented military planners, political leaders, domestic publics and world opinion with far deeper problems, both of understanding and military effectiveness. In nine of these twelve cases a key political objective was to avoid the commitment of regular Western forces on the ground: to engage in a war but only to fight it from the air.[2] The record of success in these cases is mixed. Three of these cases may be regarded as largely successful in achieving the West's objectives in ways consistent with Western values. Two of them may be regarded as successful from a Russian point of view, but in ways that are themselves destabilising and in breach of international and humanitarian law. Four other cases are considered indecisive, or as partial successes at best.

US forces tried to have a primary strategic effect in the first phase of the Afghan campaign in late 2001, creating space for Northern Alliance forces on the ground to sweep the Taliban out of power and then trying to destroy the Taliban fighters in the eastern mountains as they made their escape. The effort was tactically successful but left the US and its allies with an open-ended strategic problem when Taliban leaders were able to regroup in Pakistan (Lambeth 2005: 158–161). The Western nations both ignored and forgot important lessons about transiting from success in the air to corresponding success on the ground (McMaster 2008: 21–25).

In Libya during 2011 Western air forces tried to swing the military balance against the forces of Colonel Gaddafi, and after an initial air interdiction role settled into a campaign lasting more than seven months where they attempted to have a decisive strategic effect on the final outcome: to remove Gaddafi and help install a new Libyan government. European and US political leaders constantly carped at the time the campaign was taking, but it was a campaign that was also predicated on the requirement that there must be 'no collateral damage' – no room for targeting errors that diminished domestic support for a bombing campaign. The success of this has been disputed (Woods 2015: 279) but it nevertheless remained a key policy objective. Libyan opposition forces were eventually successful, though it remains a matter of debate how decisive air operations proved to be. The air campaign could be said to have been a necessary but not sufficient condition for success in Libya and it has certainly been irrelevant to the political chaos that has engulfed the country and part of the surrounding region since the fall of the Gaddafi regime (Bradley et al. 2016).

Western air operations against the Islamic State in Iraq and Syria began primarily with a focus on strategic effect through using manned aircraft and the latest generations of drones to attack leaders of the Islamic State movement, interdict its supply routes, and destroy the oil storage and transit facilities it had captured in its advances of 2014. However, during 2016 a varied resistance against the Islamic State gathered momentum on the ground among Iraqi armed forces, militias, Kurdish forces and multiple opposition groups in Syria, and both Western

and Russian air power shifted their roles somewhat to air interdiction and some CAS. But these were departures from the essential mission; CAS and tactical interdiction require far greater air/ground cooperation than was available throughout the battlespace.

For all the countries involved in air operations across the Levant since 2014, the essential rationale has hovered between an attempt, on the one hand, to create primary strategic effects, and on the other to exercise direct political coercion (Stansfield 2014: 1340–1343). In the case of the former type of operation, the most successful example was Israeli air strikes into Syria to prevent Iranian weapons reaching Hezbollah and directly to diminish the striking power of Iranian and Hezbollah forces.[3] But in this case Israeli objectives were relatively limited and not intended to shape the final outcome of the Islamic State phenomenon or the Syrian civil war. For the other countries intervening in the Levant, the application of air power has remained less than decisive in creating a primary strategic effect on the ground and highly contentious in exercising a degree of political coercion (Defence Committee 2016: 16, 28). A similar judgement applies to Saudi-led air operations in the Yemeni civil war since 2015. Unable to swing the balance in favour of the forces of the extant government of Yemen against the Houthi rebels and related terrorist forces, Saudi and Gulf air power has been drawn further into a sectarian civil war and has been unable to achieve any of its longer term political objectives to stabilise the country as a secure and friendly neighbouring state.

The one clear case where a primary strategic effect was largely achieved, and which has been ongoing since 2001, is in the 'drone campaign' – also featuring manned aircraft – to degrade and decapitate terrorist organisations that have declared war against Western countries. There is little doubt, at least at the operational level, that new ISTAR technologies, allied to the persistent surveillance and striking capacities of unmanned aerial vehicles, has exerted a major effect on the ability of the al-Qaeda core organisation to continue to operate and even exist in south Asia and Yemen. The same synergistic technologies have had a comparable effect on the central organisations of the Islamic State in Iraq and Syria and also in Libya. If dismantling the leadership structure of a terrorist organisation and creating a climate of fear within it can be regarded as a primary strategic effect in counter-terrorism campaigns, then the last eight years have demonstrated unambiguous operational success, at least narrowly defined, for air power used in this way (Williams 2013: 169).

Most difficult of all to operationalise, and also most politically controversial, is the use of air power as an act of political coercion. Precisely because of the difficulties in conceptualising 'coercion', great ambiguity exists over what sort of air action constitutes an attempt at coercion, and such a rationale is easily mixed into attempts to exert primary strategic effects or even in relation to CAS or air interdiction. As an example, one of the ambiguous cases listed in Table 19.1 concerns NATO air action at the conclusion of the UNPROFOR phase of the Bosnian civil war. In April 1995 the US commander had already decided that, faced with the difficulties of using tactical air power in a civil war, 'he would only accept strategic-level targets' (Rose 1998: 85). In August NATO air forces began a campaign to suppress Serbian air defences and support Western ground troops that were taking a muscular approach to restrain Serbian forces and help swing the balance towards Muslim and Croat forces. But the campaign quickly extended to Serbian command and control nodes in order to weaken the Serbian military hand at the anticipated negotiations that were drawing nearer (Ripley 1999: 279–301). It was a coercive act of increasing pain on the Serbian leadership that led Serbia to agree a ceasefire and rapidly seek a negotiated solution (Lambert 1996: 62).

A similar, though less clearly successful, development occurred in the Kosovo war of 1999 against Serb forces apparently engaging in acts of genocide in the Serbian province of Kosovo. Air power was deployed from the outset in a coercive role as a result of political frustration in

NATO capitals after the failure of the Rambouillet Peace Conference the previous month and the continuing offensive of Serbian forces in Kosovo. Air power 'went solo', as one analyst put it (Clarke 1999: 60). NATO air operations began in March with an explicit commitment to strategic coercion against the Serb leadership. NATO expected at the outset of the campaign that a few days of cruise missile and aircraft attacks to demolish Serbian air defences would have the desired psychological effects. Indeed, NATO air operations were not originally configured for anything more extensive and had then to be reorganised for what turned into a seventy-seven-day air campaign that caused considerable political heartache in Western capitals (Lambeth 2001: 232–233). Strikes took place against Serb ground targets in Kosovo but the main focus remained a coercive campaign against the leadership in Belgrade, targeting utilities, transport infrastructure, broadcasting, investments owned by members of the ruling elite, and so forth. It was one of the first attempts to use very 'smart targeting' to exert coercive pressure on a leadership group and separate it from its base of domestic support. It was, at best, partially successful when the Serbian leadership caved in to international, largely non-NATO, diplomatic pressure accompanied by the serious prospect of a British/French ground invasion of Kosovo (ibid.: 67).

A notably clear-cut, but evidently unsuccessful, attempt to use air power for political coercion occurred in the US-led policing of no-fly zones (NFZs) in northern and southern Iraq after the 1991 war. Begun under UN resolutions to enforce humanitarian policies to prevent Saddam Hussein's genocide against the marsh Arabs of the south and the Kurds of the north of Iraq, the NFZ operations initially succeeded in their humanitarian purposes. But like economic sanctions, air enforcement operations struggle to reach a politically satisfactory conclusion, and as Saddam Hussein continued in power and the NFZ flights went on, their primary purpose changed from keeping airspace clear of Iraqi aircraft to attacking military sites on the ground. In 1998 US and UK air forces conducted an intensive four-day campaign – Operation Desert Fox – to enforce Saddam Hussein's compliance with the work of UN weapons inspectors in Iraq. US and UK air action continued thereafter to dismantle as much as possible of Iraq's air power as a coercive act to 'contain' Saddam Hussein's behaviour until the NFZ operations were ended by the Second Gulf War in 2003 (Zenko 2016).

Successful, and brutal, examples of air power as political coercion are provided by Russian operations in Chechnya in 1994–1996, again in 1999–2000, in the brief war against Georgia in 2008, and then in operations in Syria, particularly in late 2016. In three of these four cases, attacks against populated areas in Chechnya, Dagestan and across northern Syria were directed against adversaries waging guerrilla campaigns on the ground but were highly indiscriminate in the way they were staged. In particular, the destruction of Grozny and – alongside Syrian government forces – Aleppo at the end of 2016 were exercises in the most violent form of political coercion. The message to those groups that opposed Moscow and its allies was clear: there would be no mercy and destruction would continue to be indiscriminate until they gave up their opposition, or acquiesced in a peace process that offered them few compromises (Tabler 2016; Russo 2016). To the Caucasus and Syrian populations who found themselves in areas of conflict the message was equally clear: allowing rebels to operate around their territory would simply bring destruction on them all. Indiscriminate bombing, the deliberate targeting of populated areas, and repeated bombing of schools and hospitals were never intended to have tactical military effects, but to convey an unambiguous message to sections of a population and its leaders that the pain of attacks would continue as long as necessary. There could be few greater contrasts than those between NATO operations in Kosovo, where 'smart targeting' was an essential part of the attempt to coerce a small group of leaders, and NATO operations in Libya, where a 'no collateral damage' requirement was set from the outset, and these three

Russian-led coercive operations that have been based explicitly on a brutal logic of widespread destruction to communicate and enforce a coercive intention.

The political future for air power

The history of the last thirty years indicates strongly that air power will remain 'the weapon of first political choice'. But it also indicates that, faced with a mixed record of success, leaders will need to take even greater account of the political context in which air power is applied.

Geopolitical wheels are always turning and in the present climate they are turning very quickly in some regions: in East Asia, with the military emergence of China; in central Asia, where China and Russia compete economically all along the 'new silk road' that China is developing; across Europe, where NATO and the European Union face multiple crises within and around their neighbourhood; with disruptive pressures in key parts of East and West Africa; and across the Middle East, with significant destabilisation in North Africa and a political meltdown in the Levant.

The stability of these regions is impossible to predict, but one common element is the greater volatility of the political landscape in all of them (Brown 2009: 235–249). As the last five years have demonstrated to political leaders in Western countries, a corresponding volatility extends to their own societies, changing the terms of political debate about national security, international commitments and the rule of law (Coker 2012: 67–68).

What might this mean to policy-makers inevitably tempted to reach for the air power instrument as they face challenges that seem to demand a forceful response? One enduring principle should be recognition of the political limitations of air power where it is deployed in the absence of a country's own troops operating on the ground in a crisis or war. Operating even on behalf of proxy forces on the ground has proven deeply problematical, since proxy forces are seldom as united – or as connected to air assets – as necessary to give air power a decisive role in complex and fragmented conflicts. If a country's troops, or allied troops, are not operating on the ground then the use of air power must be heavily supported by other instruments – diplomatic, economic, intelligence, cyber and so on – if air power is to achieve strategic or coercive effects. The historical record indicates that unsupported air power is likely to be only partially successful or else successful only in an overtly brutal way. The extreme political volatility of the current era makes the use of unsupported air power in a combat role even more risky than before.

The erstwhile symbolism of combat air power remains a dangerous temptation to leaders facing ever more intractable problems. The temptation is even greater for NATO leaders who increasingly fear they may have to deploy air power assets in competition – or even in aerial conflict – with a peer military power such as Russia, after years of taking air superiority over conflict zones for granted. Leaders should not fall into the trap of deploying air power in lieu of more expensive and meaningful military commitments. If a military commitment is appropriate, and its costs and risks properly understood, then air power will likely be an intrinsic part, but not the essence, of it.

A related principle is that leaders should consider the longer term and wider consequences of deploying air power, even when it emerges as operationally successful. For example, the 'drone war' against al-Qaeda in Pakistan and Afghanistan, for all its operational success, has been heavily criticised for having a negative strategic impact on domestic opinion in both countries, to the detriment of Western policy objectives throughout the region (Woods 2015: 285–287). The Libyan operation has been criticised for not following up the arms-length aerial campaign to defeat Colonel Gaddafi's regime and, in effect, squandering the painstaking success of air

operations that created a new opportunity for the country (Bradley et al. 2016). Indeed, though Libyan militias wanted to lead the ground offensives, the very image of 'arm's length' military involvement did much to preclude Western influence in the attempts to reconstruct a post-Gaddafi Libya. The inherent flexibility of air power, as both a symbol and a real capability that can be turned on and then off again with great precision, divorces it in the minds of many leaders from the wider strategic implications of its use.

A third principle is the need for a more shared political understanding within coalition operations of the implications of using air power. In the twenty-five cases cited, significant multinational air power coalitions – sometimes very extensive collaborations – were involved in thirteen of them. Air power is an instrument that has always lent itself inherently to coalition operations (Peach 1998: 48), and in modern warfare a coalition is frequently deployed precisely to make a political statement but avoid a genuinely risky or entangling military commitment. Such coalitions tend to build a momentum of continuity that makes them less flexible – an end in themselves, and difficult to terminate without political loss of face if they are failing. As the US Department of Defense pointed out, 'ensuring NATO's credibility' emerged as one of the three 'primary interests' embodied in the Kosovo operation – this in a completely one-sided military contest against an opponent that fielded nothing but an outdated air defence system and a few out-classed fixed-wing aircraft (Department of Defense 2000: 1). If the military campaign was one sided, the political struggle was more equal and the credibility of the biggest and greatest military alliance in history was thought to be on the line.

A final principle is that leaders should have a sensitive and up-to-date understanding of the way public opinion reacts. In the past, Western public opinion has been assumed to take a binary view of combat (Sloggett 2013: 183–184): it is seen either as extremely effective, high-tech and war winning, or else as disproportionately violent, bullying and cowardly. Just as Western leaders want to emphasise the first image, leaders on the receiving end of Western air action have stressed the second, broadcasting their victim status and sometimes making sure that their own civilians are harmed by air power in order to affect public opinion in Western countries.

This binary view seems now to have become far more nuanced. Disappointment at the outcomes of the wars in Iraq, Afghanistan and Libya have made public opinion in Western countries less optimistic about the strategic capabilities of air power. Even so, the existential terrorist threat has engendered a greater tolerance of its use in complex operational circumstances that seem to address some part of this threat. UK politicians constantly cited the experiences of Iraq and Afghanistan as evidence that the domestic public did not support the US air operations over Syria in August 2013 when the Syrian regime used chemical weapons against its rebel communities. Parliament may have had good reasons to reject US policy, but the trend in British public opinion was not one of them. Public opinion certainly reacted negatively to the way the government described the issue (Jordan 2013; Gribble et al. 2015), but not necessarily to taking action against the wider problems the Syria crisis posed. The evidence suggests that the British public was not indifferent but rather angry and exasperated at the Assad regime's use of chemical weapons (Winnett and Dominiczak 2013). Then in September 2014, in light of the emergence of the Islamic State phenomenon, some 48 per cent of the British public favoured air action against the Islamic State in both Iraq and Syria, as opposed to only 27 per cent who either opposed the idea or who wanted a more nuanced air campaign, with 24 per cent of the sample 'not sure'.

A large majority of the British public also supported the US air campaign at that time, whose operations covered both Iraq and Syria. While the UK Parliament voted to restrict UK air attacks to Iraqi airspace, some 60 per cent of the British public polled throughout that September approved of a more extensive bombing policy, while those who opposed it

remained around 15 per cent, fewer than the 24 per cent of 'don't know' respondents. This remained constant as the government agonised during 2015 over whether to extend UK air operations into Syria. In December of that year a clear majority – 60 per cent of respondents – agreed that the UK should launch air attacks against the Islamic State in Syria, specifically in response to the terror attacks in Paris. Only 24 per cent opposed the idea and 16 per cent were 'not sure' (Statista 2017). As the YouGov organisation expressed it, there was a clear consistency of support, 'suggesting the public have settled on a position, with support unlikely to deteriorate in the near future' (Dahlgreen 2015). Nor is there great concern among the majority of the British public over the use of drones for targeted killings of known terrorist suspects. In fact, between the Syria vote in August 2013 and the more sectarian turn of events in Syria in October 2014, British public attitudes appeared to harden markedly in favour of more resolute military action (Rogers 2014).

The tolerance and expectations of the British public in relation to using air power are therefore highly context specific – and so may also be volatile in the face of real air operations. This presents a challenge for all policy-makers in democratic societies, but it emphasises the importance of understanding in some detail what the public may believe is at stake in any given crisis, and also of maintaining effective strategic communication throughout that crisis. The political instincts of leaders and legislators have become a fairly poor guide to the support or scepticism the public will express about contemporary military operations – even neat and at-a-distance air operations.

Conclusion

The technologies of air power – the platforms, ordnance, space-based assets and systems integration – have reached a synergistic maturity in recent years that was foreshadowed in the First Gulf War and clearly evident by the time of the Second. But this has happened at a time when, since the turn of the twenty-first century, the geopolitical context for warfare has altered in a number of ways. The world is characterised simultaneously by greater political fragmentation and the rise of very capable international terrorist organisations, and an apparent return to the dynamics of great power politics and the prospect of sharp military competition between them, perhaps even directly. New psychological and ethical issues press upon the conduct of future warfare (Coker 2004: 141–2). Western leaders have sometimes reached for air power too casually in the last thirty years, and all the indications are that margins for political error will be much smaller in the future. If this highly potent, but ambiguous military instrument is to make the best of the technical maturity it has now achieved, it must be used more carefully than has been the case in the recent past.

Notes

1 ISTAR assets cover intelligence, surveillance, target acquisition and reconnaissance capabilities. 'Air interdiction' has been defined in many different ways according to the depth of operations within the battlespace. 'Tactical' and 'strategic' air interdiction is one distinction, as are 'battlefield' and 'deep' air support. Definitions of 'air interdiction' are a matter for the prevailing air power doctrines of different countries.

2 The three exceptions are the no-fly zones campaign, the 1995 Bosnia campaign, and the counter-terrorist drone operations after 2010. In these three cases the main effort was intrinsically air led. Air power was the optimum response to the problem, not an acceptable alternative to a better response that would have involved use of ground forces.

3 In 2013 Israel initiated regular airstrikes into Syrian territory to destroy arms shipments, pinpointed by their intelligence services, that might have been destined for Hezbollah. In 2015 Prime Minister Netanyahu made a direct statement in relation to Russian aid to Iran that Israel would regard any Iranian, or Russian, arms transfers that it felt directly threatened its security as legitimate targets for air attack. See Barnard et al. (2013), Reuters (2013) and Opall-Rome (2015).

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20

AIR POWER, MEDIA AND POPULAR CULTURE

Philip Sabin

Military air power has featured very prominently in all forms of media since its inception over a century ago. In today's more limited conflicts, winning the 'hearts and minds' of media audiences around the world has become at least as important as the practical military impact of air power employment. This chapter takes a deliberately broad approach, by discussing not just news reportage but also how air power has been depicted in books, films, and similar cultural representations. It shows that there have been very significant changes in media portrayals of air power over the past century, but that a dominant and enduring characteristic of media imagery is a focus on the changing human traumas associated with air power employment rather than on the technology, tactics, and strategy. Understanding this shifting focus on human trauma is key to winning the increasingly significant 'media war' where air power is concerned (Corum 2015; Harper and Beldon 2016).

The early focus on risk and fear

In his gripping and widely read 1951 memoir *The Big Show*, French fighter ace Pierre Clostermann describes the murderous flak which his squadron encountered during an airfield attack just two weeks before the war ended. He closes his account as follows:

> 1304 hours. We had attacked at 1303 hours. The nightmare had lasted perhaps 35 seconds from the beginning of our dive and we had lost six aircraft out of eight.
>
> *(Clostermann 2004: 288)*

Such horrendous loss rates were obviously exceptional, but the dominant experience of aircrews in all nations during the two World Wars was of the fragility of life and the gnawing inevitability of death, wounds, or capture when one's luck finally ran out (Wells 1995). Media accounts focused on the heroism of aircrews in facing such appalling risks, and on the prowess and daring of individual 'aces' such as Albert Ball and Manfred von Richthofen, who managed (at least for a time) to beat the odds and avoid suffering the same fate they meted out to their unfortunate opponents (Kennett 1990). Reports even gave an impression of 'chivalry' among the 'knights of the air', as embodied by W. E. Johns' fictional hero Biggles (who first appeared in 1932), even though the reality of aerial contests was that most kills

were achieved by sneaking up unobserved and shooting the enemy in the back (Spick 1988).

Two films from this era capture well the dominant media image of air warfare. One is the 1938 *Dawn Patrol*, in which British airmen in the First World War face the strain and sacrifice of successive perilous sorties, even extending a chivalrous welcome to a captured German pilot who they believe has just killed their erstwhile colleague. The other is the 1952 production *Angels One Five*, in which a novice RAF pilot and his more experienced colleagues display admirable pluck in resisting the Luftwaffe during the Battle of Britain, despite continuing losses which soon claim the novice's own life. In both films, the actual air fighting mostly takes place off screen; the focus instead is on the human trauma of men coping heroically or not so heroically with appalling and continuing risks. This focus on aircrew suffering persisted even within later anti-heroic portrayals of the World War era, such as Heller's *Catch-22* and Robinson's *Goshawk Squadron* (Heller 1961; Robinson 1971).

The other strand of early media imagery of air warfare stems from fear of aerial bombardment of civilians. Although the great majority of air power employment in the First World War took place at the front, and fewer than 1,400 civilians in Britain died under the puny bombs of the Zeppelins and Gothas (Castle 2015), this hitherto unprecedented threat loomed large in the media as a presage of the future. H. G. Wells had already highlighted the threat in his 1908 novel *War in the Air*, and fear of aerial bombardment (including with poison gas) played a major role in intimidating Britain's politicians and public in the 1930s, as illustrated by the bombing of 'Everytown' in the 1936 film dramatisation of Wells's novel *Things to Come* (Wells 1908, 1933; Bialer 1980). Picasso's famous 1937 painting *Guernica* is a telling indication of media preoccupations: the German and Italian aircraft which devastated the Basque town are not represented directly at all, and the painting focuses entirely on the human traumas of the people under the rain of bombs.

Although the Second World War was not as immediately apocalyptic as had been feared in terms of mass civilian casualties from bombs and poison gas, mutual restraint soon eroded and air power did indeed proceed to devastate entire urban areas on both sides. Perhaps because this destruction developed gradually and people had the chance to become habituated to the risks, the dominant media response was to celebrate the endurance and stoicism of friendly civilians, as in London's famous 'Blitz spirit' (Gardiner 2010). Goebbels infamously used media propaganda to galvanise the battered German population for a supreme effort to arrest their inexorable slide towards defeat (Overy 2013: ch. 7). Only the atomic immolation of Hiroshima and Nagasaki in August 1945 served to shock Germany's equally outclassed Japanese allies into surrender, and then only when the Emperor used the power of the media in an unprecedented radio address to head off the risk of a military coup (Butow 1967).

In the post-war world, the development of atomic and later hydrogen bombs naturally triggered a fresh wave of fear of annihilation from the air. The media were full of iconic mushroom cloud imagery from the continuing atmospheric tests, while films such as *On the Beach* (1959) imagined the end of humanity (Weart 1988). Soviet success with the Sputnik programme in 1957 sparked media alarm and recrimination in the US, though it is telling that Macmillan in Britain received more letters about the cruelty to the dog Laika (Dickson 2001; Sandbrook 2005: 233)! Nuclear annihilation was such an apocalyptic and mutually suicidal prospect that (especially after the Berlin and Cuba crises of 1959–62) media attention drifted away towards other more mundane and practical concerns, apart from a brief revival in the 'new cold war' of the early 1980s as marked by TV movies such as *The Day After* (1983) and *Threads* (1984) (Sabin 1986).

The rise of guilt

Whereas early media portrayals of air power had tended to focus on the daring of friendly aircrews and the risks to friendly civilians, the post-war world saw the rise of a new theme, in the form of guilt about the impact of one's own air power on enemy populations. This was not entirely unprecedented, since the British inter-war policy of 'air policing' as an efficient way of controlling native peoples in the Middle East and the North West Frontier had given rise to some adverse publicity at home about the perceived unfairness of bombing those unable to retaliate (Omissi 1990). In the Second World War, such moral niceties were generally overridden by media patriotism and censorship and by the feeling that friendly bombing was a justified reprisal for similar actions by the opponent. As RAF Bomber Command head Sir Arthur Harris robustly put it in 1942, 'They sowed the wind, and now they are going to reap the whirlwind' (Harris 1947: 51–52). However, even at the time, some reservations were expressed as the air war became increasingly one sided, and these reservations deepened as the bombing was viewed in hindsight (Walzer 1977; Grayling 2006).

A number of books over the past few decades (Middlebrook 1981; Lowe 2007) have highlighted the dreadful human consequences of the firestorm at Hamburg in 1943, but a far greater focus for posthumous guilt is the similar devastation of Dresden in February 1945, as the war neared its end. Although Irving's 1963 book condemning the Dresden attack has been increasingly discredited for its author's poor research and dubious sympathies, others have taken up the cause, and 'Dresden' has become a touchstone for the widely expressed view that the RAF's area bombing strategy in the Second World War was militarily and politically ineffective and killed and maimed large numbers of civilians for little compensating strategic benefit (Irving 1963; Addison and Crang 2006). Interestingly, the even deadlier fire raids on Tokyo a month later have not attracted similar levels of condemnation, mainly because they were trumped for media attention by the atomic bombs (Hoyt 2000).

As early as 1946, Hersey's book *Hiroshima* brought home to a wide readership the human traumas of the first atomic bombing, shown through the eyes of six survivors (Hersey 1946). Concern was compounded by growing realisation of the enduring and insidious dangers of radiation poisoning from the blasts and from ongoing atmospheric nuclear tests, including to future generations. Campaigns developed to ban such tests and the weapons themselves, not only due to instincts of self-preservation but also due to guilt about the morality of basing one's security on threats to use such dreadful means (Driver 1964; Nehring 2005). Films such as *Fail Safe* (1964) and *Dr Strangelove* (1964) adopted a decidedly sceptical tone towards the human failings of those operating the nuclear arsenals. The media hosted robust debates (especially in the 1960s and 1980s) about the best way to avoid further nuclear conflict, and this contributed to a growing taboo against weapon testing and use and an increased focus on limiting rather than winning the nuclear arms race (Newhouse 1989).

Meanwhile in real conflicts the use of conventional air power proceeded apace. The indiscriminate bombing of North Korea in 1950–53 attracted surprisingly little protest, and media attention focused instead on the heroics of UN pilots in the new jets, as seen in films such as *The Hunters* (1958) and *The Bridges at Toko-Ri* (1954) (Jackson 1998). However, in Vietnam fifteen years later it was a very different story. Television now allowed searing images of human suffering to be broadcast directly into living rooms across the globe, and the iconic 1972 image of the naked and burnt nine-year-old Phan Thi Kim Phúc running towards the camera after a napalm attack soon became familiar to the entire developed world (Hallin 1986). The North Vietnamese were quick to exploit the doubts about the war among many Western experts, celebrities, and media reporters, and facilitated the provision

of photos and footage that put a human face on life under the American bombs (Holzer and Holzer 2002).

It is hard to overemphasise the importance of this anecdotal media imagery. Previous air wars had been reported through statistical claims about overall losses suffered and inflicted, with enemy targets glimpsed only through grainy images of bomb bursts from thousands of feet up. Only through vicarious fascination with individual 'aces' or through imaginative reconstructions such as the various films mentioned did aerial conflict acquire an all-important human face. Now, TV viewers could see and empathise with real individuals in the target area, turning 'collateral damage' from a vague and regrettable footnote into searing images of maimed children and grieving parents. Just as charitable appeals invariably focus on and illustrate individual human examples of need rather than overwhelming and disheartening potential donors with the statistical enormity of suffering, so the rise and rapid transmissibility of the anecdotal image revolutionised media portrayals of air warfare and amplified many times over the vulnerability of audiences to guilt about insufficiently discriminate attacks. This effect became even stronger as real-time global TV reportage and rolling news channels such as CNN came to prominence, as discussed later.

The decline of air heroes

Feelings of guilt can be assuaged in part by perceptions of offsetting risks to those conducting air attacks or to one's own target population. Most people on all sides in the Second World War saw their air attacks as justified reprisals for similar enemy attacks, and were more concerned to minimise risks to their own aircrews than to reduce the risk to enemy civilians. However, in recent decades, losses among Western aircrews have fallen precipitously compared to the dreadful attrition suffered during the two World Wars. In Kosovo in 1999 and Libya in 2011, Western nations achieved the once unthinkable ideal of getting through entire conflicts without a single aircrew fatality (Lambeth 2001; Barrie 2012; Gregory 2015).

The transformation in Western air losses since the bloodbath of the World Wars has several causes. One is obviously that modern conflicts have become much more asymmetric, with gross disparities between the technical and tactical capabilities of the antagonists, especially in the air superiority contest. Although wars such as those in Afghanistan and Iraq may drag on even longer than the World Wars, and may be just as difficult in their own way to win, they are shaped by an offsetting balance of political and military asymmetries in which Western air power enjoys virtually unchallenged dominance in conventional military terms (Olsen 2002, 2010).

A second reason for the transformation is that the growing importance of guided weapons and electronic warfare has made losses in air battles much more one sided than in the attritional slogging matches of the past, due to the increasing capacity of well-led Western air forces to jam, suppress, and exploit enemy use of the electromagnetic spectrum (Withington 2008). Opposing air forces such as the Argentines and Syrians in 1982 remained vulnerable to catastrophic losses when they tried to engage Western states, and since then opponents such as the Iraqis and Serbs have tended to adopt a much more passive and cautious stance in air defence contests for fear of exposing themselves to similarly one-sided attrition (Sabin 1996). General Clark, NATO's Supreme Allied Commander in Europe during the 1999 Kosovo campaign, said that 'Milošević must feel he is fighting God' (Marshall-Andrews 1999).

A final reason for the amazing decline in Western aircrew losses is that technology has increasingly reduced the need for aircrew other than transport and helicopter pilots to place themselves directly in harm's way. Over 90 per cent of the 5,000 US aircraft downed in Vietnam

fell to flak guns like those which savaged Clostermann's Tempests (Francillon 1987: appendix A), but now smart bombs and stand-off missiles make it less and less necessary for aircrews to risk such low-altitude perils in order to deliver accurate attacks (Hallion 1997). Satellites, cruise missiles, and unmanned aerial vehicles (UAVs) allow targets to be observed and engaged without Western personnel needing to fly over them at all, a development explored later in this chapter.

The gung-ho 1986 film *Top Gun* was perhaps the last hurrah of traditional heroic media portrayals of contemporary air combat. Thereafter, media attention tended to focus on the tribulations of the increasingly few air crew who were shot down and had to face the enemy without the protection of their high-tech steeds (Peters and Nichol 1992; O'Grady and Coplon 1995). This anecdotal media spotlight on the few occasions when jets were downed served as a powerful spur to minimise such aircrew losses even further, especially given the shift towards 'wars of choice' in which Western involvement was seen as discretionary and altruistic. A particular worry was that the media spotlight would inexorably amplify the ordeal of grieving relatives or abused hostages, thereby turning a minor tactical setback into a strategic turning point (Sabin 2000).

The increasing success of Western nations in minimising aircrew losses made air power their instrument of choice to avoid the much greater human costs and risks of ground force intervention (Cohen 1994; Gregory 2015). However, this success had a paradoxical downside, since notions of heroism and warrior ethos revolve heavily around military personnel displaying courage and fortitude by putting their own lives on the line. The more they become simply efficient dealers of death from afar, the less respect they tend to attract (Lee 2012; Haynes 2016a). Apart from helicopter and transport crews (for whom the risks remained very real, as dramatised in the 2001 film *Black Hawk Down*), even the dwindling minority of Western air force personnel who do fly in combat now suffer far fewer casualties than do soldiers, journalists, and local civilians on the ground (Duncan 2011; Hookham 2013). This otherwise very welcome development has some real costs in terms of the respect which air forces command (Alexander 2011; Evans 2012). The two volumes on *Real Heroes* published by a British tabloid newspaper in 2009–2010 in support of armed forces charities focused very clearly on soldiers and helicopter crews rather than jet aircrews (Clarkson 2009, 2010). Journalist and historian Max Hastings wrote in a newspaper column in 2007 that:

> The nonsense of assuming parity between the three services must stop. The army's role is today overwhelmingly paramount. The other services perform important support functions, but they are not fighting forces in the same way ... Admirals and air marshals, today bureaucrats in uniform rather than warriors, lack the perspective, knowledge and experience credibly to preside over the armed forces.
>
> *(Hastings 2007)*

Enthusiasts and 'air power porn'

However much media respect for air forces' warrior status may have waned since the bloody air battles of the World Wars, air power does have one enduring asset in terms of its public image: the sheer thrill of high-performance flight. No self-respecting air force conference these days is complete without an inspirational opening video in which a succession of sleek jets soar across the screen to the accompaniment of a thumping rock soundtrack. Thoughtful air personnel freely admit that such 'selfies' might readily be characterised as 'air power porn'. Similar

material has long been produced as a significant sub-genre within media portrayals of air power, and it is important to acknowledge this phenomenon, since it stands as an exception to the wider media focus on human trauma rather than technology and tactics. For a large number of enthusiasts of all ages (the great majority of them male), the appearance and technicalities of manned combat aircraft exert an irresistible fascination in their own right.

A key part of the attraction lies in the physical appearance of the streamlined war machines. Many air power books consist of little more than a succession of photographs of different combat aircraft from a variety of angles and in a variety of settings and squadron liveries (Green 2016; Ripley 1996). Aviation art has long been a profitable sub-genre of painting (Wootton 2005; Taylor 2001), and many enthusiasts collect scale models of their favourite aircraft, either buying them ready made or constructing and painting them themselves from plastic kits such as those manufactured by Airfix (Brook 2015). Air shows such as those run for decades at Hendon or Farnborough in the UK offer spectators the chance to see the real aircraft in flight displays, and footage of such live flights has been captured on thousands of specialist videos and DVDs (Blake and Hooks 1990).

Many thousands of books and magazines allow enthusiasts to study and compare the evolving technical specifications and operational and design histories of different marks of combat aircraft (Eden 2004; Spick 2002). The enthusiast market also sustains a flourishing industry of publications and specialist TV programmes on the history, technology, tactics, and strategy of particular air campaigns, with experts such as Dr Alfred Price publishing detailed research for the popular audience as well as for air power professionals (Price 1998). Memoirs by individual aircrew are a very popular genre which chimes more with the general media focus on human experience rather than technicalities, and it is hardly surprising that so many such memoirs have been published over the past century.

Finally, one should mention the predilection among some enthusiasts for interactive simulation of the mechanics and challenges of historical or contemporary air combat (Sabin 2014). At first, this could be achieved only through the rather artificial means of moving counters on a map, but after decades of trivial games designed for children, dozens of sophisticated adult board game simulations of air battles and campaigns have appeared over the past half century (Isby 1977; Brimmicombe-Wood 2006). Tactical air games were transformed by the ongoing computer revolution, which allowed an increasingly vivid real-time portrayal of the view from the cockpit. Although many console games settled for being arcade shoot-'em-ups with an air combat theme, some personal computer (PC) designs such as *Falcon 4.0* (1998) went to enormous lengths to model real avionics, even recruiting real F-16 pilots to write tactical advice for players (Blankenship and Louie 1998). Ironically, virtual aerial duels on PC screens proliferated just as real air combats between evenly matched antagonists became vanishingly rare (Thompson and Smith 2008). The growing virtualisation of the Western experience of air warfare became a dominant theme in media imagery in the post-Cold War period (Ignatieff 2000), as this chapter explores next.

The rise of the robots

The 1991 Gulf War marked a turning point in media portrayals of air warfare, for three main reasons (Hallion 1992). First, from this point on, real-time satellite broadcasts and rolling 24-hour news channels such as CNN brought 'as it happens' footage directly into living rooms around the world, including from cities under air attack (Jeffords and Rabinovitz 1994). The growing pervasiveness and unrelenting scrutiny of media coverage prompted much discussion of a 'CNN effect', whereby anecdotal media amplification of human suffering would influence

state policy to an unprecedented degree, either by pressuring governments to 'do something' quickly to ameliorate a humanitarian crisis or by fatally undermining the case for intervention if heart-rending friendly or civilian casualties should occur under the eye of the TV lens, as in Somalia in 1994 (Robinson 2005; Gilboa 2005).

The second key characteristic of media portrayals of air power from 1991 onwards was an increasing focus on 'smart' weaponry. Western governments not unnaturally sought to defuse and exploit the CNN factor by releasing camera footage from guided bomb attacks to display compelling close-up video of precision strikes (Broughton 1996). At first, this created a honeymoon period for the media image of air power, with the combination of weapon video and footage from the ground suggesting surgical precision in destroying military targets while leaving surrounding civilian populations and infrastructure miraculously unscathed (Hallion 1997). The spectres of Dresden and Hiroshima seemed to have been exorcised. However, just as with the success in reducing aircrew casualties, the precision guidance success story had a downside, creating a 'revolution of rising expectations'.

It was not long before system or intelligence failures produced occasional blunders such as the bombing of a refugee-filled bunker in Baghdad in 1991 or the bombing of the Chinese embassy in Belgrade in 1999. Anecdotal media reporting naturally amplified these blunders, rather than emphasising the statistically far more common tactical successes which air campaigns scored (Sabin 2002). Since even precision air power achieves strategic results only through drawn-out attrition of enemy will and resources over many months rather than through the sweeping 'blitzkrieg' advances which land forces can sometimes conduct, impatient media commentators tended to downplay alleged progress while focusing on more immediately visible setbacks (Sabin 2012). This became especially apparent during the frustrating and drawn-out insurgencies in Iraq and Afghanistan, where Western nations feared that occasional mistakes such as bombing innocent wedding parties would motivate more people to join the insurgencies than were being killed in other, more effective strikes (Engelhardt 2013; Barry 2017). Such political concerns led General McChrystal in Afghanistan to warn in 2009 that 'Air power contains the seeds of our own destruction if we do not use it responsibly' (MacAskill 2009).

In the current context of asymmetric warfare, the enduring limitations even of precision air power compound this equivocal perspective (van Creveld 2011). Not only are soldiers viewed as heroes and martyrs through their sacrifices in conflicts such as those in Iraq and Afghanistan, but they are also seen as less detached than airmen from the surface environment, and so better able to conduct subtle and discriminate interactions such as searching inside buildings, conversing with people, taking prisoners, and building trust. Aircraft and satellites, by contrast, although able to cover much wider geographical spaces in greater safety, cannot do much independently to affect the situation on the ground except to observe it from overhead or to threaten or carry out an armed attack (Sabin 2010). The risk of 'collateral damage' during such attacks is sadly and demonstrably real, whether through targeting mistakes or the blast radius of the weapons involved, and such collateral damage attracts enormous publicity thanks in part to perceptions of unheroic airmen accidentally maiming innocents while themselves remaining safely detached from danger (Blount 2011; Tucker-Lowe 2012; Kerbaj and Shipman 2017).

This leads on to the third key characteristic of media portrayals of air power since 1991, namely an increasing focus on unmanned systems including cruise and ballistic missiles, rockets and UAVs rather than on traditional manned aircraft (McDaid and Oliver 1997). At first, US cruise missiles in the Gulf War evoked the same awe as laser-guided bombs, as they were filmed flying down Baghdad streets towards their pre-programmed targets, but it was not long before such robotic weapons acquired a much more jaundiced media image. This applies especially to

the growing fleets of armed UAVs which patrol conflict zones in the twenty-first century, operated by crews in air-conditioned cabins several thousand miles away who experience a schizophrenic combination of complete detachment from the risks of the conflict zone and persistent intimate observation of local life (Sabin 2009).

It is no surprise that media commentary has paid extensive and jaundiced attention to the growing prevalence of such 'drone' warfare, and to the human traumas it creates both for the UAV operators and for the locals exposed to constant observation and threatened attack (Woods 2015; Killeen and Jordan 2013). Film dramatisations once again serve as a vivid illustration of media perspectives. In the US TV series *Homeland* (2011–present), a captured US soldier is 'turned' to jihadism after seeing his captor's young son killed in a drone strike. In *Good Kill* (2014), a stressed drone pilot disobeys an order for a strike which would kill civilians, but then launches an unauthorised strike on a man he has seen raping a woman he has been tasked to observe. In *Eye in the Sky* (2015), military and political leaders agonise over whether to strike a jihadi bomb factory outside which an innocent young girl is selling bread. The focus throughout is on the human traumas of 'playing God', the juxtaposition of incredible surveillance and communications technology with less flexible weaponry, and the complex pattern of life in the target area (Stahl 2013).

Not only Western states employ unmanned systems. Their adversaries also increasingly use them to offset their inferiority in conventional air operations (Smith 2017). Iraq in 1991 fired Scud missiles against Israel and Saudi Arabia in a reprise of the Nazi V-weapons counter-offensive of 1944–1945 (Irons 2002). General Schwarzkopf wanted to ignore these 'militarily irrelevant' attacks, but political pressure based on media amplification of the Scud threat forced him to divert large numbers of air strikes and air defence assets to try to counter them (Keaney and Cohen 1995). Hindsight suggests that these countermeasures actually had little practical impact, but at the time media images of Patriot missiles roaring skywards to intercept the Scuds sufficed to defuse the political challenge (Postol 1991). Israel was less fortunate in 2006 when its otherwise dominant air force was unable to stop the rain of short-range rockets from Hezbollah in Lebanon, leading to widespread media perceptions of a Hezbollah victory (Arkin 2007; Kalb and Saivetz 2007; Fawdry-Jeffries 2014). Israel has since developed its 'Iron Dome' defence system to counter similar rocket barrages during its sporadic clashes with Hamas in Gaza (Lambeth 2011; Shapir 2013; Shamir and Hecht 2015). In all of these conflicts, winning the media war by being seen to minimise risks to both friendly and enemy civilians proved just as important as achieving conventional military victory.

Conclusion

As this chapter has shown, media portrayals of air power have evolved radically over the past century. News coverage has developed from print-based reports of official press releases to vivid but highly anecdotal real-time images, and now to the interactive ferment of social media (Fenton and Barassi 2011). Aircrew once portrayed as dashing warriors facing appalling risks are now seen more as functionaries tortured by the moral dilemmas of 'playing God' with other people's lives. Countries which once engineered the immolation of entire enemy cities are now reluctant to jeopardise individual non-combatants. Societies which endured dreadful bombardment in the Second World War and the threat of apocalyptic destruction in the Cold War have been spooked recently (as they were in the First World War) by attacks which are almost insignificant by comparison. The one constant amidst all this change is that, apart from enthusiasts and air power professionals, media commentators have focused much more on the human trauma generated by air warfare than on the technology and tactics of air contests.

One should not assume that the specific patterns seen in media portrayals of air power over the past two decades will necessarily endure for long. As in the past, signs of new paradigms are already emerging as the strategic context continues to shift. In Syria, the indiscriminate use of barrel bombs and chemical weapons by the Assad regime against its own citizens triggered only belated and limited military intervention by an outraged West, even though Aleppo now looks more like Berlin in 1945 than Baghdad in 2003 (Smith 2015; Philp 2017). Russia displayed little restraint in its use of air power in Chechnya and Georgia, and it subsequently joined the Assad regime in its 'anti-terror' campaign (Lefebvre and McDermott 2009; Haynes 2016b). Saudi Arabia has caused massive civilian suffering in Yemen through direct bombardment and the interdiction of food imports, but without so far provoking a suspension of Western arms sales (Hokayem and Roberts 2017; Lea 2015). Even the United States now seems somewhat less sensitive than before to civilian casualties in its drive to destroy ISIS (Callaghan 2017).

The reasons for this revival of ruthlessness in air campaigns seem to be a combination of the presumed insensitivity of the perpetrators to Western criticism, *realpolitik* in terms of a shared interest in combating jihadist terror (Spencer 2017), the difficulty of first-hand reporting from the target areas, and the widespread frustration and war weariness in the West after decades of trying and failing to solve the intractable problems of the region. The media spotlight varies little even with massive changes in the scale of air power effects. It can amplify and dramatise even the most minor setback or transgression, but it can do little more to highlight threats or crimes which are orders of magnitude more severe. In an age of mass migration, sporadic terror attacks, and a real decline in economic well-being, empathy can diminish and humanitarian restraints can erode with frightening ease.

It is also entirely possible that the 'post-heroic' character of Western air forces has already passed its apogee, and that aircrews will face increasing risks in future. The growing sophistication of air defence systems is already seriously threatening the survivability of Western aerospace platforms (Ballard 2016). The revival of military tensions with Russia, China, North Korea, and others suggests that asymmetric warfare against foes such as ISIS is by no means the only plausible contingency, and in this context, current UAVs may simply be too vulnerable, forcing renewed dependence on manned aircraft (Terrett 2012; Doyle 2013). How Western nations can afford to maintain their technical and tactical aerospace dominance despite continuing economic decline relative to other parts of the world presents an increasingly intractable problem (Gordon, Johnson, Larrabee and Wilson 2012; Jones 2016). Worrying about the perceived unfairness of dominant post-heroic air power may be a luxury which the West will not enjoy for much longer, and the heroic example of air leaders such as Clostermann may very well come back into its own in years to come.

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21

DETERRENCE AND COERCIVE DIPLOMACY

Karl P. Mueller

Almost from its inception, the potential of air power to be a coercive instrument of revolutionary proportions was central to its proponents' case that their nations should embrace and invest in this new form of military power. Most argued that the ability to strike directly against the vital centres of an enemy early in a conflict could prove decisive, either by shattering the opponent's will to fight or by crippling its ability to wage modern war (Meilinger 1997). After the Second World War, it became clear that aerial bombing was not a panacea for preventing wars or for ending them quickly, but the advent of nuclear weapons gave new and even greater power to the hypothesis that apocalyptic fear could deter war and that air and missile forces were the means that could create such terror.

Under the shadow of nuclear threats, the Cold War remained cold for more than forty years. In the absence of a third world war, limited wars large and small came to provide the battlefields in which new generations of air power were tested, with a different coercive focus. Could air power enable the United States and other major military powers to achieve their objectives in these conflicts by compelling regional adversaries to accede to their demands without the need to wage long and expensive wars on the ground? After decades of mixed results, US-led coalitions wielding new aerial weapon, sensor, and command and control capabilities would achieve a striking series of operational successes in coercive air campaigns from 1991 to 2011. Air power proponents and converts hailed the transformation of air power from a blunt tool into a precise 'instrument of choice' for policy-makers, capable of delivering victory at limited cost and risk, while sceptics and detractors pointed to the persistently high cost of prolonged counter-insurgencies in Iraq and elsewhere as proof to the contrary that air power would be less, not more, relevant in the twenty-first century than it had been in the twentieth.

This chapter will consider these two aspects of coercive air power: its use as a deterrent shield and as a compellent sword in order to solve otherwise seemingly intractable national security problems. It begins with a very brief review of the nature and dynamics of coercion.

The art of coercion

Coercion, in its broadest sense, means causing someone to choose one course of action over another by making the choice that the coercer wants to avoid appear less attractive than the alternative that it prefers, whether by military, economic, or other means. Coercion occurs at

all levels of war, from the very tactical, such as using suppressive fire to make enemy troops decide that emerging from a foxhole is less appealing than staying put, to the strategic, where the coercer tries to deter an adversary's leaders from starting a war or, once conflict is under way, seeks to convince the enemy that surrendering would be a better choice than continuing to fight. This chapter focuses on strategic-level military coercion.

Coercion includes both *deterrence* – efforts to make the adversary not do something it otherwise might do such as attacking the coercer – and *compellence*, Thomas Schelling's term for efforts to make the adversary take an action it otherwise would not such as ceding territory to the coercer (Schelling 1966). There are important differences between deterrence and compellence: deterrence tends to involve a greater emphasis on threats relative to actual use of force, and compellence tends to be more difficult than deterrence because of factors such as policy inertia. However, the two forms of coercion resemble each other far more than they differ. Moreover, coercion often falls into the grey area between deterrence and compellence, such as threats intended to make an adversary halt an invasion, which might equally well be described as compelling the enemy to stop or as deterring the enemy from advancing further. In such cases, drawing a clear line between deterrence and compellence becomes a matter of pure semantics.

Whether the context is deterrent or compellent, coercion is an alternative to the purely destructive use of force. Pure force achieves its objectives by physically changing the world, such as by eliminating an enemy or taking away its ability to act in particular ways. Coercion, by contrast, seeks to affect the behaviour of the target by altering the choices that the target makes rather than by physically constraining its options (Schelling 1966).

Most wars are coercive in that their goal is to cause the enemy to surrender or to comply with other demands without carrying on the fighting to the point where the enemy is completely incapacitated. Achieving a pure force victory by utterly defeating a foe tends to be slow, difficult, and expensive, and may result in a post-war world less desirable than one in which the opponent gives up while it still has a choice in the matter. Of course, some wars begin with coercive objectives but end up being fought to the bitter end of one side's ability to resist when the loser refuses to give in; thus the defeat of Germany in World War II should be seen as a failure of coercion, in contrast to Japan surrendering when it still retained a significant albeit much reduced ability to fight.

However, states occasionally do go to war seeking pure force victories from the outset. This typically occurs in cases in which the enemy appears immune to coercion (as in Israel's military campaign to prevent Iraq from building a nuclear weapon), is so weak that crushing it is expected to be trivial (the US invasion of Grenada), or is so abhorrent that its destruction is considered imperative (the coalition war to destroy the Islamic State).

In both deterrence and compellence, it is useful to distinguish between two fundamental approaches to coercion strategy, which have come to be known as coercion by *punishment* and coercion by *denial* (Snyder 1961). Coercive punishment works by making the target expect to suffer high costs if it defies the coercer's demands (for example, by committing aggression or by refusing to surrender). It is in a sense the opposite of pure force: punishment does not make misbehaviour physically difficult, but instead seeks to make it prohibitively expensive. Nuclear threats to destroy counter-value targets are punitive by definition; so are almost all terrorist attacks and most retaliatory strikes against terrorists' bases or sponsors that are launched in response. Giulio Douhet's prescriptions for strategic bombing are a classic example of a punitive coercion strategy: razing an enemy's cities in order to break the morale of its populace does little in the short term to affect the enemy's ability to wage war, but in theory might dramatically alter its willingness to do so (Douhet 1942). Punitive attacks are often associated with targeting civilian populations, but the most potent punitive threat is one posed against what the

enemy values most, which could be almost anything – even non-material goods such as national honour. It is important to note that punitive coercion does not depend on inflicting pain on the target, but on causing fear of future pain.

By contrast, coercion by denial seeks to cause hopelessness by convincing the opponent that defying the coercer's demands will result in failure rather than success: that a prospective invasion will fail, that continuing to fight is a lost cause with no hope of success, that actions intended to intimidate others into compliance will instead provoke them to greater hostility. How best to create this expectation depends on the adversary's theory of victory that one seeks to undermine, but often it involves threatening or continuing to defeat the enemy's military forces. Thus denial can be characterised as a Clausewitzian approach to coercion, in keeping with the Prussian's declaration that 'if you are to force the enemy, by making war on him, to do your bidding, you must either make him literally defenceless or at least put him in a position that makes this danger probable' (Clausewitz 1976: 77).

In practice, punishment and denial strategies often intertwine – the same action may make war appear more expensive and more futile – and denial, in particular, may overlap with the destructive use of pure force. Whatever its form, coercive strategy is characterised by several key features that merit frequent re-emphasis. First, coercion happens – or does not happen – in the mind of the enemy. Objective reality only matters insofar as it shapes the target's decision-making; that is, decisions to go to war or to accept peace terms depend not on what is actually true, but on what the adversary believes to be true. Second, whether complying with or defying coercive demands appears the better choice depends on the value the opponent places on both alternatives. If the prospect of not going to war appears sufficiently dangerous or costly (as it did for Japan in 1941, for example), deterrence is likely to fail even if war appears very risky and expensive; similarly, fighting on in a lost cause is often more palatable to a beaten nation or leader than accepting the inevitable and surrendering.

Finally, there is no universally optimal prescription for successful deterrence or compellence. Every case has unique combinations of features that make it vital for strategists to specify whom they intend to deter from doing what, and under what conditions. Different adversaries will often call for different deterrence approaches even in response to seemingly similar threats, and deterring the same opponent from doing several different things may call for as many different coercive strategies. Moreover, until these strategies are put to the test, and often even afterward, the question 'how much is enough?' to deter or compel will not be one that can be answered with precision.

Winged deterrence

The first major bombing raids against population centres, by German Zeppelins and later Gotha and other bombers, caused modest damage to Great Britain by the First World War's standards of carnage, but considerable alarm. In the two decades that followed, extrapolating from these events, expectations became widespread that any future major war would feature catastrophic attacks on cities, against which no effective defence would be feasible (Overy 2013). Giulio Douhet and the air power theorists of the US Army's Air Corps Tactical School (ACTS) both argued, as did others, that such raids would be the decisive element of the next war, although their reasoning differed. Douhet's theory hinged on the belief that once the bombing began, urban populations terrorised by the prospect of imminent destruction would rise up and demand that their governments sue for peace, and would overthrow any leaders who refused (Douhet 1942). The officers of the ACTS, further removed from the revolutionary events of 1917–1918 in Russia and Germany and steeped instead in American models of civics

and economics, examined the matter in more technical detail and predicted that bombing would cause modern economies to collapse, making life in major cities unsustainable and forcing governments to surrender in order to protect their constituents from famine and death (Sherry 1987). Writers such as H. G. Wells popularised similar visions of future conflict.

When put to the test in the 1940s, these expectations proved overblown. Effective bombing turned out to be far more difficult than predicted, and well-organised air defences could prevent bombers from getting through, especially after the advent of radar. Most important, economies, governments, and civilian populations showed themselves to be surprisingly resilient. But in coercion it is expectations that matter, and this made air power a potent deterrent in its early years.

The Royal Air Force was particularly taken with the belief not only that punitive bombing could keep order in the colonies but also that the threat of ruinous air attack could effectively deter major wars, and this became a central pillar of British grand strategy in the 1930s (Posen 1986). Among the factors that led to Britain's pivotal decision not to go to war against Germany in defence of Czechoslovakia in 1938, its fear of bombing by the Luftwaffe (whose strength London greatly overestimated) loomed large (Bialer 1980). Harold Macmillan would later recall that with predicted casualties in the hundreds of thousands or more within the first weeks of conflict, 'We thought of air warfare in 1938 rather as people think of nuclear warfare today' (Macmillan 1966: 522).

Six years later, post-war reality caught up with pre-war rhetoric: the nuclear revolution was under way. The first atomic bombs were of the order of a thousand times more powerful than conventional weapons, enabling a single bomber to destroy the centre of a city. In the 1950s, thermonuclear weapons brought another three orders of destructive magnitude, enough for each bomb to raze a major urban area. Both sides in the Cold War were soon producing them in quantity, shortly thereafter adding a menagerie of smaller tactical nuclear weapons for battlefield use.

The task of making sense of the nuclear revolution fell largely to civilian strategists and social scientists (Kaplan 1983). Bernard Brodie (1946) and the deterrence theorists who followed him concluded that the combination of nuclear weapons and air power had fundamentally transformed great power warfare. From the outset of a conflict, states would now face the problem of being vulnerable to devastation in short order by attacks against which they could not protect themselves. Even air defences capable of intercepting bombers with historically unprecedented levels of effectiveness would be insufficient to prevent the remainder from inflicting catastrophic damage. The advent of long-range ballistic missiles in the 1950s reinforced this situation by turning the defensive problem from basically insoluble to utterly hopeless (Brodie 1959). Increasingly robust arsenals, with bombers on airborne alert and missiles based in hardened silos and on submarines, soon rendered once-popular visions of disarming a nuclear adversary by means of pre-emptive attack fanciful.

As the first nuclear-armed state and the world's dominant industrial power, the United States for a time enjoyed a degree of superiority over the Soviet Union that made it possible to rely on threats of nuclear punishment as an efficient all-purpose deterrent threat: the policy of 'massive retaliation'. However this period of advantage was fleeting, and the Soviet Union rapidly developed its own arsenal of nuclear weapons and delivery systems, to the point where the United States and its allies were no longer safe from similar attacks (Betts 1987).

Thus emerged the condition – often misleadingly called a policy or strategy – of mutually assured destruction (MAD), in which neither superpower could anticipate with confidence a nuclear exchange that did not result in apocalyptic levels of damage to its people and industry, regardless of which side had a larger arsenal or which struck first. Smaller nuclear powers such

as France and Britain tended to embrace strategic doctrines that centred on maintaining a survivable ability to inflict prohibitively high costs on an attacker even if they could not threaten to destroy the aggressor's entire country. Although many analysts saw MAD as a stabilising factor in international politics that would help prevent world wars and made the nuclear arms race pointless, others argued that a militarily or at least politically meaningful degree of nuclear superiority could still be achieved, or that it was naïve for Americans to imagine that the Soviet Union would consider a seemingly Pyrrhic victory in a war against the United States not worth the candle (Glaser 1990).

Building and maintaining robust capabilities to launch a massive nuclear strike against the enemy was a major undertaking for each of the superpowers (Freedman 2003). In the 1950s, Strategic Air Command (SAC) became virtually an armed service unto itself in the United States (Meilinger 2012), while USAF fighter capabilities concentrated on the missions of air defence against an enemy nuclear attack and on delivery of tactical nuclear weapons (areas of focus that would leave the service woefully unprepared for conventional air warfare over Vietnam a decade later). In the Soviet Union, the Strategic Rocket Forces literally became an independent armed service.

Over the space of decades, the desire to achieve the always elusive goal of nuclear superiority gradually faded, first in the United States and later in the Soviet Union, though it never disappeared entirely. Arms control efforts increasingly came to focus on limiting or eliminating capabilities that might undermine strategic stability by creating incentives for first strikes. Albert Wohlstetter's 'delicate balance of terror' (Wohlstetter 1958) lost its delicacy, and when the Soviet Union finally collapsed, it did so with a whimper rather than a bang. Meanwhile, the spread of nuclear weapons to additional states proceeded much more slowly than many had feared, amounting to roughly one new nuclear power per decade (Mueller 2009).

Diplomacy of violence

With the end of the Cold War, air power found itself in a new policy limelight as a coercive military tool with potentially great utility for compelling regional aggressors or other miscreant regimes to change their malignant behaviour at relatively little risk to those imposing the demands. This vision of air power as an inexpensive shortcut to victory was not without precedent, of course. In the early 1940s air power enthusiasts in Germany, Britain, and the United States had hoped to bring about the rapid defeat of their enemies using long-range bombing. This achieved no rapid coercive successes, although aerial attack did much to devastate the economies of Germany and Japan and contributed to the eventual coercion of Italy and Japan to accept Allied surrender terms (Overy 2013; Tooze 2007; Frank 1999).

The Cold War witnessed two great tests of air power as an instrument of compellence (in addition to a number of other coercive bombing campaigns such as the 'War of the Cities' in the Iran–Iraq War and Soviet air warfare in Afghanistan, which generally met with little real success). The Vietnam War saw a series of American air campaigns intended to break the will of North Vietnam to carry on its war in the South. From 1965 to 1968, Operation Rolling Thunder and several related punitive bombing campaigns sought to convince Hanoi that the price of its aggression was prohibitively high. The failure of this effort was widely attributed to Washington's Schelling-inspired approach of gradual escalation – progressively increasing the scope and intensity of air attacks to give the enemy time to recognise the fate that awaited it and comply with the coercive demands while much of the promised damage had not yet occurred. In practice this approach turned out to be too clever by half (Thies 1980), but the more fundamental problem was that North Vietnam's leaders simply placed a higher value on continuing the

immensely expensive war than on the things that bombing could destroy or lives expended on the battlefield (Clodfelter 1989; Pape 1996). In 1972, the Linebacker campaigns would achieve greater, although transient, success by targeting North Vietnamese military strength.

More consequential, though usually overlooked in discussions of coercive air power because it did not involve bombing and because its compellent dimension was less conspicuous, was the Anglo-American Berlin Airlift of 1948–1949 (Reeves 2010). Though first and foremost a defensive action to ameliorate the effects of the Soviet blockade of West Berlin (a punitive coercive campaign), the airlift was also an act of counter-coercion by denial, which succeeded by preventing Berliners from starving or freezing, thus convincing Moscow that its effort to take over West Berlin without resorting to an invasion was futile.

By the early 1990s, two profound changes had occurred in the strategic landscape of coercive air power. Politically, the collapse of the Soviet Union left states such as Iraq and Serbia without effective protection by a friendly great power, which gave the United States and its allies considerably greater freedom of action in using coercive force against them. Militarily, Western and especially US air power had been transformed by a set of technological and doctrinal changes based on widespread use of precision-guided munitions and new systems and processes for battle management and the conduct of air campaigns (Lambeth 2000). These developments made it possible for a reasonable number of strike aircraft to bomb many aim-points in short order with a high degree of accuracy.

This new capability was dramatically demonstrated in the 1991 Desert Storm air campaign to liberate Kuwait from Iraqi occupation (Putney 2004). Over five weeks, the air forces of the US-led coalition rapidly demolished Iraq's integrated air defence system and then proceeded to strike numerous governmental, leadership, and infrastructure targets in Iraq while simultaneously inflicting heavy attrition against the Iraqi army deployed in and near Kuwait to defend against the coming counter-offensive (Keaney and Cohen 1995; Olsen 2003). Strikes against the Iraqi command structure and targets associated with its internal political control ultimately produced little coercive effect – senior leaders survived, the populace prudently did not revolt against their battered oppressors, and the disruption that bombing inflicted upon Saddam Hussein's regime was not very consequential because Iraq's armed forces were too outclassed by the enemies they now faced to mount an effective defence even in the absence of strategic paralysis. However, the gradual demolition of Iraqi forces dug in to the south (and the mauling of the Iraqi army's sole offensive thrust – against Khafji in late January) had a greater impact on Baghdad, which had begun angling for a negotiated cessation of hostilities by the time the coalition armies' counter-offensive began (Pape 1996). It also showcased the extent to which mechanised armies had become vulnerable to outright destruction by modern air power even when not exposed through movement in the open (Johnson 2006).

During the next two decades, leaders of the United States and its allies turned to air power as their instrument of choice in a series of military interventions. In at least four of these operations – Bosnia in 1995, Serbia in 1999, Afghanistan in 2001 and Libya in 2011 – air power was the central (but not solo) player in achieving strategic successes that defied the predictions of observers (and sometimes the expectations of the airmen themselves) that victory would only be possible if the United States committed large ground forces to combat. At the strategic level the 2001 campaign against al-Qaeda and the Taliban regime in Afghanistan was primarily a pure force effort to destroy rather than coerce the enemy (Lambeth 2005), and the same turned out to be true in Libya once it became clear that Muammar Gaddafi was unwilling to strike a bargain that would include his removal from power (Mueller 2015). The Bosnian and Kosovo air campaigns, in contrast, were conspicuous coercive successes, though the latter was far from elegant in strategic terms (Owen 1999; Lambeth 2001). When in June 1999, after

seventy-eight days of bombing, Slobodan Milošević capitulated to demands that Serbia relinquish territorial control over its province of Kosovo this represented a best-ever result for punitive compellence though air attack, which had so often failed to live up to expectations, though it was not the only factor at work in producing the outcome (Hosmer 2001a). The result even sufficed to rehabilitate gradual escalation as a coercive strategy feature in the eyes of many, thirty years after the failure of Operation Rolling Thunder led to its being branded as a fundamental strategic error.

Bombing to win?

For a number of reasons outlined early in this chapter, designing and implementing effective coercive strategies that employ air power, whether for deterrence or compellence, is an imprecise activity. This problem is compounded by the relative dearth of historical experience upon which analysts can draw for guidance. Scores of major coercive air campaigns have been conducted since the invention of powered flight, but not hundreds, and many of those cases date from the pre-revolutionary side of profound changes in air power technology and practice. The beginning of Operation Rolling Thunder was temporally closer to the Fokker Scourge of 1915 than to the present day. This does not mean that history has little to teach about the coercive use of air power, but it should instil a sense of modesty in analysts when making empirical generalisations.

In his seminal study of aerial coercion in major wars, *Bombing to Win* (1996), Robert Pape influentially argues that while denial strategies do not always produce coercive success even when they are militarily effective, punishment strategies always fail to coerce. (He also controversially extends this argument to the point of declaring that history demonstrates 'strategic bombing does not work', although that claim invokes a distinction between strategic and tactical air power that became obsolescent in the 1960s and depends on some definitional slight-of-hand such as defining the German oil industry in World War II as an operational rather than a strategic target set (Mueller 1998)).

The logic of the denial-trumps-punishment argument is straightforward: when the coercive stakes are high for the target state, such as catastrophic defeat or loss of territory (the issue at stake in all of the canonical bombing cases that Pape examines in detail), the suffering and fear that conventional bombing can produce is insufficient to outweigh the incentives for fighting on if victory (or in some cases merely improved surrender terms) still appears within reach. The historical evidence is also compelling: in 1945 Germany fought on to the bitter end despite years of devastating urban bombing, and the incineration of Japan's cities – even Douhet could hardly have dreamed of much worse destruction – did not end the war in the Pacific. Nor were punitive attacks coercively effective when applied bluntly in Korea or with exquisite deliberation against North Vietnam, although Serbia's capitulation in 1999 remains a notable exception to this pattern.

However, the 'when the stakes are high' caution is crucial. If the costs of complying with the coercive demands do not appear prohibitive, the logic of this argument breaks down and punitive coercion may again become an option. While air attacks are not likely to be threatened or employed for coercion in cases where the stakes are very low, a substantial range of situations certainly exists in which the issues in dispute are serious enough to justify the use of force, yet less than existential for the actor being coerced. Denial may still be more readily persuasive than punishment in these cases, but it is not always a feasible option.

Given the practical as well as the moral challenges (at least for Western powers) associated with carrying out coercive punishment against enemy populations, theorists such as John Warden

(Olsen 2007) and John Boyd (Osinga 2006) argued in favour of strategies directed against enemy leaders and their command and control structures, with the goal of either frightening the leadership into complying with coercive demands, or paralysing their ability to command their forces. However, such attacks have failed with remarkable frequency to produce their desired results by terrorising enemy leaders or causing uprisings against them (Hosmer 2001b), while strategic paralysis has often proven an elusive goal – and one that in some cases, such as the 2003 invasion of Iraq, might have been counterproductive in any event (Hosmer 2007).

The track record for denial strategies is more encouraging. States only rarely start wars that they expect to lose, though fighting on against desperately long odds is less unusual once conflict is under way. It is worth noting that the dramatic advances in air power capabilities made in recent decades have been particularly beneficial for denial strategies (at least to the extent that these tend to be associated with attacking military targets). Exquisite precision can be very useful in punitive attacks, but usually is not essential.

In the most general of terms, it is fair to say that coercion has a good chance of succeeding if the coercer can bring about four related conditions, and can do so prior to succumbing to any counter-coercion directed against it. First, the target should believe that victory is impossible in the current or prospective conflict, because even a slim hope of eventual success may be sufficient motivation to hold out against even great coercive pressure. Second, the opponent should be further convinced that defying the coercive demands does not even offer a prospect of producing any result better than complying with the current demands would be; even when victory appears out of reach, the enemy is likely to grasp at straws such as the prospect of forcing a negotiated compromise settlement. Third, in compellent situations, surrender now should appear a better deal than surrender later, either because continuing to resist is costly, or because the terms demanded are likely to become more severe as time passes – otherwise the natural course of action is likely to be delay. Finally, complying with the coercer's demands must be at least minimally acceptable to the adversary in absolute terms, for if it appears too catastrophic to contemplate, then any alternative is likely to seem preferable, no matter how unpleasant, hopeless, or desperate. Coercion may actually succeed without achieving all of these conditions, particularly if the coercer's demands are not great, but failure to fulfil any of them may be sufficient to make a coercive strategy fail.

Never alone

Amid the air power-centric wars of the 1990s, an old debating point returned from the dead: *Can air power win wars by itself?* The supporting argument often takes the form of asserting that the dearth of victories attributable to air power acting in isolation reveals a fundamental limitation of the instrument. However, this is a question wrongly posed.

The contention that air power has never won a war alone is essentially true. Even in interventions where the United States and its allies employed only air power in combat – in the Kosovo conflict and the Libyan civil war – ground forces played important though very different roles. In Libya, rebel ground forces acted in concert with NATO air power to defeat the Gaddafi regime (Mueller 2015); against Serbia the prospect of an eventual combined arms invasion of his country presented Slobodan Milošević with the prospect that continuing to hold out against NATO's coercive air campaign would be not only expensive but also pointless (Byman and Waxman 2000). Similarly, the military intervention in Bosnia in 1995 depended on the extensive use of ground forces (albeit not American), and the surprisingly rapid defeat of the Taliban regime in Afghanistan in 2001 involved US and allied special operations forces on the ground in addition to US air power and Northern Alliance ground forces.

Yet observing that air power never wins wars by itself misses the real point of such a historical survey: it is equally true to say that air power has never lost a war by itself. Above the level of isolated raids, air power is essentially never employed alone (much the same is true of land and maritime power). Moreover, modern airmen have rarely suggested that it should be, because advantages can always be gained from some sort of synergy between air and other forms of power, even in situations involving 'no-boots-on-the-ground' pledges or policies.

Conclusion

During the Cold War, SAC famously adopted the motto 'Peace Is Our Profession'. Often mocked for its irony, perhaps most bitingly by Stanley Kubrick in *Dr Strangelove*, the slogan captured an essential truth: the central purpose of the US nuclear arsenal (like that of the armed forces of many countries) was to prevent rather than to win wars. If the United States fought and won a nuclear war against the Soviet Union (whatever 'winning' might comprise in such a context) it would mean that SAC had failed in its essential mission.

For a quarter century following the opening of the Berlin Wall the deterrence mission receded into the background for Washington and most of its allies, as least with respect to preventing aggression by major powers. Instead, the vexing problems of the day typically centred on preventing terrorist attacks (which were often described as undeterrable), removing problematic Third World regimes or compelling them to behave acceptably, and dampening or resolving internal conflicts in dysfunctional states, with an emphasis on the use rather than the mere threat of force. At least one prominent critic went so far as to argue that it was unfortunate that many of SAC's nuclear bombers had never been used in anger, since this meant that building them had been a waste of money (Farley 2014). In fact, the deterrent effect of both nuclear and conventional air power still shapes the strategic landscape, for instance by discouraging overt state sponsorship of terrorist groups and helping to make regional aggression unattractive to almost all of the states capable of undertaking it. Successful deterrence is often invisible, especially when observers' attention is focused on active warfare elsewhere, but the fact that it recedes into the background does not mean that it is unimportant.

With the impressive expansion of Chinese military power and Russia's new bellicosity, deterring major conflicts returned to the centre of the security policy agenda in the mid-2010s. It would distort reality to call this a new cold war: the stakes are far different, the deep ideological conflicts largely absent. Yet, as was true sixty years earlier, the potential wars that pre-occupy Western planners are increasingly ones where avoiding conflict must be the objective. Fighting and winning a major war against Russia or China, or even North Korea, would signify a massive strategic failure. The task of making such a war look decisively unattractive in military terms falls very heavily – but emphatically not solely – to air forces.

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22

AIR POWER IN MULTINATIONAL OPERATIONS

Christian F. Anrig

The Desert Storm air campaign saw the emergence of a medium-altitude doctrine. The medium altitudes have given Western forces a sanctuary from which to strike precisely with near impunity, yet using them came at a price. Securing the medium altitudes and running complex air operations have required air power assets that most European air forces have lacked or have not possessed in sufficient numbers. The net result has been a disparate effort in multinational air campaigns. While the United States has in essence provided the backbone for conducting those campaigns, making tangible contributions to US-led operations has proven a challenge for European air forces.

Stressing national discretion, France has sought to proactively impose its strategic agenda onto the conduct of multinational air campaigns. To that end, French authorities have regarded autonomous intelligence as being of utmost importance. In contrast, the UK has never striven for a similar degree of autarchy, but has instead emphasised interoperability with the United States. Because of Germany's policy of self-imposed restraint, the German Air Force has so far not translated its full spectrum of capabilities into operational output. Selected smaller NATO air forces with the right training, equipment and political leeway have made contributions out of proportion to their size, while others have not been able to contribute to multinational air campaigns.

In peacetime, the permanent protection of national airspace has absorbed significant resources, particularly in light of ever-decreasing fighter aircraft inventories. Yet only a few nations and air forces have implemented measures to preserve significant resources in that area. On a more positive note, NATO has provided an effective command and control architecture for air policing to its member states. Member nations have also sought cost-saving measures through cooperation in the domain of the so-called force enablers that include, among others, air transport, air refuelling and airborne early warning. In this way they have helped mitigate European shortcomings.

This chapter first sets the background by examining operational aspects of multinational air campaigns. It subsequently looks at peacetime cooperation and finally deals with strategic considerations of multinational operations.

Multinational air campaigns

The outset of the post-Cold War era coincided with an extraordinary manifestation of American air power. The Desert Storm air campaign had a profound impact on the conduct of future multinational operations. In particular, it ushered in a shift from low-level attack to medium-altitude operations (between 10,000 and 25,000 feet), with far-reaching corollaries for the employment of air power.

Medium-altitude doctrine

At the dawn of Desert Storm, the advantages of a medium-altitude approach were not obvious to all airmen. Some fervently supported low-level attacks. Given the ubiquitous threat posed by light anti-aircraft artillery and shoulder-launched surface-to-air missiles, losses at the low level were sobering (Hallion 2013: 326). Desert Storm's air component commander thus ordered United States Air Force (USAF) units to attack from medium altitudes and suggested to coalition partners that they do the same (Nordeen 2002: 217). Not only were medium-altitude operations safer, but they also allowed for more effective navigation and target acquisition.

The shift to the medium altitudes required thorough neutralisation of medium- and long-range surface-to-air missile systems. During Desert Storm's first twenty-four hours alone, American aircraft launched hundreds of AGM-88 high-speed anti-radiation missiles. Electronic warfare aircraft augmented the defence suppression effort by providing stand-off jamming (Lambeth 2000: 112). Flying above the effective range of anti-aircraft guns and shoulder-launched missiles, defence suppression allowed the air armada to take on an entire army from the medium altitudes.

In the wake of Desert Storm, a medium-altitude approach continued to keep losses to a minimum. Over Bosnia from 1992 to 1995, NATO air forces suffered a total of four downed aircraft, three of them shot down by infrared missiles while flying at lower altitudes. Suppressing ground-based air defences proved particularly vital during Operation Allied Force over Kosovo and Serbia in 1999. Yugoslav air defence operators expended several hundred surface-to-air missiles, but thanks to defence suppression they only managed to down two manned aircraft, including an F-117 stealth-bomber early in the campaign (Lambeth 2001: 108). They proved more successful at shooting down unmanned aerial vehicles, in excess of twenty, that did not receive protective escort (Nordeen 2002: 257).

The medium-altitude approach has enabled air warfare on a completely different scale: various target sets and numerous aim points can be attacked simultaneously. Yet Allied Force unforgivingly laid bare European air power shortfalls. Precision fire, necessary for effective medium-altitude operations, was preponderantly American. Some 35 per cent of approximately 23,000 munitions expended were precision guided. French forces, which dropped by far the most significant share of European precision weapons, employed 582 laser-guided bombs (Anrig 2011a: 36, 105).

Unlike low-level attack doctrine, a medium-altitude approach with all its necessary force enablers is – from a European perspective – inherently multinational. The necessity to jointly mount air operations has elevated the importance of interoperability to an unprecedented level. For instance, lack of interoperable equipment, particularly in the domain of identification friend or foe (IFF), significantly hampered French air operations during Desert Storm (ibid.: 103). In the meantime, digital data link communications have become a prerequisite for multi-national operations. As the Swedish contingent for the Libya campaign of 2011 experienced, equipping aircraft with Link 16, NATO's standard data link for air operations, is not sufficient.

Obtaining crypto keys for full integration into an ongoing campaign took an extended period of time for non-NATO member Sweden (Egnell 2015: 327–329). Efficiently running multinational operations thus requires connectivity among all forces involved from the outset.

Required force enablers

Defence suppression has been a key enabler of modern air warfare and has been almost exclusively the province of the United States. In Allied Force, nearly all strike missions received stand-off jamming support from US Navy/Marine Corps EA-6B electronic warfare aircraft. The US also contributed the bulk of anti-radiation missile shooters, complemented by ten German and six Italian Tornado electronic combat/reconnaissance (ECR) aircraft. On a positive note, the German Tornado ECR contingent launched a significant portion of high-speed anti-radiation missiles – 236 out of a total of 743 expended throughout the campaign (Nordeen 2002: 257; Anrig 2011a: 180). Up to the time of writing, these missiles have been the only munitions that German fighter pilots have since the Second World War fired in anger. In the wake of Allied Force, NATO formally acknowledged its shortage of defence suppression assets and inadequate stocks of precision-guided munitions (Anrig 2011a: 55–56).

The air campaigns of the 1990s were followed by a decade dominated by land-centric campaigns in Afghanistan and Iraq, where opposing forces could not mount a substantial air defence threat. As a consequence, shortfalls in defence suppression did not receive adequate attention. Only in light of renewed East–West tensions did NATO re-acknowledge suppression of enemy air defences as a defence planning priority and seek to reduce its over-reliance on the United States in this area.

US air refuelling capacities have also played a preponderant role in multinational operations. According to a RAND report, the United States deployed more than 170 tankers at the height of Operation Allied Force, while Europeans mustered thirteen (Peters et al. 2001: 33). In 2013, the air forces of France, Germany, Italy, the Netherlands, Spain and the UK fielded some sixty tanker aircraft (including convertible transport aircraft), while the overall size of the US tanker fleet amounted to 640 aircraft of various types. The UK and France have provided the bulk of European air refuelling capacities. In recent years, the UK has modernised its tanker fleet with fourteen Airbus A330 multi-role tanker transports (MRTTs). The French expect delivery of the first of twelve Airbus MRTTs in 2018. Moreover, the French and German air forces each intend to operate ten A400M transport aircraft as convertible tankers (Joint Air Power Competence Centre 2014: 9–10).

As post-Cold War air campaigns have demonstrated, European air power also depends largely on US command and control. This is not only an issue of facilities and equipment, but also of training. The USAF invests significant time and effort training personnel at air operations centres (Greenleaf 2013: 40). NATO dependence on US command and control became particularly apparent during Operation Unified Protector, the Alliance's air campaign over Libya in 2011 (Anrig 2015: 305). US forces also provided the bulk of targeting expertise, one of air power's key underpinnings that most European nations have tended to neglect (Daalder and Stavridis 2012: 6).

Europe's lack of determination to improve military capabilities has aggravated consecutive US Secretaries of Defense. For example, in the midst of NATO's Libya campaign in 2011, Robert Gates voiced blunt criticism of European allies. Without substantial American support, the NATO-led operation might have fallen apart, and a host of allies were not even in a position to contribute to the operation, let alone to conduct offensive strike missions (Shanker 2011).

Peacetime cooperation

In peacetime, NATO air policing is one of the most prominent tasks of Alliance air forces and requires a non-negligible amount of resources. Cooperative frameworks aim to leverage those scarce resources. These efforts have taken place in an Alliance setting, multilaterally or bilaterally.

Air policing

NATO air policing requires Alliance members to have jet aircraft permanently on quick reaction alert (QRA) for intervention against hostile state (i.e., military) aircraft. European NATO territory is essentially divided into two air policing areas. The combined air operations centre (CAOC) Uedem, Germany, is in charge of the northern area; CAOC Torrejon, Spain, of the southern. Both CAOCs closely cooperate with national control and reporting centres in charge of national air policing against civil renegade aircraft (Allied Air Command 2016a).

With shrinking jet aircraft inventories, NATO air policing places an ever-increasing burden on European Alliance members. In light of renewed East–West tensions, the Baltic area has become a hotspot for NATO air policing. Since the Baltic States cannot yet afford their own fighter aircraft fleets, Alliance air forces have alternately provided QRA forces since 2004. As regards command and control, CAOC Uedem is in charge of Baltic Air Policing. Common on-site training has enhanced interoperability among the forces involved, including those of non-NATO members Finland and Sweden (ibid.).

To save resources, the Netherlands and Belgium established a common air policing arrangement. On 1 January 2017, Belgian F-16s began to provide the first air policing rotation for the airspace of Belgium, the Netherlands and Luxembourg (La Défense 2016). The arrangement leverages synergies between the two countries' air forces, and was rightly hailed as an example of smart defence among allied nations (Allied Air Command 2016b). Yet it is not easy to replicate for two reasons. First, geography is conducive to common air policing: the three countries have a rather small airspace, making it possible for one set of aircraft to police the entire area. Second, both countries and air forces have built up trust over decades. In late 2016 and early 2017 respectively, Slovakia and the Czech Republic endorsed plans for mutual assistance in cases of emergency. The Czech–Slovak air policing arrangement, if implemented, falls short of its Dutch–Belgian counterpart, while plans between other nations to establish common air policing have never come to fruition.

Cooperative frameworks in NATO

The Alliance established its first multinational flying unit in the early 1980s. Since then, the NATO Airborne Early Warning and Control Force (NAEW&CF) has remained one of the most successful cooperative ventures in the domain of air power. It encompasses two operational elements: a multinational fleet and the UK's airborne early warning component. With its main base in Germany, the multinational fleet currently comprises sixteen Boeing E-3A AWACS [Airborne Warning and Control System] aircraft. The international crews are mustered from fifteen NATO nations (NATO Airborne Early Warning and Control Force 2016). In response to Russia's annexation of Crimea in early 2014, the NAEW&CF ramped up its efforts to provide enhanced situational awareness of NATO's Eastern flank and was thus seen as a critical element in reassuring the Alliance's Eastern members (NATO 2016b).

Much newer than NATO's multinational AWACS force, the NATO Response Force (NRF) has been one of the most prominent frameworks in the Alliance's recent history. Launched at

the 2002 Prague summit, the NRF aims at generating a deployable joint force for operations across the military spectrum. So far, the response force has only been deployed for operations with a predominantly non-military character, such as disaster relief. It has nonetheless had a major impact upon military transformation. Based on a rotational system, allied nations earmark deployable force packages that make up a specific NRF. Each force package must undergo rigorous multinational training. In light of East–West tensions, Alliance members decided at the 2014 Wales summit to enhance the NRF by establishing a spearhead force within it, known as the Very High Readiness Joint Task Force (NATO 2017).

Providing command and control of an NRF air component is vital. At the outset, air component commands were rotated among NATO headquarters, the French Air Force and the Royal Air Force (RAF). They have also been the only European air forces to provide entire deployable air bases nationally, underlining these two air forces' special capabilities (Anrig 2011a: 23, 96–98). In the meantime, other larger European air forces are also in a position to provide command and control of an NRF air component (NATO 2015).

Bilateral and multilateral cooperative frameworks

While the USAF and, to a lesser extent, the Soviet air force built up heavy strategic airlift capacities during the Cold War, Western European armed forces were expected to fight 'in place' and hence did not require similar capacities. With power projection coming to the fore in the post-Cold War era, shortfalls in strategic airlift became glaring. To allay shortcomings, European air forces in the late 1990s began making better use of available air transport and refuelling assets through enhanced multilateral coordination and exchange of services. Cooperative endeavours culminated in the establishment of the European Air Transport Command (EATC) in 2010 (Anrig 2011a: 25–26, 56, 60, 173–174). Based in Eindhoven, the Netherlands, the EATC exercises operational control (planning, tasking and control) of major portions of the air transport and air refuelling fleets of Belgium, France, Germany, Italy, Luxembourg, the Netherlands and Spain (European Air Transport Command 2017). Luxembourg is to acquire an A400M transport aircraft, which, alongside seven Belgian A400Ms, will become part of a binational fleet available to the EATC.

In mid-2016, the Netherlands and Luxembourg agreed to jointly procure two A330 MRTTs, which will form the nucleus of NATO's multinational MRTT fleet (NATO 2016a). Luxembourg, a small Alliance member state, once more used multinational cooperation to leverage its contributions to Western air mobility. In September 2017, Germany and Norway joined this multinational endeavour, placing orders for five additional tankers. There was an option for up to four more aircraft to allow other nations to join the multinational MRTT fleet (European Defence Agency 2017). At the time of writing, Belgium was poised to follow suit.

While cooperative endeavours in the domain of force enablers have, once implemented, proven successful, fighter-bomber cooperation is a different matter. In 1979, the establishment of the tri-national Tornado training establishment at Cottesmore, UK, among Britain, Germany and Italy represented a significant step in European cooperation. Due to divergence in midlife updates to each nation's Tornado fleet, however, the cooperation petered out in the 1990s (Anrig 2011a: 174–175).

European F-16 operators have so far offered the most successful example of European fighter-bomber cooperation. In the mid-1970s, Belgium, Denmark, the Netherlands and Norway began to commonly procure the F-16. In the framework of European Participating Air Forces (EPAF), the four countries' F-16 fleets underwent a midlife update in the 1990s. Pooling of national procurement requirements formed the basis for operational cooperation.

Having accumulated considerable operational experience over Bosnia, the Royal Netherlands Air Force was the driving force behind common F-16 operations. A Belgian F-16 unit joined the Dutch contingent for Operation Allied Force in the framework of a combined deployable air task force. During that campaign, the Royal Netherlands Air Force managed to surpass the UK's larger RAF in terms of precision-guided munitions expended, and a Dutch F-16 shot down a Serb MiG-29 – the only European air-to-air kill of the 1990s (Anrig 2015: 269–270).

Against the backdrop of Operation Enduring Freedom, a Danish, Dutch and Norwegian fighter-bomber detachment deployed to Manas International Airport, Kyrgyzstan, in autumn 2002 to support the fighting in Afghanistan. Common F-16 operations became institutionalised when in 2004 Belgium, Denmark, the Netherlands, Norway and Portugal – at that time also an F-16 operator – established the EPAF Expeditionary Air Wing (EEAW). Moreover, through a common EPAF fighter weapons instructor training programme, the less-advanced partners were able to catch up and hone their combat skills (ibid.: 270–271, 303, 306).

As regards binational cooperation, the UK and France, sharing similar ambitions in power projection, have on a number of occasions closely cooperated in defence matters. In 2010, French and British authorities set out to give their countries' bilateral ties new impetus. Liam Fox, the UK's Secretary of State for Defence at the time, considered cooperation with France desirable because the French met two key criteria: the willingness to deploy and the willingness to spend on defence (Tran and Chuter 2010: 1). French President Nicolas Sarkozy and British Prime Minister David Cameron announced the Lancaster House Treaty on 2 November 2010, with the aim of improving collective defence capabilities. The Lancaster House Treaty explicitly referred to cooperation in the air power domain, such as A400M support, and to the strengthening of operational linkages between the British and French armed forces (Government, United Kingdom 2010b).

Simultaneously a tri-national partnership among the USAF, the RAF and the French Air Force was shaping up. Each air force established a strategic studies group staffed by officers from the three nations to commonly reflect on air power at the highest echelons (Reed and Tran 2010: 1). The value of these ties was soon to be demonstrated during the Libya campaign. Catalysts for this close relationship were France's fully rejoining NATO in 2009 and the Lancaster House Treaty. In the wake of the Libya campaign, the three countries' air chiefs issued a joint statement emphasising their air forces' close relationships and capacities to conduct forced entry operations at short notice, thereby singling them out as leading air forces (Schwartz, Dalton and Paloméros 2012: 19).

Strategic considerations

Intelligence has been the key underpinning of air power, but, contrary to the logic of multinational operations, nations have only reluctantly shared intelligence. Similarly, national caveats have allowed nations to retain some degree of national discretion, but have also been a source of frustration for countries bearing the brunt of operations. Both issues aptly highlight strategic considerations of force-contributing nations and the intricacies of multinational operations.

Strategic implications of intelligence

For most Europeans, multinational essentially means 'American-led'. Only France de facto aspires to launch an air campaign autonomously. For the Libya air operations, French authorities intended to establish a Franco-British chain of command, yet the British did not seem willing to follow up on such a command arrangement (Grand 2015: 166). For French airmen,

the ability to swiftly launch forced entry operations is a benchmark (Chuter 2013: 46). Conducting those operations in turn requires a multitude of national intelligence assets, due to the reluctance of key military players to share intelligence.

The run-up to the Libya campaign thus encompassed various national intelligence campaigns. Only the United States and France had intelligence assets in place to develop sufficient situational awareness for a forced entry. Prior to the start of hostilities, French reconnaissance satellites operated above Libya. To adequately assess the surface-to-air missile threat from standoff distances, the French armed forces deployed various electronic intelligence sensors – airborne, shipborne and submarine based (Notin 2012: 75, 81–85, 107–109, 149). In the foreseeable future, the French armed forces will field a space-based electronic intelligence capability.

National intelligence was to prove critical in enabling France to open the Libya campaign on 19 March 2011. Two years later, the French defence white book reaffirmed that, even when operating along allies, autonomous intelligence and a targeting capability were to be preserved (Ministry of Defence, France 2013: 92).

Experience in real operations brought home the importance of autonomous intelligence. Even though French forces contributed significantly to air operations above Afghanistan in the wake of September 11, US Central Command did not involve partners in the decision-making process. The Americans provided information and intelligence to coalition partners on a need-to-know basis, the exceptions being the United States' Anglo-Saxon partners in the so-called Five Eyes framework (Longuet 2003: 211).

Not surprisingly, British airmen thus tend to favour US-led command and control formats, pointing to reduced room for confusion and bureaucratic strife as opposed to NATO-led operations (Gray 2014: 113). They have enjoyed a privileged position over their Continental European counterparts, and US-led 'coalition of the willing' operations have allowed the British to leverage their special relationship with the United States. The UK armed forces' self-image is that of a coalition partner of choice. As a British scholar and former RAF senior officer noted, the 'enduring desire to be seen as the United States' ally of choice' is vital to the UK's strategic calculus (ibid.: 106–107). The RAF's ability to project self-supporting detachments of strike assets and force enablers with a high degree of situational awareness undergirds this image (ibid.: 134). The UK's 2010 defence review elevated military capabilities valued by the United States as critical to defence planning (Government, United Kingdom 2010a: 12). Five years later, the 2015 defence review stressed the importance of Anglo-American cooperation in operations and placed it at the heart of UK planning assumptions (Government, United Kingdom 2015: 51). This preference chimes with Britain's dependence on the United States in the domain of space-based intelligence assets – an indispensable domain for modern air warfare.

In Libya, Belgian, Danish and Norwegian fighter-bombers expended approximately three-quarters the number of the precision weapons delivered by British and French fixed-wing aircraft combined, representing a quantum leap in European precision firepower. Key USAF staff at the combined air operations centre also singled out Denmark and Norway as the most flexible engaging certain targets throughout April 2011, after US forces had ceased offensive operations. Yet despite their significant contributions, these nations were not granted access to intelligence commensurate with their efforts. In fact, the privileged sharing of intelligence among the Anglo-American partners to the exclusion of other NATO members was viewed as detrimental to the smooth running of operations (Anrig 2015: 267, 300–301, 304–305).

Co-ownership of intelligence assets will enhance smaller NATO nations' access to intelligence. In 2012, in the aftermath of the Libya campaign, Danish authorities thus decided to rejoin the NATO Alliance Ground Surveillance (AGS) project (Ministry of Defence, Denmark

2012). Through AGS, several Alliance partners commonly operate a high-altitude long-endurance (HALE) unmanned aerial vehicle (UAV) fleet with the requisite ground and intelligence infrastructure out of Sigonella, Italy.

National caveats

Some allies' propensity to impose stringent national caveats upon their forces has been a source of frustration for US authorities (Shanker 2011). They have tended to view national restrictions as impairing combat effectiveness.

To leverage Dutch contributions to multinational operations, the Royal Netherlands Air Force benefitted from considerable political leeway. For air operations over Libya in 2011, however, authorities in The Hague did not grant permission to conduct air-to-ground strikes. Investigations into the Netherlands politically and militarily supporting the US occupation of Iraq in 2003 and the issue of extending Dutch military operations in Afghanistan in early 2010 led to the fall of the government. The ensuing general election resulted in a political constellation less favourable and conducive to robust out-of-area operations (Anrig 2015: 294–296).

Far-reaching support for American-led operations thus led to a political backlash in 2011. Yet Dutch airmen's innovative approach to air power made up for restrictive national caveats. Using their targeting pods, F-16 crews conducted non-traditional ISR (intelligence, surveillance and reconnaissance) missions (ISR without the specific, dedicated means to perform these missions). The air component commander, Lt Gen. Ralph Jodice, later judged that in light of scarce tactical reconnaissance assets, the Netherlands' contribution was critical (ibid.: 298, 302).

As in the Netherlands, authorities in Berlin have regarded acting in conjunction with allies as a cornerstone of German defence policy. Yet they have only cautiously and with restraint committed to out-of-area missions. In late 1994, pressure to deploy German Tornado ECRs grew. Only in mid-1995 did German authorities commit their dedicated anti-radiation missile shooters to operations over Bosnia, and German Tornado crews operated within narrow national rules of engagement. While NATO could not directly draw upon German defence suppression aircraft, the mere presence of Tornado ECRs inhibited hostile surface-to-air missile activity. In 1999 German Air Force units finally participated as 'equal partners' in Allied Force, with German Tornado ECRs shouldering a significant portion of the defence suppression effort (Anrig 2011a: 170, 178–180).

Yet Germany's experience in Allied Force has remained an exception. It came as no surprise when Berlin did not commit to the Libya campaign in 2011. German Tornado ECRs would have been valuable assets. Italy, the other European Tornado ECR operator, committed itself only hesitantly to Libya air operations. Vital European assets to neutralise Libya's air defences were thus missing in the opening stages of the campaign (Anrig 2011b: 93).

Even though Tornado ECRs leveraged German air power in the Balkans, the fleet was slashed from thirty-four to twenty aircraft at the beginning of this decade (International Institute for Strategic Studies 2011: 112; International Institute for Strategic Studies 2012: 119). Since that fleet offers a sought-after capability in multinational operations and since it is convenient in terms of national caveats – primary targets being ground-based air defences – the decision is difficult to comprehend from the outside. Land-centric operations of the last decade, during which defence suppression was not required, might have boded ill for the Tornado ECR force.

In contrast to peace enforcement operations, authorities in Berlin have regularly committed German Air Force units to the Baltic Air Policing that safeguards the Alliance's sovereignty in a sensitive neighbourhood. Germany has also contributed significantly to cooperative

frameworks, for instance supplying a third of NATO's multinational AWACS force (Anrig 2011a: 185, 200).

Similarly to Germany, albeit for different reasons, Turkey has contributed to Western air campaigns within narrow national confines. For instance, Ankara did not authorise the Turkish Air Force to conduct offensive sorties during the Libya campaign, and its KC-135 tanker aircraft were detailed to support Turkish missions only. This restrained approach has stood in stark contrast with Ankara's campaign against the Kurdistan Workers' Party (PKK) (Anrig 2014: 75, 78, 81, 104–105).

In 1999, conscious of the relative magnitude of their contribution, French authorities sought to impose restrictions on the conduct of an entire operation. Through NATO councils and committees, they effectively shaped Operation Allied Force (Ministry of Defence, France 1999: 11–12). Moreover, French President Jacques Chirac, who in addition to President Bill Clinton and Prime Minister Tony Blair was vested with veto power, frequently expressed concerns about collateral damage in the Belgrade area and about targets in Montenegro (Anrig 2011a: 106). Yet the level of European (i.e., French) political influence on the campaign, combined with a conspicuous transatlantic capability gap, produced sour feelings across the Atlantic. Lt Gen. Michael Short, the campaign's air component commander, singled out France as unduly inhibiting the course of the campaign and putting allied airmen at unnecessary risk by restricting targets, particularly surface-to-air missile sites in Montenegro (Clark and Short 1999: 12–14). At the same time, intra-American disputes arose on how best to run the air campaign. While Short intended to go after leadership targets in Belgrade in a shock-and-awe fashion, Gen. Wesley Clark, Supreme Allied Commander Europe, identified Serbian ground forces in Kosovo as the centre of gravity (Daalder and O'Hanlon 2000: 198). France might thus also have served as a convenient post-war scapegoat.

Conclusion

While the medium altitudes have allowed air warfare to be waged on a completely different scale, they also have required a plethora of force enablers. Due to scarcity or lack of those assets, cooperation has become a necessity for European air forces. Only the US armed forces have the critical mass to provide these force enablers in sufficient quantities. Cooperative frameworks have helped to mitigate European shortfalls. Yet even a commonly procured European tanker fleet is likely to fall short of actual requirements in real campaigns (not all tanker aircraft are available at any one time); according to an American rule of thumb, the fighter-tanker ratio is supposed to be 4:1. Even a more lenient ratio would require a considerable tanker fleet for medium-sized operations.

In light of an austere economic environment, maintaining sizeable combat aircraft fleets has even become a challenge for the larger European air forces, making it more difficult for them to field the required force enablers. Force specialisation among European nations has often been heralded as a remedy, yet it has proven to have limits, since not every partner is likely to participate in any given scenario. As noted, the coalition could for instance not draw upon Europe's dedicated defence suppression assets in the opening stages of the Libya campaign in 2011. Dependence on US force enablers is thus likely to persist in real operations.

The good news is the ever-increasing versatility of modern airborne platforms. For instance, modern combat aircraft might – with the right armament and sensors – inherently wield a defence suppression capability. Likewise, modern transport aircraft, such as the A400M, can easily be turned into tanker aircraft. Air power's growing flexibility, if leveraged, can significantly contribute to restoring the balance between force enablers and fighter-bombers,

between the shaft and the spear. Taking advantage of air power's versatility must thus become the underpinning approach if European nations want to make tangible contributions to multinational operations.

Pooling of assets has proven more successful than force specialisation. Despite Germany's abstaining from the Libya air campaign, the EATC had full authority to task German transport planes to resupply the Belgian and Dutch contingents in Greece and Italy. Cooperative frameworks have also enhanced interoperability and supported force transformation in peacetime. Yet whether joint force frameworks such as the NRF will ever be deployed for robust rapid reaction operations remains to be seen. In a number of countries, parliamentary consent for troop commitments is either required or strongly desired. Obtaining such consent usually requires a certain amount of time and thus runs contrary to the mechanisms of multinational rapid deployments. However, Article 5 operations – NATO's collective defence – might present a different issue.

European nations share strategic core interests, but they also have very different points of departure. For the UK, leveraging its special relationship with the United States has been paramount. In contrast, other nations have been more hesitant to commit troops and have done so only within the narrow confines of national policy. Germany's reluctance to employ its military at the higher spectrum of force has at times been at odds with the country's emphasis upon NATO as the bedrock for German security. Yet undesired outcomes – or, depending on the vantage point, 'negatively perceived outcomes' – of deployed operations confirm those countries in a more restrictive approach to the use of force. Similarly, diverging access to intelligence has created unequal partners and has thus added to friction. To underpin its strategic interests and to proactively influence multinational operations, France has thus gone out of its way to deploy a coherent set of intelligence assets. National intelligence has also enabled France to swiftly launch autonomous forced entry operations, as the French military did in Mali in early 2013.

Smaller Alliance countries with a transatlanticist stance have regarded the United States as their most important bilateral security partner. For them, demonstrating relevance and trustworthiness in real operations is also about preserving Washington's security guarantees. From their vantage point, burden sharing cannot be discussed only in terms of defence spending, but also in terms of willingness to commit to multinational operations.

With the exception of France, European contributors to major air campaigns have almost unanimously conceived their contributions in an American-led framework. For the foreseeable future, European air power will thus remain dependent on the backbone provided by the United States.

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COSTS OF COMBAT AIR POWER

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This chapter focuses on fixed-wing combat aircraft rather than the full spectrum of platforms, which would include large aircraft and rotary-wing systems that also contribute to air power. However, many of the cost features of specialist military large aircraft and helicopters are similar to those of combat aircraft. The rising costs associated with combat air power (as well as other major defence platforms) are not a new story. The most noted writer addressing the topic has been the US industrialist and former government official Norman Augustine, the author of the famous laws relating to defence acquisition. When the *Defense Acquisition Research Journal* chose to reproduce his original 1983 work in 2015, Augustine took the opportunity to comment on and confirm his previous conclusions.

> The earliest of my immutable laws – perhaps the most infamous among them – addressed the increasing cost of tactical aircraft. It showed that the unit cost of such machines increases at a very predictable rate – a factor of four every 10 years … This led to the following law, based on a straightforward extrapolation of the defense budget and the entire half-century's experience then available in building military aircraft: In the year 2054, the entire defense budget will buy just one tactical aircraft.
>
> *(Augustine 2015: 2)*

He went on to observe that the *Economist* magazine had recently confirmed that the prediction remained on track (ibid.). Writers in the UK, led by Neil Davies, David Bangert, Philip Pugh and David Kirkpatrick, have also sought to measure the trends towards increasing costs in defence equipment, with the latter adopting the phrase 'Starship Enterprise' for their summary of the most expensive conceivable aircraft (Kirkpatrick and Pugh 1985; Kirkpatrick 1995; Bangert and Davies 2015; Davies et al. 2012, 2015). Chalmers (2009) focused less on inter-generational cost increases and instead addressed the percentage annual increases in equipment costs.

While the general trend towards increasing unit costs is undeniable (Eskew 2000), measuring the trend precisely is actually very difficult for a number of reasons. First, aircraft and their weapons programmes take years, even decades, to go from the beginning of development into operational use, requiring constant adjustment of figures to express them in a consistent, commonly understood form. Also costs and prices are commercially sensitive information which

neither governments nor companies may wish to present in full detail. Next, when platforms involving different countries are compared, the exchange rates used can have a significant effect on apparent and relative costs.

Furthermore, aircraft, especially when they have had a problematic development history, are often accepted by a customer government even though they have not yet attained all the performance targets laid out in the requirements and contract. Further development work to complete the aircraft is required after production has begun. Sometimes this development work is funded as part of the original development effort, but sometimes it is allocated to a second phase. The F-35 appears particularly problematic in this regard in that the US Marines have declared it operational despite the Pentagon's Test and Evaluation Office finding hundreds of unresolved problems (Director of ROT&E 2016a, 2016b). Also, when an aircraft has a very long life (such as that enjoyed by the B-52 bomber and the F-16) the extended period between introduction of that aircraft and its eventual replacement is usually justified by an extended range of small and significant upgrades made to the original aircraft. This can obscure the perception of when a 'generational' change takes place. Finally, comparison of unit costs across aircraft requires the generation of standard packages of cost information about precisely what is included in terms of test equipment, training manuals, simulators, spares packages, and so on. To illustrate, should the cost comparison of the AV-8B and the F-35B include the costs of preparing surfaces on which the F-35B can land safely and vertically given the heat such landings generate? The AV-8B places no such demands on its landing surface.

In brief, when comparing aircraft costs over decades, decision-makers may have to address a large set of 'apples and pears' issues. This chapter therefore presents specific aircraft cost numbers with some wariness and reluctance, instead pointing later to detail about fleet sizes as evidence of the impact of cost increases.

With combat aircraft, three broad areas of cost must be considered: initial development, production and in-service, with the proviso that development work normally continues for most of the (in-service) life of the aircraft. Moreover there is a further problematic element – the tendency of costs to rise above those forecasts when decisions and commitments were made. This increase is most marked in the development phase. To date, the literature has paid the greatest attention to development and production costs, but often the in-service costs cause the greatest difficulties for operators.

This chapter suggests that the three categories of costs combined are reaching the stage where a more complex pattern is emerging, even for the richest states. This has resulted in an inclination towards less-capable manned aircraft and of course much-expanded use of a large variety of unmanned air systems, or 'drones'.

Development costs

Western states (and, while we have little information about non-Western states, there is little reason to think that their situation has been different), have exhibited a clear tendency for envisaged, planned development costs to rise significantly from one generation of aircraft to another. In broad terms, whereas the Tornado development cost was a matter of hundreds of millions of dollars, the Typhoon's development cost was billions and that of the F-35 is in the tens of billions.

This is unsurprising given that requirements, reflecting changing technological possibilities, called for ever more complicated and capable individual platforms. In the air, while personnel quality, imagination and preparation are of great importance, platform performance has often tended to be decisive. The pressures for outstanding technology are therefore particularly great.

In addition to aeronautical factors such as speed, range and agility, aircraft have been required to incorporate an ever-wider range of sensors that could examine the aerial domain, and increasingly the land and sea domains, and carry a broader mix of weapons. Increasingly they must minimise their radar signatures. All these considerations are often difficult to reconcile: for instance, an aircraft with good stealth characteristics tends to struggle with agility. In computing terms, the lines of (integrated) code in an aircraft continue to rise, with the F-35 code exceeding ten million lines for the aircraft alone and more in the support equipment.

Safety represents another issue: the concept of an acceptably safe aircraft has become more rigorous over time, not just because the rising expense of a platform makes its loss less acceptable, but also because of more demanding health and safety regulations. Between 1948 and 1988 the US lost 8,500 personnel 'in and around aircraft carriers', a rate of over 200 a year (LaGrone 2014). Such losses today would be unacceptable and, certainly in the UK, standards for aircraft safety have become significantly more stringent since the 2006 loss to fire of a Nimrod aircraft.

Safety is a particular consideration with regard to fly-by-wire aircraft in which the pilot sends instructions to computers through the flight controls. Flight control software must be shown to work both in theory and in practice. Thus a massive amount of 'development' cost for aircraft comprises testing first on the ground and then in the air to see if the system as a whole works as it should in different contexts. For the latest combat aircraft, the prime contractor has had to go through tens of thousands of test points and of course deal with any issues that arise.

Development has also to address the challenges of integrating weapons onto combat aircraft, another source of increasing expense given the complexity of integrating ever smarter missiles with ever more complex airframes and sensor.

One way to keep development costs and risks under control is for a new aircraft to rely on an engine already in production, and for new engines to be fitted first to established aircraft. However, performance requirements and sometimes political considerations mean that this guidance has often been set aside. The F-35, for instance, uses a new engine and has a completely novel lift fan element for vertical landings. As for the A400M, although the prime contractor Airbus wanted to use an established engine from Pratt & Whitney Canada, the French government did not want the reliance on a US-owned company that this would have entailed and insisted on the development of a new European engine.

Increasing development costs are not a monopoly of military systems; indeed they are common in the commercial world, including the car engine, microprocessor, and (perhaps) pharmaceutical sectors. However, the difference in those civil markets is that production can be spread over perhaps millions of units, whereas in the defence sector production of over a thousand aircraft of one type is rare. For example, in the fourth quarter of 2015 Apple produced 80 million iPhones of different models. Moreover, new applications and product outlets for new generation microprocessors are constantly being developed. So, while inter-generational development costs may be rising in the civilian world, they tend to increase at a lower rate than production volumes. Conditions are very different even between the civil and military aircraft worlds. In round numbers, Boeing and Airbus both make around forty civil aircraft every month. Thus defence markets are usually very different from commercial sectors.

Cost escalation

A further area of problem is the tendency for costs to rise above the levels envisaged when an aircraft project was formally launched. Cost escalation can occur at any point in the life cycle

(Arena et al. 2006) but it has been particularly apparent in the development phase, and often quite early in that phase (Jordan 2012).

This has often been attributed to the impact of what has been called the 'conspiracy of optimism', in which suppliers and customers combine their activities to make the original estimate too low. On the customer side, there are pressures to write an ambitious requirement for reasons of desired military edge but also because, in national approval processes, a project is more likely to receive endorsement if it offers a radical increase in capability. Suppliers may believe that if they do not win what can be a once-in-a-decade contract in a competition, they may have to leave the sector. They may also hope that they can change the terms of the contract that is eventually issued when the inevitable requirement changes are received, and that they can recoup any losses during the in-service phase when they are likely to be the monopoly supplier for many goods and services. Then customers in turn are drawn to accept even visibly optimistic bids because equipment budgets are invariably tight, and the less funding is allocated to one project, the more is available to another. Christensen (2015) has demonstrated the presence of optimism in statistical terms across the acquisition cycle in the US.

Because both the acquisition side and the supplier side can be drawn to agree to lower than realistic cost forecasts, both the UK Ministry of Defence and the US DoD have moved to create cost forecasting groups that are 'independent' of the teams managing a project. In the UK this capability is located within the Cost Analysis and Assurance Services section of the Defence, Equipment and Support (DE&S) organisation, whereas in the US, where procurement is executed from within the armed services, the Directorate of Cost Assessment and Program Evaluation (CAPE) is located centrally in the DoD, within the Office of the Secretary of Defense in the Pentagon.

Also to be noted is the relationship between time and cost. If a project is delayed, either because of a government funding reduction (as happened in the early 1990s with Typhoon), or because a critical element of the project proves problematic, the extra time taken for the project means it costs more, because staff working on the project may have to be paid to do little until activities get back on track. In defence projects as elsewhere, time is money, as was fully explored in the report on UK defence acquisition prepared by Bernard Gray (2009).

However, Western nations must recognise that accurately forecasting the costs of developing and producing a machine such as a combat aircraft is an inherently difficult task. Thus cost forecasting in some Western countries has become a specialised profession (e.g., see www.scaf.org.uk) involving expertise in particular mathematical techniques including bottom-up analysis (where every step in a project is defined and costed), analogous techniques and parametric methods. In the latter two cases, comparisons are made between the system of concern and other systems considered significantly similar, and with earlier types of the same sort of system. In simple terms, using expected ship or aircraft weight to forecast its cost is a case of analogous forecasting.

Clearly all forecasts involve risk, and at least two approaches have been offered as means to reduce risk and enable defence ministries not to commit firmly to projects until they have a reasonable degree of confidence as to what they will cost. The first is associated with the UK and asserts that the government should not commit to a demanding project until at least 15 per cent of the estimated development and production cost has been spent (McKane 2005). The basic argument is that the more is spent, the more is known and the better understood are the needs and challenges of the project.

The second has been long advocated by the US Government Accountability Office (GAO 2016) which asserts that projects should not be launched until the component technologies they require are significantly mature (using the Technology Readiness Levels developed by the

National Aeronautics and Space Administration). The GAO also states that project approval should be staged according to specified levels of knowledge being achieved (ibid.).

Both these approaches have run up against tendencies in government to push projects through approval stages early, before the suggested monies have been spent or knowledge acquired (GAO 2005). In addition, when projects exceed their forecast costs, governments are often unwilling to cancel them because of the operational capability implications and a reluctance to write off expended public money.

Unanticipated cost escalation is not a monopoly of aircraft projects and occurs often across defence programmes. It is a major driver behind the constant and public efforts to improve defence acquisition, especially in the US and the UK.

Production costs

The next major element in combat aircraft costs is that more complicated aircraft, with more systems and capabilities, have also tended to cost more and take longer to produce. The F-35 comprises 300,000 parts from at least 1,100 suppliers (Freedberg 2017). As noted initially, accurate and comparable costs even for production have to be treated with care, but it is worth noting that a 2006 French study (defence-aerospace.com 2006) found that whereas the F-15E had a cost per kilogram ($5,303) slightly less than that of caviar ($6,000), more recent aircraft had much higher costs. Gripen, Rafale C and Typhoon all had costs per kilo of around $14,000, and the figure cited for the F-22 was $23,472. The price of gold at that time was $18,700 per kilo. A post on the Defense Issues website in 2013 shows a similar tale of flyaway costs rising as more modern aircraft appeared (Defense Issues 2013).

This threatens a cost increase spiral even if development costs run according to plan. All manufacturing activities benefit to some degree or other from learning and economies of scale: the more of something is produced, the larger the orders that can be placed with suppliers, which should mean lower prices. Also, as assemblers produce more of a system, they learn how to perform tasks more quickly and to overcome specific obstacles. They follow a learning curve; traditionally in the aircraft industry that was expected to be at least 10 per cent (i.e., when production doubles, production costs should fall by 10 per cent). Some studies suggest higher numbers can be achieved; Lockheed Martin claims, for instance, that the man-hours needed to build the F-35A were reduced from 130,000 in 2006 to 43,000 in 2016 (Weinberger 2016).

However, if production numbers are limited because costs are high and the customer's budget is limited, manufacturers cannot get far down a learning curve and orders placed with suppliers must be small. This essentially was the fate of the B-2 and, to a lesser extent, the F-22.

Collaborative projects such as Tornado and Typhoon were inspired both by the advantages of sharing development costs and by the possibilities of a larger production run for a multilateral market. Although the Tornado was exported only to Saudi Arabia, the needs of its three partner countries meant that a production run of over 800 aircraft was possible, albeit using three different assembly lines. Typhoon in 2017 has orders for more than 700 aircraft.

With the F-35 the US sought to contain this problem by specifying an aircraft that would replace several different aircraft (F-16s and A-10s in the USAF, the AV-Bs of the US Marines, and the F-18/A-Fs of the US Navy and Marines). To further enlarge the market for the plane, the US government signed up a number of foreign partners early in the project. When formal development began in 2001, the US alone expected to buy 2,852 aircraft (later reduced to 2,443; GAO 2012). With domestic and foreign customers, it could then justify investing heavily in production technology that would operate efficiently when building numerous aircraft.

However, there are no simple answers in this area. To generate a large number of orders for the F-35, the US had to specify a particularly complicated aircraft with extensive sensor and self-protection capabilities and air-to-air and air-to-surface warfare systems. Its development costs significantly exceeded its early time and cost estimates and the F-35 had to undergo two Nunn–McCurdy reviews in the US system.

By 2020 Lockheed Martin hopes to produce seventeen F-35 aircraft a month: a massive increase over the fifty-three scheduled for the whole of 2016. To date (2017) Lockheed Martin and its partners have demonstrated a capacity to reduce production costs along a predicted curve during a decade of Low Rate Initial Production (LRIP) contracts. This statement, however, should be read in conjunction with awareness that the aircraft produced do not have the Block 3F software and other capabilities envisaged for the end of the initial development process and are not as reliable as needed. They will require significant further re-work.

Purely national projects have had to wrestle with the control of production costs. Saab and Dassault deserve credit for being able to construct the Gripen and Rafale respectively at an acceptable cost even at a low rate. An important element of cost control is to plan early for the sorts of production rates that will be feasible.

Development costs and production costs are sometimes brought together in a unit price per aircraft with (fixed) development costs spread over the produced fleet. Davies et al. (2012) addressed the unit cost element: their figures show the scale of increases for UK aircraft and that simple performance metrics such as speed or operating altitude do not easily explain the higher prices involved. Table 23.1 shows that, comparing the three aircraft, the cost increases were disproportionate to improvements in the performance indicators used. That remains true even if the levels of performance improvements mentioned are multiplied together: rounding the base numbers in the table, Typhoon weight was 1.7 times that of the Hunter, speed was 2.2 times the Hunter, and range was 1.6 times the Hunter, for a total of 6.0. However, the Typhoon cost fifteen times more than the Hunter.

Table 23.1 Cost increases for Hunter, Tornado and Typhoon.

Aircraft	*Into service year*	*Unit cost (£m)*	*Unit cost base*	*Weight (kg)*	*Weight base*	*Speed*	*Speed base*	*Range*	*Range base*
Hunter	1955	4.29	100	6509	100	715	100	1819	100
Tornado	1979	25.59	597	11487	174	843	117	1943	107
Typhoon	2006	66.64	1553	11150	171	1550	217	2900	159

In-service support

With combat aircraft in service their support costs will significantly exceed the original acquisition cost. The official estimate for the F-35 is that it will cost nearly $400 billion to develop and create the full fleet, and a further $600 billion to support the aircraft in service (GAO 2016). As a broad proposition, it might be expected that the more complicated the machine, the greater the cost of operating it in terms of maintenance, repair, and so on. Indeed, not only do combat aircraft cost more to develop and manufacture, but they also tend to cost more to maintain once they are in service.

Increased costs in this phase should be expected because combat aircraft have usually not been designed with reliability and maintainability as the focus of attention. Combat aircraft are

like Formula 1 cars, requiring extensive attention between uses. Mean time between failure (MTBF) – the average period between system malfunctions – is a common reliability metric. As aircraft incorporate more and more systems for navigation, engine control, surveillance, communications, protection, fire control/weapons release, and so on, they have more parts that must be looked after and that can fail.

The traditional acquisition problem during the in-service phase has been that the support element was often not given enough early attention. Until relatively recently – in the UK the Smart Procurement Initiative (SPI) of 1998 can be said to mark a turning point – defence agencies in the UK and elsewhere tended to procure equipment without much concern about what it would cost to operate. Procurement and 'logistics' were usually organisationally separate and thus, as far as requirements and procurement staff were concerned, in-service support was often seen as someone else's problem.

However, by the time of the SPI the UK had recognised the frequent heavy burden of support costs and the need to understand them at an early stage. Developing the accounting systems to allow accurate calculation did not happen overnight, but a crucial British organisational change came in 2007 when the Defence Equipment and Support organisation was formed. Henceforth the teams that bought equipment would also have to arrange its in-service support; the procurement team could no longer 'throw it over the wall' to the user community.

There is no escape from the reality that combat aircraft have become more expensive to fly. The impact of this phenomenon has been mitigated to a degree by the increased use of ever more capable simulators that are expensive to buy but comparatively cheap to operate.

Total whole-life costs and annual costs of ownership are not easy to calculate given the recognised elements of Integrated Logistics Support (ILS) that have to be provided and accounted for, ideally as part of the development process. The UK Ministry of Defence's JSP 886 (Ministry of Defence 2016) identified eleven of these, some of which carry more continuous costs during the in-service phase than others. However, by 2017 the list had grown with the addition of a further five items. Table 23.2 provides the list.

Table 23.2 UK MoD integrated logistics support elements.

JSP 886	Creation and maintenance of an ILS plan
	Creation and maintenance of a maintenance plan
	Supply support; broadly, the arranged supply of spares
	Provision of support and test equipment
	Facilities and infrastructure
	Training and training equipment (for the support function)
	Technical information
	Packaging, handling, storage and transportation
	Manpower and human factors integration
	Reliability and maintainability
	Disposal and termination
Additions by 2017	Software support
	In-service monitoring
	Whole life costs
	Obsolescence

Support costs, reflecting all the elements in the ILS model, are most simply reflected in aircraft by the costs per flight hour that are sometimes stated and the maintenance man-hours (MMH)

per flight hour that they require. Using US Navy baseline data, Giovanni de Briganti (2016) calculated that the F-35 in its first four years of service will need 50 MMH per flight hour, much higher than the F-22 at 10.5. However, no standard way of measuring these figures exists, and they are sometimes calculated by dividing the number of flight hours flown by the total number of working hours of the maintenance staff associated with the unit.

Offering precise evidence about increases in support costs is challenging because of the complexity of the calculations involved and because different reports include different elements (Bouito et al. 2015). One simple consideration is that some elements vary with how much a system is used (fuel and parts) while others (maintenance personnel) must be paid for whether the system is used or not. As Bouito et al. (ibid.) have shown, reducing flying hours per year can reduce total cost, but increase cost per flight hour. Some calculations also include an element of the original capital development and production cost, a consideration that greatly increases cost per flight hour. Flight cost per hour figures from different sources usually include different elements in their calculations, so comparisons from different sources have to be treated with care (ibid.). Moreover, direct support costs for parts and repair work can be expected to follow a 'bath-tub curve', with a newly developed system being improved through engineering changes, and then costs eventually rising as the system ages and more parts fail, as in any machine. Lockheed Martin is working hard to reduce F-35 support costs (Lockheed Martin 2016). In 2014 the GAO had warned 'that the DoD's support strategy may not be affordable (GAO 2014).

The Business Insider website published contrasting figures, some from the US Air Force and others from the DoD's Comptroller, in less than six months about an overlapping range of aircraft. Both sets of information, however, illustrate how flight costs reflect age and relative aircraft simplicity (see Table 23.3; Macias 2016; Bender and Nudelman 2016).

Table 23.3 Comparison of flight costs per hour.

Aircraft	*Flight cost per hour (Comptroller) in US$*	*Flight cost per hour (Air Force) in US$*
A-10C	5,944	
F/F-18F	10,507	
F-15C	23,124	
F-22	34,971	58,059
F-35A	28,455	67,550
B-2		130,159

A 2012 statement by a UK Minister underlined that the most expensive option may be to own something but not fly it much. Philip Dunne told Parliament that 'the standard marginal flying hour cost for a Tornado was £3875, including the cost of fuel. Excluding fuel costs reduces the figure to approximately £2267.' Clearly the key word in the above is 'marginal', because at other times the government has said that the flying cost per hour of Typhoon was £90,000 an hour, compared with £45,000 for the previous-generation GR4 Tornado. However, these latter figures include 'forward and depth servicing, fuel costs, crew costs, training costs and significantly the cost of capital charge and depreciation. The Typhoon cost per flying hour reflects the smaller numbers of aircraft currently in the fleet and their relatively short period in service' (Hansard 2009).

Not surprisingly the increase in support costs has generated a range of efforts to control and reduce them, although cost reduction as a performance metric has to be evaluated alongside

others, not least availability rates. The general heading for such improvements in the US is Performance Based Logistics, which has often involved the outsourcing of more support functions to the private sector. The UK has sought lower costs, inter alia, through better inventory management and 'contracting for availability'. The latter, instead of making the contractor responsible only for the supply of parts, requires the contractor to have a specified number of a complete system available for use at specified times. Part of the logic here is that, when a contractor must provide a ready system, it is incentivised to improve reliability so that it will have to do less work. Especially if it has a long-term contract covering perhaps eight years or more, the contractor can re-engineer problematic parts of a system, introduce the changes, and recover the costs it incurred in the re-engineering effort. A Private Finance Initiative such as that covering the RAF Voyager fleet of transport/tanker aircraft is the ultimate form of contracting for availability, but availability contracts have been used to good effect in many support areas for Tornado and Typhoon, as the National Audit Office has confirmed (NAO 2007).

Beyond Western nations with their considerable transparency about their defence performance, only anecdotal evidence is available about states' financial capacity to support their aircraft and generate acceptable availability rates and sustainability performance. This author's more than thirty years' experience at the interfaces of industry and a number of governments suggests that many combat aircraft customers can afford to achieve only modest usage and readiness rates.

Reduced fleet sizes

In light of all the elements described above, in which development, support and even production costs have been consistently rising, even larger states have accepted constantly diminishing fleet sizes. Table 23.4 shows the extent of reduced air force combat aircraft fleets in Europe since the end of the Cold War, which is also the period during which the Typhoon and the Rafale have been brought into service. Counting the number of aircraft with fighter and fighter ground attack capabilities belonging to air forces, as reported in the *Military Balance* publications of 1990–1991 and 2017, shows that the size of fleets of four major European allies declined by over 50 per cent in three cases and nearly 50 per cent in Italy. Moreover combat aircraft numbers have fallen much more sharply than the national defence budgets that pay for them.

Table 23.4 Combat aircraft fleet size and defence share of GDP.

Country	*Combat aircraft 1990*	*Combat aircraft 2016*	*% change*	*Defence budget in constant $: 1990*	*Defence budget in constant $: 2015*	*% change*	*Defence share of GDP: 1990*	*Defence share of GDP: 2016*	*% change*
France	533	231	–56.6	69,538	60,747	–12.6	3.6	1.8	–50
Germany	565	209	–62.7	73,042	47,046	–35.6	2.8	1.2	–57.1
Italy	425	223	–47.5	36,794	28,460	–22.7	2.1	1.1	–47.6
UK	430	207	–51.9	64,666	59,730	–7.6	4.1	2.2	–46.3

The times may be changing

The age of the manned combat aircraft is far from over, with the US committed to yet another manned strategic bomber despite the problems of the B-1 and the B-2. This time, Northrop

Grumman is the lead contractor. But, with the most advanced combat aircraft costing what they do, more governments are looking to other solutions, most obviously ground-based air defence, for the protection of their airspace.

Some states have sought (and are seeking) to expand their domestic industrial capabilities through the development of national jet combat aircraft that will not be comparable with what the US offers but will be affordable and adequate to deal with likely adversaries. These nations include South Korea and India, later joined by Turkey and Japan, but success so far has proved elusive in these cases. The entry barriers (including access to capital, technical knowledge and managerial expertise) for would-be new suppliers in the combat jet market appear highly significant.

Even the US has an interest in acquiring lower cost solutions using less complex human-piloted systems for operations in which ground-based defences are modest and there is no air-to-air threat. Twenty-first century Afghanistan and Iraq both met these criteria for the US and its allies. Although the debate ebbs to and fro, the US seems likely to keep its A-10 aircraft in service and Textron in the US has attracted some interest to its Scorpion private venture project for a $20 million combat aircraft. Several states, not least those where the most relevant type of conflict is counter-insurgency, have an interest in more simple, cheaper-to-operate aircraft with strong cost-effectiveness credentials (Bier 2017). Most intriguing, Pietrucha (2016) has argued that, had the US used propeller-driven strike aircraft in Afghanistan, the fuel costs of the operation would have been massively reduced and many fewer people would have died in the process of transporting the fuel into theatre through dangerous territory. The US has indeed bought the Tucano aircraft for supply to the forces of Afghanistan, and that aircraft has also sold well in Latin America and Indonesia. Possible future alternatives includes the use of large, civil-origin aircraft able to deliver large numbers of stand-off missiles against ground targets.

These developments are supplemented by the drone revolution: the increased use of remotely piloted or even autonomous air vehicles for surveillance, communication, strike and other purposes. The largest drones, such as the US Predator/Reaper, with their associated equipment are similar in purchase cost to less capable combat aircraft. The UK is paying just over $600 million for twenty of the latest Reaper models, which the UK has named 'Protector'. Moreover, such systems require significant support and massive amounts of data that such systems generate must still be analysed – in the main – by a significant number of human beings, who require salaries.

The variety of drones continues to expand, with some drones of military value costing only hundreds of dollars. Vehicles of all sizes are being developed in dozens of states, and by perhaps thousands of companies. Small ones are available for surveillance and basic strike roles even for non-state actors such as the Islamic State in Iraq and Syria. In many ways drones are already democratising and transforming air power. Their importance can be expected to grow still further once they have the sense-and-avoid systems and other safety features that will allow them to operate in civil airspace. The US is leading the way in looking at how drones can be used with manned aircraft, including Apache.

However, the unmanned aircraft story is just beginning. Military requirements for such systems can be expected to demand ever more in terms of range, operating altitudes, speed, payload and so on. This will increase costs and make such platforms less disposable. This will increase the protection needs of these systems which in turn will increase costs. Thus the drone market can be expected to evolve in the same manner as that for conventional combat aircraft, with the most capable ones becoming disproportionately expensive (Scott and Williams 2017: 55).

Conclusion

Each stage of an aircraft (development, production and support) presents particular financial challenges for governments and industry. The early involvement of external partners in the F-35 is a sign that even the US cannot carry the entire burden of developing and producing very advanced combat aircraft by itself. The B-2 and the F-22 were important cases where development processes consumed money that had been envisaged for the procurement phase, resulting in very high overall costs.

Public awareness is probably greatest about the cost overruns associated with many combat aircraft projects, especially in the development phase. Here costs are relatively easy to measure and monitor, as they are in the production phase. But in reality most of the money for combat aircraft is spent when they are in service. The size of these sums requires specialised accounting systems and competent accountants to capture but over something like a decade they will exceed what was paid for the system in the first place. It is these costs that increasingly are making the most advanced aircraft hard to afford for most states. Even when the purchase itself might be affordable, states may not have the money to use and look after the aircraft.

Thus the increased attention being paid to less capable but useful aircraft (such as Scorpion and Tucano) is understandable, and drones also hold significant promise. However, the costs of the latter are likely to rise like the costs of aircraft, as governments will require them to have more range, agility, autonomy, etc., as well as better protection against anti-drone systems. In essence, therefore, cost increases in defence present a challenge that may be managed, but not solved.

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24
AIR POWER AND INDUSTRY

Keith Hayward

Having an independent source of aircraft development and manufacture has historically implied a degree of security of supply and some expectation (not always realised) of technological superiority or at least equality in conflict with an adversary. An indigenous industrial capability may also build equipment more closely tailored to national air power doctrine. Buying proven, often less expensive 'off-the-shelf' equipment has advantages, but at the cost of accepting dependence on external sources of supply. Moreover, nations that have come to depend on foreign suppliers may run some risk that the price of equipment will increase as national options disappear.

However, this assertion contains more than a hint of a circular argument: once a nation has acquired a large aerospace industrial base – perhaps after a major wartime expansion – sustaining that base, whether for employment or in the hope of economic benefit, becomes a long-term policy. *In extremis*, industrial interests and requirements may supersede those of the military.

In general, local development and production have been regarded as a strategic asset, especially for a nation with any pretension to being a leading military force. Even as international competition through arms sales has become more intense in the twenty-first century, thereby driving down costs, many states continue to promote domestic development and production as a guarantee of independence.

This chapter adopts a roughly chronological approach to showing the transformations that have occurred, or are still occurring, in the industrial base of air power. The first section covers the initial phase, which saw the establishment of aircraft manufacturing: an industry created and expanded under the impetus of two total wars. The next describes the second phase, characterised by the advent of guided weapons and increasingly complex *aerospace weapon systems*, which largely created the oligopolistic structure of modern defence aerospace companies. The third section examines the emergence of a *globalised* defence aerospace industry – globalised in terms of both the *vertical* structure and operation of defence aerospace companies and the *horizontal* spread of national defence aerospace manufacturing capabilities. The fourth section considers the view that the military aerospace industry is undergoing another transformation driven by the advent of robotic platforms and a set of new corporate players in the aerospace industrial system.

With the exception of the first period, which we define as ending in 1945, the temporal boundaries between each period are deliberately left vague, as many issues and facets continue

to echo down the decades since the end of the Second World War. The chapter concludes with a summary and a consideration of possible lines of future evolution in the world military aerospace industry.

The air power industrial base – created by 'total war'

The evolution of air power has moved in lockstep with the emergence and expansion of an industrial base to develop and produce the equipment on which it depends. This initially meant transforming essentially experimental aircraft into true weapons during the First World War, which also saw the emergence of industrial-scale production. The Second World War continued this process, creating a vastly expanded industrial complex in all of the major powers, especially in the United States.

The first sign of an aircraft industry in the making appeared at the Royal Balloon Factory (soon renamed the Royal Aircraft Factory), established at Farnborough, near London. The British government invited early aviation pioneers to set up small manufacturing facilities in government-owned sheds at the Farnborough facility and selected promising designs for use by the Royal Flying Corps. The outbreak of war in 1914 led rapidly to a transition from cottage industry to a more recognisable industrial system. British aircraft production expanded and employment leapt from a few thousand in 1914 to 112,000 in 1918. A similar transformation occurred in France and Germany and the other major European powers.

The interwar period, certainly up to the early 1930s, saw military production superseded by a rapid growth in civil aviation, driven by a series of technological innovations. In the United Kingdom, as elsewhere during the 1920s, employment shrank and military contracts were curtailed (Hayward 1989). Technical leadership also began to slip across the Atlantic, as growing demand saw the emergence of larger and more capable companies. Rearmament in Germany triggered expansion of aircraft production in France and Britain, with employment in the UK aircraft industry rising from 21,000 in 1930 to 128,000 in 1938. Japan also acquired the makings of a modern aircraft industry. Inevitably, the outbreak of war in 1939 precipitated a massive increase in the aircraft industrial base on both sides of the Atlantic. War also drove a series of key technical innovations, including rocket and jet propulsion and on-board electronics. Aircraft generally became more capable, with higher speeds, longer range and heavier payloads (Millar and Sawyer 1968).

In the United Kingdom, by the end of the war military aircraft production had created an industry employing 1.7 million people. Even though Britain had pioneered the jet engine – the single most important aviation innovation of the Second World War – an over-cautious research policy, budget-driven production cutbacks, and the high priority afforded to the acquisition of nuclear weapons undermined the nation's aircraft industry.

The United States saw an ever-greater expansion in production of both combat and transport aircraft during the war, putting it in a position to dominate post-war world markets. Ambitious research and development (R&D) put the United States increasingly ahead of its competitors: a position confirmed by the massive increases in defence spending and particularly the share allocated to aircraft and missiles as a result of the Cold War (Bright 1986).

Transforming the industrial base: from aircraft to aerospace industry

In the decades following the Second World War, the industrial base widened to include electronics and a broad range of science-based capabilities, particularly following the emergence of strategic and tactical missiles and space programmes, with the *aircraft* industry morphing into an

aerospace industry. The development of missiles and rockets, with their heavy dependence on electronics, also facilitated a point of entry for a number of new players that leveraged specialist competence in electronics to challenge the traditional aircraft companies for government business. Research, development and production generally became more complex, development timescales lengthened and aircraft systems became increasingly expensive through successive generations (Hartley 2014).

The increasing complexity of military aircraft design and scale of production led to the emergence of specialist suppliers. To some extent this had been evident in the 1930s, with several specialist engine companies (although a number of aircraft firms still produced their own engines) and suppliers for equipment such as propellers. By the 1960s, this had created complex supply chains led by a small number of prime contractors or systems integrators that conceived and managed the programmes. Below this level, various other 'original equipment manufacturers' (OEMs) would in turn develop subsystems and organise their own supply chains. This further blurred the boundaries between aircraft development and other industrial sectors, and complicated programme management with a need to treat military aircraft programmes as 'weapon systems.' Integrating a series of interrelated subsystems and equipment increasingly became the most challenging task, with the prime contractor acting as the focus of activity and single point of contact with the customer.

Recent years have seen a tendency for some prime contractors to become 'vertically integrated' – developing in-house competence in electronics and other high-value equipment sectors either by acquisition or organic growth. This has been motivated by the attractions of increasing managerial control over complex programmes and the resulting ability to tap a greater share of contract value. Government customers concerned to maintain some degree of competition in the defence aerospace industry – at least at the subcontractor level – have often resisted this trend. But actions to maintain competition have proven problematic, as commercial pressure, declining defence budgets, fewer new programmes and often the absence of international competition continued to encourage rationalisation. This dilemma would only be resolved through the acceptance of a degree of globalisation of military aerospace industrial structures and supply chains.

The increasing scale and scope of the defence aerospace sector also changed the relationship between state and industry to create a largely symbiotic relationship, irrespective of formal ownership. The US aerospace industry was privately owned, with firms competing for major contracts. In Western Europe, ownership was a mixture of private and nationalised enterprise, but given the relatively small size of the national industries the scope for competition was limited (Hayward 1994). In many cases, a degree of overt or implicit central direction tended to shape industrial affairs. The Soviet aerospace industry was fully state controlled and directed, although individual design bureaus 'competed' for selection. Large central factories handled production (Dancy 2015).

The relationship between government and industry created a procurement-led industrial culture, with high barriers to entry and with the state absorbing much of the cost of development – effectively a tendency towards a supply-side oligopoly (in some cases monopoly) and demand-side monopsony. This was also the 'contract state', where the customer and supplier negotiated the terms under which programmes would be executed, including profits. In many cases, the contract was based on a 'cost-plus-fixed-fee' approach – a process that, while helping to encourage innovation by removing risk from the corporate sector, also tended to encourage cost escalation (Hartley 2014).

In addition, the period saw a gradual separation of civil and military aircraft development and production, although the divergence was less marked in engines and electronics. By the

mid-1970s, several aerospace prime contractors had exited or sold off their civil interests. On the other hand, the emerging commercial space business, with a few notable exceptions, remained heavily dependent on military contracting and R&D. Most commercial satellite platforms were derived from military programmes and defence R&D; for example, the majority of launch vehicles are based directly or indirectly on ballistic missile technology.

With increased development costs and a diminishing frequency of new programmes, the tendency towards industrial consolidation accelerated. This was most evident in Western Europe, leading in many cases to the creation of single 'national champions'. Even the United States saw a gradual consolidation of military aircraft system integrators, with only three major combat aircraft companies (Hayward 2005).

Managing complex supply chains was one of the constant tasks performed by the maturing aerospace defence industrial base. Companies below the primes and OEMs varied in size and technical competence, and for several decades after 1945 most 'built to print' – that is to say, they followed requirements determined by companies higher in the chain. Few conducted independent R&D. However, into the 1980s growing system complexity and deliberate strategies on the part of primes and OEMs to reduce the number of companies in their supply chains led to an increasing degree of responsibility for design and development passing down the chain. At the same time, supplier companies were also expected to assume some of the contact risk involved in a programme. Firms at lower levels consolidated and acquired the R&D competence to meet these demands. Latterly, as 'lean manufacturing' concepts exerted an impact on the defence sector, primes and OEMs began to partner with suppliers to improve efficiency.

With the onset of collaborative development, co-production agreements and offset requirements to support export sales, supplier firms in the Western nations were also more likely than not to lose business to a foreign supplier, particularly in the build-to-print and 'commoditised' component sectors. This was one of the more invidious consequences of American and British attempts in the 1980s and 1990s to introduce more competition into the defence industrial system.

Transforming the defence aerospace base through globalisation

Globalisation has had two related dimensions: *vertical globalisation*, defined here as a change in industrial structure with the growth of international programmes and supply chains; and *horizontal globalisation* – the spread of advanced military aerospace industrial capability outside the United States, Russia and Western Europe. Some elements of globalisation were noticeable in the 1960s, if not earlier, but the impact of both forms of globalisation became most evident from the 1990s on (Hayward 2001).

'Vertical' globalisation

Historically, the aerospace industry evolved as a national strategic asset supported politically and financially by national governments. Internationalisation of development and production was rarely accepted, although license production was a well-recognised means of both filling gaps in national capability – as in UK military helicopters throughout the post-1945 era – and serving as a means of developing an indigenous base, as in Germany and Italy in the 1950s and 1960s (Uttley 2013; Hayward 1994). While other manufacturing sectors were quick to seize upon the economic and commercial benefits of multinationalisation, aerospace industries were constrained by national security and protectionism. Supplier companies were less affected than

systems integrators, and international supply chains did emerge post 1945, but even here critical subsystems tended to be developed domestically.

The rising cost and complexity of equipment and latterly the diffusion of the sources of technological innovation began to encourage the internationalisation and increasingly the globalisation of military aerospace development and production (Hayward 2009). This was first felt in Western Europe, leading to the evolution of government-to-government collaboration. Programme-based collaboration held the promise of cutting development costs and widening the base market. In most cases, these gains proved illusory, with development costs tending to increase as a result of inefficient work-sharing agreements and delays caused by political disputes (Hartley 2014). The emergence of European transnational companies, such as Airbus Defence and Space, the missile company MBDA and Leonardo (helicopters), has to some extent improved the industrial basis for collaboration. However, the absence of a strong, unified customer base, as well as the continuing presence of national industrial and technological interests, still impedes the emergence of an integrated European defence aerospace industrial base.

The United Kingdom's strong operational and industrial relationship with the United States has further complicated the development of an integrated European defence aerospace industry. British companies are still deeply engaged in European projects, but the United Kingdom is the largest investor in the US defence sector (as well as being one of the countries most open to inward investment). Its main prime contractor, BAE Systems, is the third-placed contractor for the US Department of Defense (DoD). The United Kingdom is deeply involved in the F-35 programme as, uniquely, a level-one partner with a significant degree of technological and industrial engagement (Italy, the Netherlands and Norway are other European partners in the F-35). The UK aerospace industry is fully integrated with European missile production and space ventures, but the level of transatlantic investment and the imminent implementation of 'Brexit' from the European Union (EU) and possible loss of access to burgeoning EU-funded defence R&D mean that Britain's place in the future European military aerospace industrial base is surrounded by uncertainties.

In recent years, budgetary pressures have also forced the United States to accept a degree of interdependence in the development of some key aerospace systems, as well as foreign participation through inward investment in its national aerospace industrial base. However, strict controls over the transfer of technology, and foreign ownership of defence industrial assets and leadership in core military aerospace technology, have limited the impact of globalisation on the United States. The presence of foreign-owned aerospace companies in the American market and the continued pressure created by costly national programmes may further blur the boundaries of even the US aerospace industrial base.

'Horizontal' globalisation

Globalisation has also occurred 'horizontally', with more states looking to develop a national military aerospace capability, in some cases facilitated by mandatory cooperation and technology transfer as a condition of defence sales. Few, however, have been able to design *and* to manufacture world-class products indigenously (Israel and Sweden are exceptions, and even they have often depended on outside suppliers of key components and equipment).

States have various motives for acquiring a national military aerospace capability. National security and the perceived value of some degree of national independence of supply are important reasons. Other interests also shape policy: these may be entirely domestic and largely economic, related in this instance to the perceived technological and industrial value of creating or strengthening a domestic aerospace industry.

Japan has built an impressive military aerospace capability through licensed production of mainly US designs. Even so, from the 1970s on Japan launched several indigenous combat aircraft programmes (such as the FSX) with the aim of reducing dependence on external sources and obtaining additional technological benefits that might have commercial value (including civil aircraft development). In the event, these aircraft performed no better than comparable US or European products, and were highly expensive (Samuels 1994).

Other countries, such as India and South Korea, have shown a similar mixture of motives in trying to launch indigenous combat aircraft production, but again largely failed in the attempt. Procurement of foreign aircraft has remained their primary source of aircraft and missiles, with licensed production or some form of technology transfer to bolster domestic firms. In the case of India, a cumbersome procurement bureaucracy and overly aggressive technology transfer requirements have often complicated foreign deals and have deterred cooperation with Western companies (Menon 2016).

Chinese aerospace policy represents one of the most comprehensive attempts to enter the top levels of aerospace development and production (Hayward 2013b). Although some element of economic growth is associated with Chinese aerospace development, this is largely confined to the civil sector, with military aerospace development more directly related to national security goals. If successful, Chinese military aerospace development would pose a serious long-term challenge to US air power dominance in the Western Pacific. An increasingly sophisticated domestic defence industrial and technological base matches China's doctrinal and operational initiatives. The movement away from reliance on domestically sourced equipment has been a matter of choice (reduction of dependence) and circumstances (reluctance on the part of traditional allies – Russia and Ukraine – to transfer technology). China has put considerable effort into overcoming serious technological deficiencies through systematic investment in R&D and illicit access to Western technology through exploitation of dual technology, cyber-attack or conventional espionage.

Structurally, the Chinese aerospace industry closely resembles the state-owned, vertically integrated system of the former Soviet Union. However, China has begun to reorganise its defence industrial assets, the better to design, develop and manufacture advanced weaponry. This will include limited privatisation of all but the most sensitive of the state-owned defence companies to encourage private investment. The industry still has significant deficiencies in some key areas such as engines, and continues to import Russian designs, but China is investing heavily in this and other sectors to reduce external dependence. China has also emerged as a significant arms exporter, primarily to developing states (Saunders and Wiseman 2011).

A third transformation: the advent of RPAS

The advent of the remotely piloted aerial system (RPAS) adds another pressure towards globalisation, in some respects transforming the industrial base required to support an air power capability. Fundamental changes in defence technology implied by military transformation have historically challenged the existing structure of defence companies, encouraging new entrants and new combinations of players. Latterly this has prompted members of the civilian high-technology community to enter the defence business. Yet a decade or more since this mantra was first rehearsed – and taken up in official studies in the United States, the United Kingdom and elsewhere – the traditional defence industrial world today seems remarkably unchanged in terms of which firms continue to dominate the list of top 100 defence contractors.

One recent study of the changes in defence technology argues that while the extent of 'transformation' brought by 'networked warfare' has been overrated, the development of

unmanned combat vehicles might be the genuine article (Dombrowski and Gholz 2006). Unmanned aerial vehicles (UAVs) raise some fundamental questions about the defence technological and industrial base and the structure of supply chains – 'once developed, robotic technology is often cheap and mass producible' – and the basic technology is easily copied and hence diffusible (Singer 2009). New entrants have made headway and more established aerospace contractors have often struggled to catch up. As a senior Rockwell Collins executive observed, 'a lot of success came out of nowhere, not out of the major airframe primes'. This is new territory; implying radically different business models if the potential of this technology is to be fully exploited (Hayward 2013a).

For many states, RPAS development offers an ideal low-cost entry to the defence aerospace industry. The wide variety of RPAS types means that the barriers to entry at the mini-platform end of the market are substantially lower than for any other type of aircraft. Countries with established information technology (IT) industries are especially well placed, particularly if they can exploit clusters of related companies and capabilities. Similarly, the potential for ultra-long-duration surveillance and communication modes, and the evolution of micro-RPAS vehicles with nanotechnology and insect-like forms, present areas of development open to new entrants drawing on a new range of technologies.

The RPAS has also challenged conventional aerospace development and manufacturing processes. RPAS concepts emphasise the importance of rapid prototyping and the use of standard components. Production also tends to have a short lead-time and often occurs in small batches – the antithesis of usual combat aircraft cadences. However, as military requirements become more sophisticated, the industrial base will be required to develop custom-built power plants, offering dual power and electrical generation, miniaturised multi-spectral sensors and advanced control and communication systems.

Traditional aerospace prime contractors tend to focus on the more expensive, complex and high-performance end of the unmanned spectrum. This is perhaps understandable, as the so-called unmanned combat aerial system (UCAS) will most closely resemble the conventional combat aircraft platform in terms of cost, complexity and, perhaps, a more traditional industrial footprint. As a result, the traditional barriers to entry will remain high. Procurement of such an expensive and complex item will also favour traditional defence primes accustomed to working within national weapons acquisition systems.

The emergence of new industrial players reveals the 'transformational effect' of the RPAS. The ability of new entrants to stake a claim in the sector results in part from the relatively primitive nature of the standard RPAS platform – often little more than a sophisticated model aeroplane, or increasingly a mass-produced 'quadricopter' – more an item of consumer electronics than of aerospace technology. The bulk of the US RPAS industry in terms of numbers comprises relatively small start-up enterprises specialising in small vehicles. One of the most successful of the aerospace prime 'outsiders' is General Atomics Aeronautical Systems Inc. (GAAS), maker of the Predator and Sky Warrior. GAAS, established in 1993, is an affiliate of General Atomics, which still focuses on its original business of nuclear power plants and on the energy sector generally. GAAS's initial interest in unmanned aircraft followed its acquisition of a small company, Leading Systems, which was developing a small unmanned aircraft, the Amberdrone. Leading Systems was launched as a private venture, which attracted Pentagon interest and in time led to the Predator series. The aeronautical systems affiliate now provides unmanned aircraft, radar and electro-optic solutions for military and commercial applications worldwide. GAAS has captured some 80 per cent of the world market for medium-sized RPAS, and is well positioned to maintain its leadership (Hayward 2013a).

Stimulated by the nation's concern both to protect its borders and to minimise casualties, Israel's industrial base was an early entrant into RPAS development. The Israeli unmanned aerial system (UAS) industry has successfully penetrated world markets. Israeli companies have sold extensively to a range of customers either directly or by providing licenses to overseas UAS developments. They are also unconstrained by the Missile Technology Control Regime (MTCR). However, Israeli UAS manufacturers are at a critical junction. While they have the technology to produce very advanced capabilities, they may lack the necessary mass to be able to compete in the world market. Israel Aerospace Industries (IAI), Elbit Systems, Aeronautics, BlueBird, Innocon and UVision are developing new systems, but the market is becoming more competitive.

The advent of the RPAS and predictions of future business growth quickly led established aerospace companies to take an interest. In some respects this was a defensive reaction to a technology that threatens to replace a major market – the conventional combat aircraft – but it also represented a genuine opportunity for new business. One response was to acquire specialist companies. Northrop Grumman, whose Global Hawk is one of the largest and most complex unmanned intelligence, surveillance and reconnaissance (ISR) platforms, gained much of its UAS capability by buying Ryan Aeronautics. Ryan had developed a range of target drones and, with significant input from Northrop Grumman's all-round capabilities and financial strength, this led to the Global Hawk. More recently Northrop Grumman bought Swift Engineering, designers of a blended-wing UAV and specialists in quick prototyping (Hayward 2013a).

Another entry path may be through the complex weapons sector. Raytheon has such ambitions, using its skills in sensor and control systems as well as its experience in the missile business to develop UAS capabilities. Boeing also acquired its long-term UAS partner, Insitu Group, as part of a reorganisation of its UAS assets. Insitu started out using surfboard makers to build basic UAV platforms for tuna spotting. Boeing's takeover of Insitu was triggered by the latter's decision in July 2008 to seek UAS work on its own. Boeing now operates Insitu as a separate subsidiary, with an independent operating model, as part of Boeing's UAS business unit in the company's military aircraft division. Retaining the small company's innovative spirit in the larger organisation remains an issue, although so far Boeing's political and wider resource base seems to have benefited the Insitu team.

Europe has lagged behind both the United States and Israel in developing RPAS vehicles. BAE Systems has developed its own UAS competence through a series of company and government/industry technological demonstrators. It has also purchased capability, notably the US-based Advanced Ceramic Research, a 60-person tactical UAV manufacturer. BAE has created a Global UAS Strategy Team based at Warton, with American and Australian arms, to spearhead and coordinate its unmanned systems business in the United Kingdom and worldwide. In 2007 BAE Systems, together with a number of UK equipment companies, started development of the Ministry of Defence-funded Taranis UCAV demonstrator. BAES is also the lead UK element in the Anglo-French collaborative work on advanced RPAS launched in 2012 and confirmed in 2016.

France is also leading a collaborative UCAV technology demonstrator programme, the Neuron, in a partnership that includes Dassault, Saab, the Hellenic Aerospace Industry (HAI), EADS (Spain), Leonardo (Italy) and RUAG of Switzerland. With half of the funding coming from the French side, the Neuron has a strong French-led management structure. Italy has had some success in developing and deploying a range of medium-sized RPAS vehicles. Germany, by contrast, has achieved little success with a programmes based on the Global Hawk and has so far been unable to gain much traction for a wider European RPAS programme. Significantly,

many of the European armed forces have deployed US equipment or technology based on Israeli concepts and hardware (Hayward 2013a).

In principle, Europe undoubtedly has an industrial base capable of sustaining a strong UAS capability. However, it is already evident that Europe will have to work hard to avoid the perennial trap of duplication and redundancy. Powerful industrial and political interests support 'sovereign' capabilities, and European industrial politics could damage the prospects of launching a coherent set of collaborative RPAS programmes.

Elsewhere, the RPAS technology has spread rapidly. Currently, over 80 states have some form of unmanned programme, with over 700 platforms in total either in development or deployed. A significant number of these may be prototypes rather than usable vehicles, or one-off experimental concepts, but this represents an impressive challenge to the oligopoly of established combat aerospace design centres. Established or emerging aerospace nations such as Russia and especially China have entered the RPAS sector, and even non-state actors have acquired basic capabilities, either through improvisation or through off-the-shelf purchases of small RPAS. Indeed, this route is increasingly regarded as a potentially major terrorist threat (Birmingham University Policy Commission 2014).

Taking stock and future directions

Although this chapter has introduced the idea of a 'globalised' military aerospace industrial base, as well as suggesting that the advent of the RPAS has also 'transformed' that base structurally, in reality perhaps the impact of both may be less significant. The future of the industrial base underpinning air power will in many respects resemble the immediate past as much as the present. The conventional aeroplane, albeit with even greater capabilities, will remain at the centre of operations and therefore of development and production. This will be *supplemented* by novel platforms with more or less robotic autonomy. These will be designed and produced by both old and new industrial players, even if the RPAS continues to challenge traditional forms of production and purchase. Some signs are emerging that as more commercial technology is adopted for military use, supply chains may widen, with some new entrants. In areas such as military space, a new breed of space entrepreneurs is already pushing the traditional space manufacturing companies hard and could replace them on cost and capability grounds (German Ministry of Economy and Energy 2016).

The trend towards the increased use of commercial suppliers may help in general to reduce the costs of acquiring and operating aerospace systems. The United States is making increased use of commercial satellite operators for meeting routine traffic demands and this trend is likely to continue (Ferster 2016). The incorporation of commercial off-the-shelf components into complex aerospace systems may also help to drive down costs, and paradoxically to increase technical capability, as many civilian technologies are now superior to specialised military components. However, the cost of complexity – and many military aerospace systems are among the most complex items ever produced – may not diminish. Developing and verifying the millions of lines of software needed to fly and operate the F-22, F-35 and then other 'fifth-generation' aircraft will remain an expensive and protracted exercise.

The relative importance of platforms and complex weapons, already evident in the 1990s, will continue to shift in favour of the latter. Even more important, the electronic and IT content of both platform and weapons – and especially the platform – will continue to increase. The advent of software-upgradable platforms, electronic enabling packages, multiple sensor suites, intelligent materials, connectivity and swarm concepts for coordinating several unmanned and manned aircraft autonomously or otherwise, will further complicate and dilute

the nature of the aerospace defence industrial base. Given that again many of the underlying technologies are central to a dynamic civil economy and are widespread in the international economy, the advantages currently afforded to the established aerospace powers may diminish.

Structurally, the military aerospace industry will assume a more 'global' identity, especially as more states seek to build their own aircraft, but, lacking the comprehensive backing of an engine and equipment industry, will be forced to incorporate foreign elements. Costs will continue to push even the United States into further collaborative programmes; it may even relax its rules on foreign ownership. Shifting currency values, especially in the United Kingdom, may encourage further expansion abroad of US companies, and EU-located firms may still want to access the relatively large UK market.

But herein lies a paradox: more *states* are looking to acquire an air power industrial base, even if only in elementary form, and are likely to build only the simplest of RPAS vehicles. Even in a future Europe – with or without the United Kingdom – while more money might come from EU budgets and a more integrated European customer might perhaps procure the equipment – the core industrial components of much of the military aerospace industry will have clear national identities within existing and possible future European transnational enterprises. Where relevant, national consolidation may continue: in the United States political opposition on competition grounds appears to be diminishing in the face of economic realities, so a further round of rationalisation is possible. There is also unfinished business in France, with the future structure of the French defence industry still to be resolved.

The realities of defence industrial interdependence may even work counter to the centrifugal politics of 'Brexit'. In November 2016, only three months after the 'Brexit' referendum, the United Kingdom and France signed a Memorandum of Understanding on missile manufacturing at MBDA that will leave each dependent on the other in a key weapons sector. This could eventually become a blueprint for more cost-effective defence procurement and technology development in other areas. The result should lead to a significant improvement in industrial efficiency, leaving MBDA with the freedom to locate work at specialised facilities in either country (Osborne 2016).

China and Russia may also begin to experience a limited form of globalisation – perhaps on a bilateral basis. However, this will be limited by their mutual suspicion, and certainly their distrust of outsiders will constrain opportunities to work with Western companies on military programmes. In general, China will demonstrate the continuing link between national air power doctrines and operations and a national industrial base. Over the next decade, assuming continuing levels of investment, China will narrow the remaining technological gaps between it and the Western powers.

This chapter has focused on the manufacturing aspects of the military aerospace industrial base and the 'transformations' that have occurred or are occurring in that base. Perhaps another transformation should be added: namely, the notion of *defence services*. Over the last thirty years, these have multiplied and grown in financial and security significance. Manufacturers, seeing the value chain implications of delivering long-term services, have sought to adapt, sometimes by developing autonomous service subsidiaries to deliver support contracts. In other cases, they have partnered with service specialists, often applying novel financial constructs, to win business. In some (but by no means all) instances, the defence customer has realised significant savings from contracting with commercial service specialists. Whatever the exact outcome of individual service contracts, service contracting will no doubt grow as demands on stretched defence budgets increase, with a continuing and uncertain effect on the traditional military aerospace base.

Conclusions

The military aerospace industrial base has grown from a state-sponsored 'cottage industry' into a large, complex and expensive industrial structure. Although increasingly globalised as a manufacturing sector, *national* security requirements still play a major role in shaping that sector's operations and terms of trade. Aerospace is still a highly *politicised* industry that depends on a state customer (or a few state customers) to support its business model. The role of the state in shaping the industrial environment will also remain evident through the deployment of mechanisms designed to control, or to direct, the export of arms and the transfer of technology. This represents perhaps one of the strongest forces of continuity in the military aerospace industrial base.

A more profound and subtle change may also be occurring in the composition and the dynamics of the military aerospace industrial base. New weapons concepts and commercial actors have begun to indicate a conceptual shift in the nature of this industrial system or complex. Smaller, more agile, largely commercially orientated high-technology enterprises are beginning to hint at a more radical 'transformation'. Even if firms are not necessarily 'smaller' (Silicon Valley capitalisations are anything but 'small'), the arrival of companies that do business in a very different way from the likes of Boeing, Lockheed Martin and BAE Systems may bring about a thorough reformation in the defence aerospace market – at least in the United States and Western Europe. Elsewhere, traditional forms of the relationship between supplier and customer will likely linger far longer.

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PART V

Case studies

Air power in its national context



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CHINESE AIR POWER

Xiaoming Zhang

In 1999, Beijing put forth a goal to develop the People's Liberation Army Air Force (PLAAF) into a strategic service. Since then, the PLAAF has been rapidly advancing its capacity to defend against perceived threats to national sovereignty and territorial integrity. This advancement includes a significant improvement of the PLAAF's offensive and long-range capability by equipping it with fourth- and fifth-generation fighters, airborne early warning aircraft, aerial refuelling tankers, intelligence collection and jamming aircraft, and long-range anti-aircraft and anti-missile systems.

A decade ago, the PLAAF was an antiquated force outfitted with obsolete weapons systems operated by personnel applying outdated employment concepts. How did the PLAAF progress towards becoming a powerful and modernised service in such a short period?

This chapter starts with an overview of the development of Chinese air power from an historical perspective on certain factors that appeared to play a significant role in shaping the PLAAF's organisation, equipment, doctrine, and tactics to implement its concepts of air war. These factors include Chinese defensive thinking, the PLAAF's combat experience, and the interference of the Chinese Communist Party (CCP) leadership. Given China's growing economic and military power in the last decade as well as changes in its bureaucratic politics, security interests, and technology, the chapter then examines the evolution of the PLAAF into a new air force, including its successes and challenges in China's quest to become a strategic service.

The PLAAF's early combat experience

The PLAAF was established on 11 November 1949. Chinese defensive thinking provided the doctrinal guidance for its development. From the outset, the PLAAF leadership preferred to build an air force that possessed more fighters than bombers. Its theory was that the role of fighters dovetailed well with the defensive cast of Chinese military thought. Bombers attacked enemy countries and territories – an aggressive act – but fighters were defensive in nature and, if successful in fending off attacks, would ensure air superiority (Lü 1989: 144). The PLAAF's immediate mission, therefore, was to attain air superiority over the Nationalist Chinese on Taiwan, provide support to the planned amphibious assault on Taiwan, and then develop itself into a force capable of defending China's airspace and waters.

The Korean War experience was a driving force for the PLAAF to further emphasise air defence and procurement of fighters that would constitute the largest and most important element of the Chinese air force. Throughout the war, the PLAAF basically limited its air operations to protecting key transportation lines and military targets in an area of the so-called 'MiG Alley' south of the Yalu River. While recognising America's air superiority, PLAAF leaders discounted the role air power had played. They found it particularly interesting that air bombardment inflicted fewer casualties upon Communist forces than ground fire. Given their confidence in the human factor – that men could overcome weapons – and their own guerrilla war experience, they remained convinced that People's Liberation Army (PLA) ground forces could overwhelm stronger opponents and win any future war, with air power used to supplement the power of the army (Liu et al. 1992: 309).

After the Korean War, in the later 1950s, the PLAAF constantly engaged in air combat against the Nationalist Chinese air force for the control of airspace over the coastal areas directly across the strait from Taiwan. The PLAAF's MiG fighters had limited range, and depended on ground control intercept (GCI) in air combat. As during the Korean War, the PLAAF took a passive stance and waited to respond to intrusions by the Nationalist air force, which was much smaller but thus free to choose the time and method of aerial combat. This trend continued in the 1960s as one major focus of the PLAAF's day-to-day activity, with the PLAAF constantly scrambling its fighters to intercept intruding Nationalist and American aircraft, many of them spy planes (Zhang 2003: 279–282). This air defence experience thus resulted in the PLAAF's continuing to emphasise an air defence strategy and the development of fighter planes, radar, and ground anti-aircraft systems, while devoting only a small portion of the overall force structure to delivering limited air-to-surface ordnance.

Air defence combat experience led the PLAAF to define a set of operational principles that stressed the use of overwhelming force to achieve the protection of friendly forces and the destruction of enemy forces, the subordination of military objectives to political ones through strict adherence to the central authority's operational policy, and the study and application of PLAAF experience and tactics drawn from the Korean War and combat against the Nationalist air force. Preparing for the enemy's bombing attacks, the air force developed some countermeasures, including mental preparation, camouflage, quick repair, and deployment of Chinese bombers to the region at risk in order to strike back. This principle eventually led the PLAAF leadership to believe that the use of air power was more for deterrence than for offence (Pei and Xie 1992: 139).

Political influence on the PLAAF

Over the years, China's political system has not only influenced the PLAAF's development, but is also crucial to understanding the Chinese air force. The PLAAF is accustomed to using the Chinese leadership's instructions and speeches as guidance to define its doctrine, mission, and force structure in order to maintain political support. This PLAAF tradition continues to influence thinking and efforts to pursue development of a modern air force. Despite their long revolutionary experience, Chinese leaders, particularly Mao Zedong, the founder and strategist of the PLA, had no knowledge of air and naval warfare. Even so, the PLAAF codifies these leaders' sporadic instructions as profound military thought guiding the development of Chinese air power. This approach is attributed partly to traditional Chinese filial piety and partly to the CCP's highly doctrinaire and centralised institutional system.

When it was first established, the PLAAF used the chairman's message of encouragement to the air force, 'creating a powerful air force to eliminate the remnant enemy [the Guomingdang

(Nationalist) legacy forces that had evacuated the mainland for Taiwan] and consolidate national defence', to characterise the air force's contemporary and future task. While recognising the importance of air power in national consolidation and development, none of the Chinese leaders offered any systematic thinking on the air force and air power employment. One common view shared by these political and military leaders was that air power should be used to ensure command of China's airspace through air defence. Although a few of them occasionally mentioned the use of bombers to strike deeply into the enemy's rear positions, they never seemed to imply any offensive action beyond China's own territory (Yao 2005: 9–19).

Studies of the military thoughts of Chinese leaders on the air force and its employment dominated the PLAAF's theoretical inquiries for a long period of time. As a result, for most of its existence until recently, the PLAAF made no serious efforts to explore the various means of employing air power within the framework of China's defence strategy. Even now, PLAAF studies, to some extent, still incorporate the military thoughts of these past political leaders in their current pursuit of modern air power theory. Thus, PLAAF thinking and doctrine are still imbued with the PLA's traditional political jargon. This at best pseudoscientific approach accounted for the PLAAF's failure to ascribe the military thoughts of the earlier leaders to the PLAAF's long-standing perception of itself as a homeland defence force whose task was, first and foremost, to defend China's airspace and maintain only a limited role and modest capacity to support the army and navy (Deng 1997; Shang 2004).

By the early 1970s, the PLAAF had grown into a force of which two-thirds flew fighters. Although it had become one of the world's largest air forces, its equipment was outdated, limited in capability, and not even equal to that of some countries surrounding China. Since the creation of the PLAAF, China had favoured an air force based on quantity instead of quality to address technological deficiencies and maintain the air force's overall combat capabilities (Wang 2000: 281). When the PLAAF did engage in aircraft development, the aircraft produced were outright copies or simple derivatives or extrapolations of Soviet designs such as the Ilyushin Il-28, Tupolev Tu-16, and the Mikoyan-Gurevich MiG-17, MiG-19 and MiG-21. The sheer numerical superiority of the PLAAF compared to its potential regional opponents convinced the Chinese leadership that the PLAAF had built an adequate and credible air defence force capable of deterring and, if necessary, resisting any attack into Chinese air space.

That view was shattered by the dominant role that air power played in Desert Storm and the military conflicts since the 1991 Gulf War. Even so, one political legacy remains: the latest PLA campaign theory holds that the employment of air power is more a political matter than a military one, subordinate to the needs of China's political and diplomatic struggles. If its use is required, the political, not military, leadership will make the decision. This perhaps explains why the development of the air force still requires the personal involvement of the Chinese political leadership (Zhang 2006: 543–544).

The PLAAF's evolving thinking on air power

The early 1990s awakened the PLAAF to the realisation that China had fallen far behind the West in both technology and doctrinal thinking about air power. Time and space were no longer the allies of those who were once so confident that China's existing air defence systems could prevent any attacks deep into the nation's heartland. Serious doubts were raised about the traditional interpretation of China's defence capabilities, including the common belief that an inferior force could overcome a superior enemy. Drawing on lessons learned from Iraq's defeat in the 1991 Gulf War, the Chinese central military leadership pointed out that 'a weaker

force relying solely on the defensive would place itself in the position of having to receive blows', and that only by 'taking active offensive operations' could the weaker force now seize the initiative (Hua et al. 2008: 368). Following such a line of thinking, PLAAF strategists looked to Western writings for theoretical guidance. They highly appreciated Douhet's argument that 'a weaker air force could also defeat a stronger enemy one provided it can compensate for the difference in strength by showing more intelligence, more intensity, and more violence in its offensive actions' (Douhet 1998: 250). Accordingly, new thinking emerged, arguing that the PLAAF must shift from a purely defensive to a combined offensive–defensive posture by adding more offensive forces (Hua et al. 2008: 368).

China's evolving security interests, including potential confrontation with Taiwan, also favoured consideration of augmenting the PLAAF's offensive capabilities. Since 1993, Beijing has adopted a new military strategy, placing an emphasis on fighting and winning a future regional war under high-technology conditions along China's periphery. The momentum of the independence movement in Taiwan was viewed as posing an increasingly serious challenge to China's sovereignty and security (Ye 1999: 8). The Chinese military leadership made the proper readjustment to the air force's strategic missions, requiring it to maintain strong capabilities not only for defensive operations, but also for offensive ones. The air force's new mission requirements include securing air dominance over China's own airspace, supporting the army and the navy, and directing paratroop operations, as well as carrying out independent air campaigns. In an offensive campaign, the PLAAF should be able to launch attacks against the enemy's air assets on the ground in a potential local conflict along China's coast (Shao, Zhang and Hu 1997: 47).

In early March 1999, Jiang Zemin, former secretary-general of the CCP and president of China, explained the air force's strategic objective: to transform gradually from a homeland air defence force to one that was capable of both offensive and defensive operations. He then charged the air force to 'bear the brunt of, and be employed throughout the entire course' of the conflict, and 'to complete certain strategic missions independently' (He 2005: 4). In November, for the first time, the PLAAF set an ambitious goal: to develop itself into a 'strategic air force'. China simultaneously adopted a three-step implementation strategy for air force development over the next several decades (Dong 2005: 47).

According to its 2008 Defence White Paper, China expected to lay a solid foundation for the development of the PLA into a more high-tech and more balanced network-centric joint force by 2010, to accomplish mechanisation and make major progress in informatisation by 2020, and to reach the goal of modernising national defence and the armed forces by the middle of the twenty-first century (Information Office of the State Council 2008). This constituted a logical follow-on to a strategic vision the PLAAF introduced in 2004, calling for the development of a long-range strategic air force and the active involvement of integrated air and space operations with information and firepower systems. Hu Jintao, the secretary-general of the CCP and president of China at the time, endorsed this vision, making clear that the PLAAF is a strategic service and a key component of the PLA. He instructed the air force to speed up its transformation and engage in leapfrog development (Shang 2009: 47, 552).

Under the guidance of this new development strategy, the PLAAF embarked on a two-stage transformation. The first stage lays a framework for a force capable of both offensive and defensive operations by increasing the number of high-performance offensive aircraft, combat support aircraft, and advanced surface-to-air missile (SAM) systems. The second stage welds fighter aircraft, surface-based defence, and command, control, communications, and intelligence elements into an integrated operational system able to conduct both air offensive and defensive

operations under the conditions of informationisation. The development of China's air force capabilities focuses on four areas:

- offensive capability to protect national security and national interests from the air and space;
- integrated air defensive and anti-missile capability for monitoring and attacking objects flying in air and space;
- superior capability over its main opponent (presumably Taiwan) and a certain counter-information capability against its strategic opponent (presumably the United States); and
- strategic airlift capability to conduct both airlift and airdrop operations (Shang 2009: 557–558).

In short, as reflected in President Xi Jinping's 2014 speech, the PLAAF must be a service that is capable of offence and defence for integrated air and space operations and of 'providing a strong support for the realisation of the China dream and the dream of making the armed forces strong' (Ma and Tian 2014).

China's quest for modern weapon systems

China pursued a 'walking on two legs' policy to modernise the air force through development of domestic technology and purchases of foreign systems. China has historically sought to be self-reliant in military production through either reverse-engineering or incorporating foreign technology. In the last decades of the twentieth century, China manufactured more than 6,000 J-6 (Chinese-made MiG-19) and J-7 (Chinese-made MiG-21) aircraft (Tang and Yang 2003: 37; Dai 2005: 21). These aircraft were not only short range but also short sighted. China's indigenous defence industry offered no immediate solution to achieve the PLAAF's strategic vision (Song 1996: 104). Moreover, huge investments and many years would have been necessary to create a far more sophisticated industrial base.

The only stopgap measure appeared to be foreign purchase and assistance. The West had imposed its arms embargo on China following the June 1989 event at Tiananmen Square. Beijing therefore had to turn to Russia for assistance in modernising its air force. In 1992, China bought three batches of Su-27s – a total of seventy-four aircraft – along with their accessories. The Su-27 was one of the world's most modern aircraft and had a state-of-the art weapon system, but had limited offensive capabilities as a fighter. The Chinese decided to purchase the Su-27 because they were impressed by its aerobatic performance (Liu 2004: 573, 593). Moreover, the purchase satisfied the PLAAF's urgent need for modern aircraft. In 1996, China entered into an agreement with Russia on the licensed production of 200 Su-27s at the Chinese aircraft factory in Shenyang. This inaugurated China's reproduction of Su-27 aircraft, which the Chinese named J-11 (Si 2007: 26–27).

Apparently the Chinese very quickly became dissatisfied with their fleet of Su-27s, which could not carry out long-range ground attack missions with precision weapons and had inadequate flight ranges. In 1999, China concluded a $1.85 billion contract with Russia to purchase thirty-eight Su-30MKK fighter-bombers with upgraded avionics, larger weapon payloads, and air-refuelling capabilities. It later placed two additional orders for thirty-eight aircraft for the air force and twenty-four Su-30MK2s for the PLA Navy Aviation Force (PLANAF). The acquisition of these new Russian-made fighter-bombers empowered the PLAAF with real long-range strike capabilities, and inevitably tipped the military balance in East Asia (Si 2007: 27–28). More important, building on Sukhoi technology, China has been able to produce the much more advanced J-11B/D fighters and J-16 fighter-bombers fitted

with an indigenous datalink similar to the US Link-16, and carrying ultra-long-range air-to-air missiles capable of attacking Airborne Warning and Control System (AWACS) aircraft and tankers behind the enemy line.

While purchasing advanced aircraft from Russia, China continued its efforts to develop domestic systems, which began to bear fruit in the early 2000s. Su-30s were too expensive and also not compatible with carrying the Chinese indigenous weapons. The air force turned to the domestic aircraft industry for the JH-7 fighter-bomber, which the PLAAF had initially rejected in favour of the Su-30. The improved variant, the JH-7A, has been upgraded with two more powerful domestic-made turbofan engines and a new fire control system capable of launching precision strikes using anti-radiation missiles, laser-guided bombs, and long-range anti-ship missiles. By carrying large electronic warfare (EW) pods, it can provide an electronic escort for the attack group. As a result, the JH-7s have allowed the PLA to phase out the antiquated fleet of Q-5 attack aircraft and H-5 bombers (Zhang 2011: 287–288).

However, the PLAAF's most urgent need was for a multi-role single-engine fighter that could replace the large number of its obsolete J-7 fighters. After more than a decade of effort, the Chinese aviation industry successfully developed J-10s with the characteristics of fourth-generation jet fighters, powered by a Russian AL-31F-type engine. The first batch entered service early in 2003. Since then, J-10 has been continuously upgraded with enhanced fourth-generation electronics, including both passive and active electronically scanned array (PESA/AESA) radar and a Chinese-made WS-10 turbofan engine, currently known as the J-10B/C. The PLAAF is reportedly very enthusiastic about this new multi-role fighter that, as part of a rapid replacement programme, is enabling the PLAAF to compete against American F-15, F-16, and F-18 fighters flown by its potential adversaries. It is estimated that up to 400 J-10s of different versions are currently in service with the PLAAF and PLANAF (Hui 2017). More J-10s are expected for the PLAAF because it must still phase out its sizeable fleet of J-7s.

Since the late 1990s, China has also placed increasing focus on information technology as a leapfrog measure to close the PLAAF's cyber and EW gap with the United States and Western Europe. The development of sophisticated command, control, and communications (C3) and intelligence, surveillance, and reconnaissance (ISR) capabilities has been the PLAAF's most urgent priority (Cai and Tian 2006: 554–556). China has developed two 'high-low' versions of an indigenous AWACS: the high-end KJ-2000, based on the Russian Il-76MD airframe; and the low-end KJ-200 based on the Y-8F-200 transport platform. Simultaneously, China developed eight other types of EW aircraft: the High New (Gaoxin) series. These two AWACS platforms were handed over to the PLAAF in 2005 and 2006, respectively. Since then, China has developed the next-generation medium-sized AWACS (KJ-500), with the AESA radar on-board carried by the Y-9 transport platform. The aircraft has the same capabilities as the KJ-2000 but is less expensive to produce. The KJ-500s entered service with both the PLAAF and PLANAF in late 2014 and early 2015, respectively (Hui 2017). Integration of these systems is well under way across services to increase PLA joint operational capability.

In retrospect, although the US government successfully pressured Israel to cancel the sale of the Falcon AWACS to China in 1999, China appears to have pulled together sufficient talent and resources to build its own system despite this seeming setback. The chief engineer and designer of the Chinese AWACS project later claimed that China's radar technology had reached the same level as that of leading foreign countries and that, in some areas, it is even better (He 2009: 12–16). Efforts by the United States and European countries to prevent China from obtaining high-technology weapons similarly appear to have failed.

While engaged in stopgap efforts, China has also concentrated on the development of a series of '20s' military aircraft, including the J-20 stealth fighter, the heavy-load transport aircraft Y-20, the medium helicopter Z-20, and the long-range strategic bomber H-20. Except for the H-20, which is expected to become operational as early as 2019, both the J-20 and the Y-20 had their maiden flights in 2011 and 2012, respectively. The Y-20, based upon some Il-76MD technology, appears similar to the US C-17. The J-20 is a truly meaningful fifth-generation fighter, allegedly competitive with the American F-22. The Y-20 officially entered service in the PLAAF in June 2016, and the first batch of six J-20s was handed over to the air force for operational test and evaluation by the end of 2016 (Hui 2017).

Western media argue that the J-20 would not be as influential as the US F-22, the first fifth-generation fighter commissioned by any air force. Chinese experts, however, disagree, contending that the J-20 is set to break the Western monopoly (Defence 2016). The overall performance of J-20 will continue to improve in the coming years as more powerful Chinese domestic-made engines with thrust vector control (TVC) capability become available. More significantly, the appearance of the J-20 has already reshaped the air power landscape in the East Asian and western Pacific regions, prompting Japan and South Korea to pursue development of their own fifth-generation stealth fighters or to purchase the US F-35s.

The Y-20s that enter service will represent a key step towards reaching China's goal for building a strategic air force. In the coming years, the fleet of Y-20s will greatly improve the PLAAF's rapid nonstop reach capability across both theatre commands and continents. It will also provide a new platform for the next-generation AWACS to replace the KJ-2000s. Moreover, China's own ability to manufacture large transport aircraft will prevent the PLAAF from depending on foreign suppliers to meet its urgent needs, and thus avoid another dilemma like the one it faced in 2008 when Russia failed to deliver thirty-four Il-76MDs as scheduled.

Recent organisational reforms

The Chinese military system had long consisted predominantly of ground forces and was accordingly organised under the influence of army-centric thinking. The PLA's four general departments – the General Staff Department, General Political Department, General Logistics Department, and General Armament Department – served as the headquarters for all services, namely the ground force, navy, air force, and the second artillery force. The departments were staffed primarily by army officers. Military regions served as the command organisation for ground troops, while playing a concurrent leadership role for the personnel of other services located within their region. Ground force officers commanded the military regions, and the commanders of the other services could only serve as their deputies.

Since its inception, the PLAAF was organised along military region lines with four departments as its headquarters and an operational command in each military region. It has combined aviation with ground-to-air defence forces, consisting of the aviation, SAM, anti-aircraft artillery (AAA), and airborne units, as well as communications, radar, electronic countermeasures (ECM), chemical defence, technical reconnaissance, and other specialised elements. These units followed the hierarchy of division, regiment/field station, group/battalion, and squadron/company (Information Office of the State Council 2002). Over the years, the PLAAF has developed its organisational structure with multiple components and layers, many of which overlap, generating redundancies. Kenneth Allen, an American expert on the Chinese air force, makes a pointed remark criticising the PLAAF for still relying on a traditional organisational structure to serve 'the needs of the service even as the world around it has changed dramatically' (Allen 2012: 121).

Since the early 2000s, air force personnel have requested Chinese military authorities to consider reorganising the PLAAF into functional air commands, separating the air force from the PLA military region system and thus making it a truly independent service. Some even recommended that to become a more offensively oriented air force, the PLAAF should follow the US Air Force's (USAF's) 'expeditionary force' model and organise air force units into air strike groups with a mix of fighters, bombers, and EW aircraft (Liu 2003: 394–397). The idea of adopting the USAF model seemed too bold and unrealistic.

Beginning in 2012, the PLAAF has embarked on a new round of experimental reforms in order to improve its performance in the offensive and defensive roles. Four deputy corps-level bases were created to command brigade-sized aviation, SAM/AAA, and radar units responsible for regional air defence. Several air divisions were reorganised into air brigades, each of which has four or five flight groups, one maintenance group, and four airfield support battalions. The PLAAF believes that this two-tiered command system (base-brigades) is more capable of executing air defence duties, making the air force ready for the establishment of air defence identity zones (ADIZs), which happened in 2013. The remaining air divisions were reorganised with three subordinate regiments after the PLAAF abolished military regions' transition training bases. Focusing on offensive roles, the PLAAF expects these units to be deployed nationwide in response to China's air security needs. Meanwhile, the PLAAF created an additional transport division and three special aircraft divisions, attempting to enhance its long-range airlift and airborne early warning (AEW) capabilities. Nowadays, the Chinese air force has become better structured and much more technologically sophisticated, transforming itself into a new service (Loudouzi 2013).

In December 2015, the PLA undertook a major overhaul of its command and control system. Four general departments were downgraded and reorganised into functional departments and offices of the Central Military Commission (CMC), China's highest command authority. Military regions were replaced by five new theatre commands to command ground, naval, and air forces assigned to their theatre during peace and war. The military services are only responsible for organising, training, and equipping units even though their leadership had traditionally played a role in commanding operations (CMC 2016). As the reforms continue to unfold, it remains to be seen how the PLAAF will perform under this new joint command and control system, particularly at the time when all aviation divisions are being steadily downsized as brigades.

Preparing for modern warfare

Since 2010, China has been increasingly concerned with its maritime security, especially focusing on the areas separated by the first island chain between the East China and South China Seas. Domination of the skies over these two seas gives China a decisive advantage in defending its sovereign territories, such as Taiwan, and disputed islands, such as Diaoyu/Senkaku, Paracel, and the Spratly Islands. The PLA has not fought a war for more than thirty years, while the PLAAF had very limited experience flying over water. On 23 November 2013, China declared the establishment of the East China Sea ADIZ in response to the Japanese government's action to nationalise Diaoyu/Senkaku islands. To adapt to this new mission demand, the PLAAF departed from its tradition, which mainly focused on training and operations over land and coastal territory, by increasing training for maritime operations.

First, the PLAAF created a maritime training base in the Gulf of Tonkin with two major facilities: an over-water target range for air force pilots and a search and rescue training installation equipped with helicopters and rescue vessels (Yang and Wei 2016). Second, the air

units stationed along the coastal areas have increased their training missions over water, allegedly amounting to 40 per cent of their training hours. Third, the air units stationed at the interior areas are regularly rotated to coastal airfields to conduct overwater training and operations.

More significantly, in 2015, the PLAAF began to conduct high-seas training over the western Pacific and its South China Sea waters. In September 2016, it organised the largest operation to date that involved more than forty aircraft, including H-6K bombers, Su-30 fighters, Il-78 tankers, AWACS aircraft, and Tu-154 and Y-9 electronic intelligence (ELINT) planes. These aircraft took off from different airbases and flew to the western Pacific through the Miyako and Bashi Straits, respectively. These flights often triggered Japan to scramble their fighters to respond. Japan reports that the Japanese Air Self Defence Force scrambled 644 times against Chinese aircraft over a nine-month period of 2016, a 42 per cent increase over the same period of the previous year (Kyodo News 2017). In one 2016 incident, the Japanese fighters even shot decoy projectiles at Chinese air force Su-30s (Johnson 2016). The Chinese air force spokesman underscored, 'this is common practice for the air forces of sea-adjacent states … and the PLAAF will continue and normalise its long distance over sea flight' (Zhang 2016).

To develop similar fighter weapons and tactics training programmes as those the USAF has, the PLAAF reorganised its test and training base at Dingxin, turning it into a modern combat training base, with a new 'blue force' (brigade-sized unit) equipped with J-20s, J-10s, Su-30s, and J-16s playing the role of the 'opposition force' and combat electromagnetic environment simulators. Air units are required to go to Dingxin to participate in the annual 'Red Sword/ Blue Shield' exercises to prepare them for the possibilities of actual high-tech combat. These exercises are known as the equivalent of the USAF's Red Flag series, which involves aviation, SAM, radar, and electromagnetic units conducting uninterrupted and unrestricted confrontations around the clock (Li and Deng 2016). The PLAAF uses a multi-information airborne digital information recording system for recording the air combat information. The PLAAF also established the 'Golden Helmet' competition for fighter pilots in 2011 and 'Golden Dart' competition for attack aircraft pilots in 2013. Most winners of these competitions are 'young' pilots who are more likely to accept the less-scripted training than older pilots who grew up with a 'follow the plan' mindset (Fengyu 2013).

In addition, the PLAAF regularly participates in joint multiservice exercises to improve its ability to perform critical missions such as precision strike, intelligence gathering, command and control, and air defence. Most of these joint exercises are described as cross-military-region and 'scenario-based' exercises, and thus provide opportunities for units participating in these exercises to develop rapid response and joint operations capabilities in unfamiliar environments and under complex conditions. The concepts that underpin these training events reflect an extensive understanding of the types of functions that air force units will be expected to perform in future conflicts.

Conclusion

The PLAAF still faces many challenges in reaching its development goals. To understand China's claims about the development of Chinese aerospace power for the present and the near future, it is necessary to consider several issues, including strategy, force structure, the officer corps, the enlisted force, unit training, logistics, and maintenance. The PLAAF's strategic vision, calling for the development of a strategic air force with long-range capabilities, as well as integrated air and space operations employing firepower systems that incorporate advanced information technology, is modelled on US practices as the Chinese have perceived them. One

major constraint is that the PLAAF does not possess its own space assets or strategic missiles, which are controlled by PLA Rocket and Strategic Support Forces, respectively.

For the past several years, China has made efforts to streamline and optimise the PLAAF's force structure. Nevertheless, the PLAAF remains a mixed force of aviation, ground-based air defence, radar, and airborne units, while space assets are still separate from it. This mixed-force structure will continue to complicate China's air and space decisions, particularly with regard to training and allocating roles and missions among the services and branches, and will influence resource allocation for Chinese air force modernisation. Currently, the PLAAF still has quite a number of the older J-7 and J-8 fighters in service, and so do its air defence forces, which remain equipped with obsolete SAM and AAA systems. The size of the Chinese air force and its offensive capabilities will remain limited until the phase-out of its obsolete weapon systems in the next few years.

The most severe constraint is perhaps the PLA's political and organisational culture – a relic from its founding – demanding absolute loyalty to the Party. The PLAAF is no exception to this. Moreover, with the current ground-force-dominated culture and the emergence of different cultures for the other services, the PLAAF's relationship with other services and organisations has been complicated, but will not change significantly until a new joint force culture emerges. No doubt, change is under way within the ranks of the PLAAF, which embraced a new concept of operations that emphasised developing an air force capable of both offensive and defensive operations and fielding an increasing number of modern weapon systems. Nevertheless, it will take a much longer time for the PLAAF to cultivate new ways of doing things and to develop a new organisational system.

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26
RUSSIAN AIR POWER

Igor Sutyagin

The Russian Air-Space Force (RuASF) is one of the Russian armed forces' three military services and one of the world's oldest air forces.[1] As early as 1885, the Russian Imperial Army operated aeronautical units (Kartashev 2014), and the first two military units armed with aircraft were established in Russia in 1911 (Aviaru 2017). On 12 August 1912, the Imperial Military Air Fleet was established (Ministerstvo oborony 2017). Since 1992, the modern Russian air force has undergone several rounds of reforms. Its most recent incarnation as RuASF dates to 1 August 2015, when the Air Force and the Air-Space Defence Troops were merged into a new streamlined joint service. The RuASF is tasked with defending Russia and its troops against enemy strikes originating from, or in, air and space, as well as delivering Russia's conventional and nuclear strikes deep in the enemy's rear and in support of Russian troops on the battlefield. The RuASF is also charged with providing ballistic missile early warning (BMEW) and monitoring space, as well as with controlling Russia's own space assets and launching military or dual use satellites (Ministry of Defence 2017).

Structure of the RuASF

The RuASF is organised into three branches: the Air Force, Air Defence and Ballistic Missile Defence Troops, and Space Troops. There are also units that report directly to the RuASF headquarters (HQ).

Air force

The RuASF's Air Force includes five Air and Air Defence Armies (A-AD Army; see Table 26.1), and two specialist commands (Long-Range Aviation Command, and Airlift Command). The A-AD Armies operate under a system of dual subordination. In addition to reporting administratively to the Air Force HQ, each A-AD Army is under the operational command of its corresponding Military District (MD)/Operational-Strategic Command and acts as its air arm. In addition to air and air defence divisions, each A-AD Army normally includes several regiments/brigades of 'army aviation' (rotary-wing platforms – gunships and transport). Mixed air divisions comprise regiments of tactical aviation (fast jets) and mixed regiments (both fixed- and rotary-wing) of light-to-medium air transports.

Table 26.1 Organisational structure of the Russian Air-Space Force.[2]

Branches	*Armies/commands*	*Divisions*
Air Force	4th (Southern MD)	1st Guards, 4th, 27th MAD 31st, 51st ADD
	6th (Western MD)	105th MAD 2nd, 32nd ADD
	11th (Eastern MD)	303rd MAD 25th, 26th, 93rd ADD
	14th (Central MD)	21st Guards MAD 41st, 76th ADD, 24th ADBde
	45th (Northern Fleet)	98th Mixed Air Regiment 1st ADD (plus Nth ADBde planned)
	Long-Range Aviation Command	22nd Guards, 326th HBAD, 203rd Guards ABTReg
	Airlift Command	12th, Nth ALAD, 144th AWACS Reg
Air and Ballistic Missile Defence Troops	1st AD-BMD	4th, 5th ADD, 9th BMDD
Space Troops	15th (Special Purpose)	153rd, 820th, 821st Chief Centres, Plesetsk space-port

The units which report directly to Air Force HQ include education, training, and research establishments, as well as the independent mixed air brigade deployed to Syria. The directly reporting 929th State Flight Test Centre bears responsibility for military flight test programmes and for maintaining the Russian supreme command's fleet of airborne command posts (ABCPs), including Il-80 'Aimak' ABCPs, Il-82 strategic relay aircraft, and the Il-96-400VPU Russian equivalent of 'Air Force One'. The 8th Air Division provides air transportation for Russia's top political and military leadership and uses most of the second-tier command's ABCP fleet.

Long-Range Aviation Command

The Long-Range Aviation (LRA) Command is the RuASF's strategic arm, comprising its intercontinental (Tu-95MS/Tu-95MSM Bear, Tu-160 Blackjack), and medium-range (Tu-22M3/Tu-22M3M Backfire) bombers. The Command's 203rd Guards Regiment of air tankers encompasses all of Russia's specialist air-refuelling tankers (thirteen Il-78M and five older Il-78 tankers). The Su-24M Fencer tactical bomber can also perform ad hoc air-refuelling duties, as a standardised UPAZ pumping-hose unit can be fitted to one of the jet's hard points to transfer fuel from the internal and/or drop fuel tanks to tactical aircraft.

Airlift Command

The Airlift Command provides strategic airlift capabilities and currently includes one operational airlift division headquartered in Tver, halfway between Moscow and St. Petersburg. As of spring 2017, another, smaller division was being established in Orenburg in Central Russia. The Command controls Russia's only regiment of Airborne Warning and Control System (AWACS) aircraft: the 144th Air Regiment with thirteen A-50 and A-50U.

Air Defence and Ballistic Missile Defence Troops

Although their name may suggest otherwise, the RuASF's Air Defence and Ballistic Missile Defence (AD-BMD) Troops do not encompass all the RuASF's air defence units. Rather, the AD-BMD Troops are responsible only for the air and ballistic missile defences of Moscow and its surrounding territory (together known as the Central Industrial Region) where a substantial share of Russia's high-technology military-industrial potential is concentrated. These forces come under the 1st AD-BMD Army (see Table 26.1). To provide very early warning of incoming air threats, the 1st AD-BMD Army fields two 29B6 'Konteyner' over-the-horizon – backscatter (OTH-B) radar systems in Mordovia and Amur Province (under construction as of 2017). Plans have been mooted to create a network of up to ten 'Konteyner' radar sites to provide 360-degree OTH-B coverage of all approaches to Russian territory.

Space Troops

The RuASF's Space Troops run Russia's BMEW system, the networks for space monitoring and in-flight control of Russia's own space assets, as well as space launch facilities in Russia. The Space Troops are the sole service provider of orbital systems control for both Russia's military and civilian space programmes. The Russian spaceport at Plesetsk reports directly to Space Troops HQ. The Space Troops coordinate their space launch activities with, and partially rely on, Russia's civilian space agency, *Roskosmos*, which operates Baykonur, leased from Kazakhstan, and Vostochniy, Russia's newest spaceport, under construction in the Russian Far East.

With the exception of space launch, all of Space Command's activities are the responsibility of the 15th Army (Special Purpose). This consists of three Chief Centres – division-level formations – which each carry out one of the Space Troops' three key tasks. The 153rd Chief Centre (CC) for Testing and Control of Space Assets controls Russia's military and dual-purpose satellites, tracks Russian space launches, and provides information support to the national space and missile flight test programmes. Thus, the 153rd CC coordinates the activity of seventeen Command and Measurement Centres (CMCs), which receive data and telemetry from satellites, measure their orbital parameters (some of the CMCs are equipped with optical and laser locator instruments), and generate and transmit control commands to satellites.

The 820th CC of the BMEW system currently includes fourteen radar installations, either operational or under construction. Each site has one or more line-of-sight BMEW radars that together provide 360-degree overlapping radar coverage around Russia's territory. In addition to the line-of-sight radars, in the future the 820th CC will operate the 'EKS' third-generation space-based BMEW system designed around the dual role, early warning, and communication 14F142 Tundra satellites. Current plans assume a constellation of ten Tundra satellites to be established by 2022. Currently one Tundra is in orbit (launched in November 2015), with another launch planned for 2017. The USSR and then Russia operated the 'Oko', and then 'Oko-1', space-based BMEW systems from 1979 and 1996 respectively, but by 2015 these assets were no longer usable.

The 821st CC for Space Monitoring encompasses a network of five radar and optical space sensing centres (to be expanded to twelve), as well as the 'Sledopyt' system for passive sensing of radio-frequency-emitting space objects and measurement of their orbital parameters (there is currently one 14G6 'Moment' sensing and measurement station, with three more planned). The BMEW radars of the 820th CC, as well as the AD-BMD Troops' 'Don-2N' Moscow BMD combat engagement radar are routinely employed to detect and track non-cooperating (foreign) space objects and feed the information obtained into the national space monitoring

system. The laser locators of the 153rd CC's CMCs can also be used to make precise measurements of the orbital and geometric characteristics of non-cooperating space objects. The 821st CC also cooperates with the Russian Academy of Sciences and some Russian universities, which operate their own, less-capable satellite tracking stations, including laser locators.

The modernisation programme of the Russian Air-Space Force

The RuASF is currently in the midst of an ambitious rearmament programme launched in 2010. The fifth-generation aircraft for tactical (PAK FA or T-50/Su-57), strategic (PAK DA) and transport (airlift) aviation (PAK TA or PTS 'Ermak') are all under development, the latter on the basis of the Il-106 design of the early 1990s. The RuASF also envisages the PAK DP (MiG-41) fifth-generation, long-range, heavy fighter-interceptor. However, all these programmes are currently plagued by serious delays. The T-50 design is a refinement of one of the earlier Su-27 design schemes considered in 1974 (namely the T-10-12 – Su-27 *sans suffixe* is T-10S or T-10-7). The T-50 is inferior to F-22 and F-35 fifth-generation designs in certain respects, particularly its radar cross-section, which is in the range of 0.3–0.5 m^2. The T-50 design has been slow to enter production; for example, the AL-41F2 ('Item 30') engine specifically intended for the T-50 will not be delivered before 2023–2025. Consequently, the RuASF finally admitted that it did not expect substantial numbers of T-50s in combat units before 2020–2025 (with the interim AL-41F1 ('Item 171') not fully meeting the specifications for a fifth-generation engine.

While original plans envisaged mass production starting in 2015, the number of T-50s to be acquired by 2020 has fallen from fifty-two to sixty jets to six. Deliveries of the subsonic flying-wing design PAK DA might start after 2028–2029 (and not 2020 as initially planned), while PAK TA could arrive by 2024, although Russian aviation experts agree that the latter date looks over-optimistic. Development of the Il-214 medium transport, the underperforming equivalent of YC-14 (aka MTA or IRTA, a joint Russian–Indian project aimed to replace the venerable An-12), resumed in mid-2017. Development of PAK DP will commence in 2019 at the earliest and the aircraft might begin to replace MiG-31 around 2028.

Given these circumstances, the brunt of RuASF's effort inevitably focuses on modernising existing aircraft and acquiring their upgraded versions. The backbone of the tactical air force will comprise 115–143 Su-30SM/Su-27SM, 98 Su-35S and 170 MiG-35S newly built fighters (RuASF plans to have 700 fighters of all types, or 40 per cent of the overall fleet of all categories, by 2020), as well as 124–140 Su-34 fighter-bomber/tactical bomber jets, and 120–150 upgraded Su-25SM3 attack aircraft, with the older aircraft also remaining in service. Production of the modernised Tu-160M2 will be resumed in 2022 (two years later than originally planned, production of between thirty and fifty aircraft is envisaged). Thirty Tu-95MS will be modernised as Tu-95MSMs to carry Kh-101/102 cruise missiles and approximately thirty Tu-22M3 are being modernised to the Tu-22M3M standard. An extensive modernisation and service-life extension programme is under way on 113 MiG-31BS/BM heavy fighter-interceptors (out of 235 existing MiG-31s), of which sixty MiG-31BS will be modernised to the MiG-31BSM standard by 2019 (with MiG-31BM avionics). The acquisition of 109 Yak-130 turbojet and 150 Yak-152 propeller combat-trainers, as well as sixteen (and potentially more) SR-10 forward-swept-wing jet trainers, is also planned.

The RuASF contracted for thirty-nine Il-76MD-90A heavy transports (aka Il-76MF or Il-476) for delivery by late 2018, but that number will be reduced due to cost overruns. The start date for deliveries of Il-112V and Il-114-300 light transports (comparable to CASA CN-235 and Saab-2000 respectively) has been delayed until 2021 (originally planned for 2018, then

2019). Production of the Ukrainian-designed An-140 and An-148 light transports was halted in Russia in 2015 and 2017 respectively due to Ukrainian sanctions. Considerable efforts are being made to upgrade the Russian electronic warfare, electronic intelligence and signals intelligence aircraft fleet, deploy the A-100 Il-76MD-90A airframe-based next-generation AWACS/Joint Surveillance Target Attack System aircraft from 2019 and expand the RuASF's chronically insufficient fleet of tankers with a mix of thirty to thirty-one Il-78M-90A (based on the Il-76MD-90A airframe) (Chernysheva 2016) and 2-10 Il-96-400TZ models.

The RuASF continues rearmament with 120 Mi-28N/Mi-28UB and 140 Ka-52 gunship helicopters which both first flew as long ago as 1982. In 2016, after the delivery of eighty-six and seventy-one of these aircraft respectively, the number of helicopters to be acquired was reduced from the 167 and 180 originally planned. Forty-eight Mi-35M are also currently in production. Deliveries of Mi-38 (equivalent to EH-101, under development since 1986) and 100 Ka-62 (UH-60, 1990) transport helicopters are expected from 2018 and after 2020 respectively. RuASF has continued acquisition of thirty-eight Mi-26T heavy helicopters and new upgraded versions of the venerable Mi-8 medium helicopters (including 140 Mi-8MTV-5 and 132 Mi-8AMTSh, of which 100 and 87, respectively, have been delivered by mid-2017). The development of the modernised Mi-26T2V heavy helicopter is to be finished by the end of 2018. Helicopter and light fixed-wing transport aircraft production is severely hampered by Russia's current near-total dependence on Ukraine for supply of turboshaft and turboprop engines, which Russian industry has failed to overcome despite repeated efforts since 2002. The development of unmanned aerial vehicles (UAVs) is a top priority for the RuASF: the number of UAVs in the Russian armed forces increased from 180 in 2011 to 1720–2000 by 2017 (the majority of UAVs are in the Army, not the RuASF). However, Russian industry struggles to produce heavy, long-range UAVs. All the existing Russian UAVs are tailored for electronic warfare or/and target-spotting tasks and although the development of three types of armed strike UAVs – 'Okhotnik', 'Zenitsa' and 'Inokhodets' – has been announced, the programmes lack sufficient funding.

Russian operational concepts for joint operations imply that artillery fulfils 60 per cent of Russian forces' total fire tasks, with air power and 'other means' (special operations forces and combat engineers) responsible for 35 and 5 per cent respectively. This explains the comparatively lower emphasis on air-to-ground tasks for the RuASF, as opposed to air-to-air combat. The inevitable outcome of this doctrine has been worse results in developing modern sophisticated air-to-ground weapons, as opposed to air-to-air capabilities.

Russian air-to-air missiles (AAMs) still roughly match the performance of their Western equivalents. The R-37 (AA-13) 285-km-range AAM was finally introduced into service in 2014, with an extended-range – up to 350–370 km against high-altitude targets; versions (R-37M and 'Item 810') are under development. The R-77M upgraded version of the R-77 (AA-12) almost matches the AIM-120C-5 in performance, and the ramjet-powered extended-range (up to 160–180 km) variant of the missile ('Item 180PD') has been advertised. The K-74M upgraded digital version of the R-73M (AA-11) short-range AAM (AS-11 Mod.2, under development since the late 1990s) is intended to narrow the performance gap between R-73M and AIM-132 until the next-generation K-30 AAM (under development since 1986), which is the closer equivalent of AIM-132, will be ready for service. The KS-172S-1 ultra-long-range AAM project was cancelled in Russia due to the lobbying efforts of competitors.

The emphasis on the suppression of enemy air defences as the prerequisite for successful air-to-air operations is shown by Russia's development of effective stand-off anti-radar missiles, such as Kh-58/Kh-58U (AS-11, 120/245-km range) and Kh-31P/PD/PM (AS-17, 110/250/280-km range). At the same time, Russian achievements in developing air-to-ground

missiles (AGMs) for general air support missions are far from impressive. While the Kh-59M/MK (AS-18, 115/285-km range) stand-off AGM is in Russian service, the missile's operational effectiveness when launched at the longer range proved so low that in Chechnya, for instance, Russian air forces ceased to employ AS-18 AGMs after just four attempts. Prospects for AS-18 modernisation also appeared bleak as the weapon's guidance system was produced in Ukraine. Taken together, that left the RuASF until recently with just the Kh-25M and Kh-29 families of close air support AGMs with a range of 10 km and the KAB-500 and KAB-1500 series laser-guided, TV-guided and satellite-assisted bombs with even shorter ranges of 6 to 8 km as 'stand-off' weapons, alongside the free-fall bombs and sub-munition dispensers. Not surprisingly, precision-guided munitions (PGMs) comprised 3 and 0.5 per cent of all munitions used by Russian air forces in Chechnya (1994–1996) and Georgia (2008) respectively.

To tackle the shortage of stand-off land-attack capability (except ARMs) which would be operationally vital in any conflict with a peer opponent, the RuASF is currently engaged in an aggressive rearmament programme. The Kh-38 family of modular 40-km-range AGMs (with four different types of guidance systems) has been in service since 2012. The Kh-58MK2 localised low-observable version of the AS-18 AGM (advertised range 290 km, while 170–190 km seems more realistic), as well as the 'Grom-1' winged version of the Kh-38 AGM (280 km range), are powered stand-off munitions, roughly equivalent to Joint Air-to-Surface Stand-off Missile and Joint Stand-off Weapons (JSOW) Extended Range respectively.

A range of unpowered PGMs is also being introduced into service: guidance/wing kits are designed to provide stand-off capability to Russian free-fall bombs, similar to that of Joint Direct Attack Missile Extended Range. FAB-500M62TG AF-5M is one example – the range for this type of winged munition is said to vary from 6–8 to 80–100 km depending on the variant. 'Grom-2' (a 'Grom-1' weapon with its rocket motor replaced by a second warhead) and KAB-250S are intended as equivalents to the Small Diameter Bomb (SDB-I/II), and the PBK-500U 'Drel' ('Drill', development ordered in 1985) gliding sub-munition dispenser (30 to 50 km range) is designed to be the Russian equivalent of the JSOW. The Kh-555 and Kh-101 (entered service in 2013) long-range, conventional, air-launched cruise missiles (ALCMs), as well as the Kh-55SM and Kh-102 (their nuclear-tipped variants) are in service with the LRA Command, while the prospective ultra-long-range Kh-BD ALCM is under development for Tu-160M2 and PAK DA.

The RuASF is introducing new S-400 air-defence (AD) missile systems with fire-control radars able to engage up to ten targets simultaneously. Fifty-six battalions are planned by 2020; thirty have been delivered by spring 2017. The existing 48N6DM surface-to-air missiles (SAMs) allow a 250 km intercept range, while the overdue 400-km-range 40N6 SAMs originally intended for S-400 will only see service with the S-500 mobile AD-ballistic missile defence system (roughly equivalent to the US Terminal High Altitude Area Defense system). Difficulties with development of the SAM active radar seekers have remained unresolved for at least the last decade, thus delaying the introduction of the 40N6 SAM and the 77N6 ultra-long-range (600 km) SAM/ballistic missile interceptor for the S-500. The 9M96/9M96-2 (40 and 120 km range respectively) SAMs are intended for the S-400 and the newer S-350 Vityaz AD system (thirty-eight battalions planned by 2020, but delivery had not started by mid-2017); the Vityaz was designed to replace the ageing S-300PS/PM AD systems.

The 'Pantsir-S1/S2' short-range (up to 20 km) AD systems are deployed alongside S-400 (eighty-six vehicles delivered by mid-2017 out of 200 planned by 2020) to increase the combat survivability of Russian air defences that provide point-defence against incoming ARMs and PGMs. Meanwhile the 'Pantsir' family of SAMs seems to be a dead-end branch as the radio-link-controlled unpowered intercept stage of its missile will increasingly lose both accuracy and

energy for sharp manoeuvre with distance. The 40-km-range 'Pantsir-SM' variant of the original 'Pantsir-S1' is therefore of questionable operational value.

Russian missile defences are being modernised, with the A-135M 'Amur-M' Moscow BMD system being upgraded to the A-235 'Nudol' standard and the introduction of the S-500 already announced. Plans to deploy ten battalions of S-500 starting in 2015 were announced in 2011, only to be changed in early 2017 to production of a prototype by 2020 and deployment of just five battalions around 2025 or later. BMD of Russia's deterrent forces, rather than territorial BMD, is to be the S-500's primary task.

Table 26.2 Percentage of modern equipment in the A-AD Armies, February 2017.

A-AD Army	*Average*	*Aircraft*		*AD systems*
		Fixed-wing	*Rotary-wing*	
6th	48	48	54	45
4th	50	41	37	80
14th	32	26	35	29
11th	48.5	34	78	31

The RuASF rearmament plans as designed in 2009–2010 were all based upon the assumption that unobstructed access to Western technologies and components would be guaranteed. That assumption allowed for wide incorporation of imported parts, above all Western electronic components, into contemporary Russian weapons designs. Even so, the gap is widening between the most modern Russian and Western designs, especially in airborne fire-control radars' capabilities. Reliance on imported components in Russian aviation systems averaged 92 per cent in 2015 with plans to decrease it to 71 per cent by 2020. Yet Russian industrialists admit that imported electronic components of modern Russian avionics (e.g., in the Su-35S avionics suite) cannot be substituted for domestic equivalents without a fundamental degradation in the corresponding systems' capabilities. While current Western sanctions do not affect the smooth flow of supplies under contracts signed prior to July 2014, the adverse political environment created by Moscow's adventurism in Ukraine means that Russia cannot take Western military-related supplies for granted. Meanwhile, contracts signed with Western suppliers before 2014 understandably do not cover industrial-scale supplies for the most modern Russian weapon systems in the advanced development stages in 2014. Thus, current sanctions affect possible future supplies and restrict Russia's ability to mass produce the newest weapon systems in the near future. This forces Moscow to concentrate on modernising Soviet legacy systems instead. Therefore, the current rearmament programme allows the RuASF to maintain a certain degree of technological advancement and slow down the widening gap between the RuASF and its Western opponents. Yet it cannot close the gap completely.

The RuASF: training and operations

The RuASF has taken part in three air campaigns over the last 25 years; in Chechnya (1994–2004), Georgia (2008), and currently in Syria since September 2015. Its performance has been comparatively poor on all three occasions. At the time of the Chechen campaign, the Russian Air Force was experiencing a period of neglect, with average pilot flying time falling as low as ten to thirty hours per year due to underfunding. The Georgian campaign revealed an

extremely inadequate level of coordination between different branches of the air arm and between the air force and the land forces it supported. Similarly, the campaign demonstrated very serious insufficiency in the Russian forces' reconnaissance and target-spotting capability. The Russian Air Force lost seven aircraft, with another four damaged beyond repair during combat operations. This equals one loss to every seventeen sorties flown, partially to friendly fire. PGMs comprised 3 and 0.5 per cent of all munitions used by the Russian air forces in operations in Chechnya and Georgia respectively.

Russian military planners addressed these problems after 2008 and the RuASF has achieved a substantial increase in pilot flying hours (see Table 26.3). The number of drones in Russian service, mainly tasked with target spotting, also increased tenfold. Despite these efforts, the RuASF's Syria campaign continues to suffer from insufficient reconnaissance, especially target designation for PGMs. As in Chechnya and Georgia, the Syrian air operation has been characterised by a comparatively low degree of sophistication in terms of the tactics used. Indeed, indiscriminate air strikes are as much a feature of the Syrian campaign as they have been in previous operations. Moreover, the accuracy and reliability of Russian PGMs (around 3–4 per cent of all munitions used) also turned out to be low.

Table 26.3 Pilot flying time (hours), by types of aviation units.

	2001	*2003*	*2006*	*2007*	*2008*	*2012*	*2013*	*2014*	*2016*
Average	–	12–44	40	75–80	60–80	97	113	120	'120+'
Tactical	10–20	36	20–25	55–60	60–65	–	–	–	125
Strategic	20	–	–	80–100	120	100	–	–	120
Airlift	54	–	60	–	–	–	–	–	170

In general, the RuASF has used Syria as a proving-ground for its newest operational concepts, including strategic redeployment (aircraft arrive to operate in Syria from as far away as the Russian Far East), rear support in forward areas and operational interaction among air, ground and naval forces, as well as coordination between Russian and foreign forces (the RuASF has carried out joint operations with Syrian and Iranian forces and the Turkish Air Force). New hardware is also being tested in combat: certain flaws were detected in the Su-34, Su-30SM, Su-35S aircraft, KAB-500S satellite-assisted bombs and many other systems. For example, standard Russian aircraft defensive aid suites proved to be ineffective against modern man-portable air defence systems and the like. Outsourcing maintenance of the air brigade in Syria to industry representatives instead of RuASF engineers made it possible to keep 80–90 per cent of aircraft airworthy. In regular units within Russia, airworthiness is at a lower level but the RuASF HQ aims to achieve 95 per cent airworthiness by 2025.

RuASF personnel are being rotated through Syria for combat training purposes: 86 per cent of all crews gained combat experience there by spring 2017. Back in Russia, the RuASF's training is becoming more sophisticated, especially since the beginning of the Syrian operation. Some of the Cold War training scenarios have been revived, albeit on a much smaller scale and frequency. The lack of modern operational command and control systems prevents Russian forces from conducting real network-centric-style operations. Instead, the Syria operation shows that the RuASF is forced to rely on obsolete command and control methods.

In Russia, pilot flying time is measured as the amount of time in which the aircraft remains airborne. This differs from the USAF, which measures flying time from the moment the aircraft

first moves under its own power on the ground to the point when the aircraft comes to a complete stop after flight.

The RuASF: strategic and operational roles

The role played by the RuASF in Russian defence and foreign policy is determined by the Russian Federation's National Security Strategy (2015), Military Doctrine (2014) and the Foreign Policy Concept (2016), as well as certain aspects of Russia's defence posture. Russia's Foreign Policy Concept of November 2016 (FPC-2016) postulates that 'Force is becoming an increasingly important factor in international relations' (Ministry of Foreign Affairs 2016: para. 6). At the same time, the FPC-2016 underlines that, with the growing interconnection of the world, 'attempts to ensure stability and security within a single territory are doomed to fail' (ibid.: para. 7). This implies the need to use armed forces with extra-territorial reach to guarantee Russia's security – the highest priority of Russian foreign policy (ibid.: para. 3a).

Operating, when necessary, in international air space, the RuASF therefore contributes to the nation's foreign policy by seeking 'to ensure strategic deterrence and the prevention of armed conflicts' (Instituto Espanõl de Studios Estratégicos 2017: para. 36) by using a mix of interrelated different tools. The Russian Navy, although it possesses similar extra-territorial capabilities, is in much poorer shape than the RuASF nowadays due to much higher renovation costs after many years of neglect during the post-Soviet period. The price-tag for naval operations is also much higher than that for air operations, which makes the RuASF the natural first choice for conducting beyond-the-borders operations aimed to 'ensure strategic deterrence and the prevention of armed conflicts'.

RuASF's deterrent role

While the RuASF contains one leg of Russia's nuclear triad – the Long-Range Aviation Command – the Service's deterrent potential lies largely in its defensive, rather than offensive capabilities. Indeed, the strategic nuclear forces' (SNF – the nation's strategic nuclear triad) command and control doctrine relies on the national BMEW system (currently operated by the RuASF) as the ultimate safety-lock for triggering nuclear retaliation. The SNF's executive command chains would only be activated if the BMEW system positively identified an on-going nuclear missile attack. Planners in the USSR/Russia traditionally assume that any full-scale strategic nuclear attack against Russia will start with a massive ICBM and SLBM strike, with intercontinental bombers participating in the second wave of strikes. The emphasis is therefore placed on the detection of ballistic missiles, rather than bomber/cruise missile attacks, as the ultimate indicator of a strategic nuclear attack.

The space- (when operational) and/or land-based segment of the BMEW system detects incoming ballistic missiles, while the land-based BMEW segment confirms the data and calculates the incoming missiles' launch areas and rough prediction of impact zones (taken together, this information allows planners to judge the nature of the strike). The data is then automatically fed to the command and control network to alert forces, initiate teleconference consultations on the retaliatory strike decision, and allow the issuing of release codes by the Supreme Commander to execute a retaliatory strike.

The RuASF is therefore a vital component of the national-level decision-making process and strategic retaliatory strike execution which forms the organic element of the nation's deterrent capability. However, the Service's deterrent role is not limited to those command-enabling aspects. Decision-makers in Moscow perceive that, due to Russia's geostrategic

situation, the main threat to Russia's security on both strategic and operational levels is represented by foreign air and space/missile strike capabilities (RIA Novosti 2017). It is crucial, therefore, to convince adversaries of Russia's ability to defend its command and control structures, as well as its retaliatory forces. Adversaries would never initiate conflict with Russia if they were fully aware of the impossibility of decapitating and disarming Russia's nuclear capabilities (Vesti 2015).

Air defence, air combat and strike operations

The RuASF's ability to defend troops and the nation is not restricted to intercepting incoming strikes, but also extends to the Service's strike capabilities. The Russian military often notes that, as proved by military conflicts over the last several decades, the aims of war cannot be achieved by defensive means alone. Russia's air and space defence is therefore envisaged to be proactively planned and executed as a combination of both offensive and defensive operations. On that ground, attacks on an adversary's air assets at their bases, destruction of carrier platforms (including naval surface combatants and submarines) rather than launched munitions, suppression of enemy air forces' command and control system, as well as the degradation of enemy space assets' combat efficiency, are all considered by the RuASF as integral elements of air defence actions, rather than as purely offensive operations on behalf of the Russian land and naval forces (Vesti 2015). In addition to that, the prevention and hindrance of enemy air operations in the Russian troops' operational areas and air strikes in support of Russian troops are among the RuASF's major operational tasks.

The threshold between the RuASF's strategic and non-strategic (theatre- or tactical-level) strike operations is becoming increasingly blurred. Although the distinction still exists, as manifested by the organisational division between the LRA Command and the tactical air forces within the Air Force, it is less and less clear. This is part of a deliberate choice by the Russian military leadership, to avoid making a hugely expensive 'sacred cow' out of strategic nuclear air forces which are not involved in conventional operations. This policy is determined by the Military Doctrine's provision which calls for the development of 'multifunctional (multipurpose) weapon systems' (Rossiyskaya Gazeta 2014: para. 46b) to ensure 'rational sufficiency and effectiveness' of Russian military forces (Instituto Espanõl de Studios Estratégicos 2017: para. 41).

The deeper integration of the strategic bomber force into the RuASF's tactical air operations is exemplified by the appointment of attack aircraft pilots with combat experience to command the LRA Command and the 22nd Heavy-Bomber Air Division: Major-General Sergey Kobylash[3], the attack jet pilot with combat experience on Su-7/17/25 in both Chechen wars (1994–1996; 1999–2005) and the Russian-Georgian war (2008) was appointed as Commandant, Long-Range Aviation Command in 2016 (Khodarenok and Zvigorskaya, 2016). The involvement of heavy bombers in Russian bombing and cruise missile strikes in Syria since September 2015 is evidently aimed at refining tactics and training crews of the heavy-bomber units for conventional missions. At the nuclear level and according to Soviet-era military plans inherited by the Russian Federation, the combat task of Russia's strategic bombers is to deliver a second wave of strikes against targets surviving the initial retaliatory ICBM and SLBM strike.

Airlift and its role in the general defence of the nation

The same doctrinal requirement to ensure cost-effective defences determines one more RuASF mission. The geographic expanse of Russia, paired with the limited human resources

available for defence, make strategic mobility the ultimate requirement for the Russian military in general and the Russian land forces in particular. Dedicated storage and servicing bases (BKhiRVT) are located at areas of potential military threat to Russia, containing pre-positioned brigade-level assets, maintained by a limited detachment of civilian personnel. In the event of conflict, troops from regular brigades deployed elsewhere in Russia would be airlifted light to BKhiRVTs near the anticipated combat zone to access the stored equipment before reinforcing the local forces in a matter of days, if not hours (Sutyagin and Bronk 2017: 20). The concept of BKhiRBT in general thus evidently parallels the US strategy of 'prepositioning' critical assets. The ability to rapidly reinforce threatened areas frees Russian military planners from the need to raise and maintain approximately 30 per cent more land troops (fifteen additional manoeuvre brigades, as disclosed by the existing BKhiRVT deployment pattern) (ibid.: 21).

Russia's Airlift Command can transport personnel of up to five-and-a-half to six motor-rifle brigade equivalents (between 25,000 and 27,000 troops, or around 10 per cent of all available manoeuvring forces) with light arms in one wave. The Ministry of Defence plans to further expand its airlift capacity (Grachev 2016) to guarantee mobility for troops and effective rear support for forward-operating troops. Hence the Airlift Command is in fact an important force multiplier for Russia's land defences, and a military force component that provides a more economical and cost-effective way to defend the nation.

Political use of the RuASF

Russia's National Security Strategy of December 2015 states the nation's commitment to rely mainly on non-violent means to protect its interests, resorting to military force only if other means prove ineffective (Instituto Espanõl de Studios Estratégicos 2017: para. 29). The Russian Military Doctrine of December 2014 contains its own equivalent of that statement (Rossiyskaya Gazeta 2014: para. 5). However, such seemingly peaceful Russian doctrinal provisions do not preclude the pro-active and even aggressive use of military actions short of open violence. On the contrary, military actions are nowadays the indispensable tool of Russia's foreign policy, with the RuASF playing an important role.

Indeed, the National Security Strategy states that 'consolidating the Russian Federation's status as a leading world power' is one of Russia's top long-term strategic national interests (Instituto Espanõl de Studios Estratégicos 2017: para. 30), with Russia's national security directly depending on 'the extent to which the strategic national priorities are implemented' (ibid.: para. 32). Meanwhile, within the framework of the existing world order, Russia is increasingly losing its competitiveness and its status as a 'leading world power'. For that reason, one possible solution is to change the very rules and norms of 'world governance'. To that end, the Kremlin is seeking to resurrect a new/old Russian sphere of influence or 'zone of privileged interests' as the means by which Moscow seeks to offset Russia's inability to compete within the existing rules-based framework of international relations (Sutyagin 2016: 88).

It is not enough, though, to simply re-establish a sphere of influence: what really matters is securing that sphere afterwards, even if Russia is in a position of relative weakness compared to its Western counterparts. Critically, for Moscow the only way to close the gap between power and reality is to create and maintain an 'aura of power', described by then-US Secretary of Defense Harold Brown back in January 1980 as the ability

> to get away with a relatively unbalanced posture' due to 'excessive expectations and fears where and how we would apply [military power]. To some degree, the aura of power has

> even substituted for its substance and its presence in many of the disturbances with which we have had to contend.
>
> *(Brown 1980: 99)*

Given that Russia remains inferior to the West in all but two respects – nuclear weapons and the will to use force – an 'aura of power' would be a valuable addition to the limited resources Moscow possesses to guarantee its desired 'leading world power' status. For example, by adopting an intimidating strategy, the Kremlin has successfully raised 'expectations and fears as to where, when and how' it 'would apply its capability' to use violence. In turn, the fear of Russian violence, allied with an exaggerated expectation that the Kremlin will use violence, are successfully dividing Western powers and blocking their will to respond, particularly in Europe. Put simply, Moscow believes that the only way to achieve policy goals is to intimidate intrinsically stronger opponents to deter them from challenging Russian policy (Sutyagin 2016: 90–91). Using Russian air assets in this assertive manner allows Russia to maintain a comparatively low probability of miscalculations and accidental clashes while strongly conveying Russia's alleged will to 'apply its capabilities', leaving observers with excessive expectations and fears with regard to Russian policy. These fears create opportunities to win diplomatic concessions from the West, thus the aggressive employment of the RuASF is instrumental to ensuring Russia's national interests.

Conclusions

The RuASF is a fading power which has had almost all of its prospective rearmament programmes delayed or downgraded due to a lack of adequate technologies. The capability gap is widening between Russian and Western weapon systems belonging to the same fourth generation, and lifting sanctions on Russia in connection with its actions in Ukraine can only slow the widening of this gap, not close it. The RuASF does its best to address recent inadequacies in its personnel's training, but disparity in some critical capabilities cannot be fully compensated by improved flight skills of Russian pilots or intensive training of air defence crews.

Meanwhile it would be arrogant and short-sighted to disparage Russia's capability to gain an upper hand in a conflict with Western countries. Such a capability is largely based on the Kremlin's will to exercise calculated brinkmanship in pursuit of psychological superiority over Western decision-makers – and the Western politicians' lack of will to act in similar way. In a conflict seen as a 'contest of wills', which should be won before the first shot, the technological superiority of Russia's peer opponents might be counterbalanced by Moscow's willingness to bluff dangerously (as recent buzzing of Western warships and warplanes confirmed) while the West avoids risk and prefers negotiations and compromise to open hostility. There is no doubt that the RuASF has the potential to obstruct Western air operations and inflict losses on Western air forces, primarily because of the RuASF's emphasis on developing extensive air defence systems. The Russian air arm is also able to raise large formations of relatively unsophisticated aircraft which the high-technology, but comparatively small Western forces (unless fully mobilised NATO-wide) might find difficult to oppose just because of the numerical imbalance.

The combination of these factors makes the RuASF a difficult adversary for any peer opponent not fully determined to suffer for the sake of victory over Russia. Meanwhile, one cannot predict the outcome of a hypothetical confrontation on the basis of comparison of combat capabilities alone: war is the state's business. Moscow's skills in intimidation and willingness to accept losses, and the West's extreme sensitivity to casualties, could allow Russia to 'steal'

victory from its indisputably better equipped peer opponents. That is why the West needs to take Russian air-space capabilities seriously: not because of the Kremlin's desire to be treated 'fairly', but because of the real and likely possibility that the Russian Federation will use the RuASF's capabilities to pursue its policy goals.

Notes

1 Alongside the Navy and Ground Troops, and two directly reporting branches: the Strategic Rocket Force and Airborne Troops.

2 Abbreviations:

ABTReg	Air Regiment of airborne tankers
AD	Air Defence
ADBde	Air Defence Brigade
ADD	Air Defence Division
ADiv	Air Division
ALAD	Airlift Air Division
AWACS Reg	Air regiment of AWACS aircraft
BMD	Ballistic Missile Defence
BMDD	Ballistic Missile Defence Division
HBAD	Heavy-Bomber Air Division
MAD	Mixed Air Division (comprising air regiments of different types – fighter, bomber, reconnaissance, etc.)
MD	Military District

3 Russian ranks (Army/Air Force):

O-1/OF-1	Junior Lieutenant – still in use, while very rare
O-2/OF-1	Lieutenant
O-3/OF-2	Senior Lieutenant
O-4/OF-3	Captain
O-5/OF-4	Major
O-6/OF-5	Lieutenant-Colonel
O-7/OF-6	Colonel
O-8/OF-7	Major-General
O-9/OF-8	Lieutenant-General
O-10/OF-9	Colonel-General
O-11/OF-10	Army General

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INDIAN AIR POWER

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Only a handful of Indians were military aviators during the First World War, when air power was first used as an instrument of war (Nair 2017). This occurred largely because the British government did not permit Indians to become military pilots. In fact, participation of Indians in the military forces as officers had only been introduced, on a very modest scale, in 1918. The award of a King's Commission meant that the Indian officer would be permitted to command British troops, not just Indian soldiers. By 1925, the pressure for 'Indianisation' had gathered some momentum, and on the recommendation of a committee chaired by Lieutenant General Sir Andrew Skeene a few selected Indians were sent to the Royal Air Force Training College at Cranwell in England for training and commissioning into the air force that was yet to be established.

The Indian Air Force Bill was passed by the Indian Legislature in April 1932 and came into force on 8 October 1932, when the Governor General gave his assent to it and the IAF Act was published in the Gazette. The Indian Air Force (IAF) now celebrates 8 October as Air Force Day (Indian Air Force Act 1932). The first flight, equipped with four Wapiti biplanes, was formed in April 1933 and saw some action in the North-West Frontier Provinces assisting the army in controlling restive tribesmen. The build-up of strength was slow for a number of disparate reasons, and at the outbreak of the Second World War in 1939 the fledgling service numbered sixteen officers and 144 men, while it had only one fully established squadron in its strength. Even though India was threatened with a Japanese invasion, the IAF grew slowly, reaching four squadrons in 1942 and the approved strength of ten squadrons by February 1944. All these squadrons took part in the counteroffensive against the Japanese in the Burma theatre, flying Spitfires and Hurricanes in support of the ground offensive. Even though numerically small, the IAF flew around 16,000 sorties in the Burma campaign (Tanham and Agmon 1995).

When India was declared independent after being partitioned in 1947, the IAF, now with the prefix 'Royal' in acknowledgement of its service during the Second World War, was reduced to six squadrons plus a half squadron equipped with transport aircraft. The RIAF was commanded by a British officer, Air Marshal Sir Thomas Elmhirst, who insisted on the service being granted fully independent status. The title of 'Royal' was dropped when India became a Republic on 26 January 1950. However, the first three Chiefs of Air Staff were British officers and it was only in 1954 that the first Indian Chief of Staff of the Air Force, Air Marshal Subroto

Mukherjee, took over the reins of command. However, from the very beginning air force planners had decided on building a balanced force, based on the concept of the air force being able to provide air defence for the nation as well as carry out offensive strike operations. It was also oriented towards providing support to both the army and the navy, both for combat operations as well as air mobility. This fundamental premise of the core function of the IAF has remained unchanged for the past eight decades.

This chapter examines the wars and conflicts in which the post-independence IAF has played an important, and at times critical, role at both the strategic and operational levels. In the analysis of the conflicts the chapter highlights the lessons that the IAF learned from them. The chapter goes on to assess the ability of the IAF to counter the evolving threats to the nation. It analyses the challenges facing Indian air power and looks into the future prospects for the air force of the most populous democracy in the world.

A strategic force – forged through war

Although it played a significant role during the Second World War, the IAF is defined today by the experiences gained during the conflicts that it fought in the post-independence era. At independence the IAF was structured to function as an effective adjunct to land operations and continued to develop as a tactical force for the next few decades. The lessons that it learned from the early wars were also narrowly focused on a land-centric concept of operations. It was only in the 1970s and thereafter that the IAF started to view national security in its broader perspective and commence a concerted drive to develop into a strategic force that could provide holistic air power in direct support of national security imperatives. The true interpretation of a 'balanced force' emerged only in the 1990s.

The Kashmir conflict of 1947

On 22 October 1947, Pakistan launched an attack into the state of Jammu and Kashmir, which forced the Maharaja and the political leaders of the state to accede to India. India's Cabinet approved the accession of Jammu and Kashmir on 26 October and the Indian Army was airlifted into Kashmir by IAF Dakotas and also requisitioned transport aircraft from civil airlines. At this time there was no land route into Kashmir and considering that the enemy forces had reached the outskirts of the capital Srinagar, this rapid infiltration of the army from the air saved the city from being captured. The small fighter force supported the Indian Army at crucial phases of the operation, while the small transport fleet was the lifeline for the army throughout the conflict, which was fought in extremely harsh conditions (Kumar 2007). From an Indian perspective the war was almost won when the government decided to approach the United Nations to settle the dispute peacefully (Chaturvedi 1978). Paradoxically, this action perpetuated the dispute!

The first war that the IAF fought brought home very clearly two fundamental requirements for the infant force: the need to be prepared for rapid deployment and the contribution that airlift can make to the outcome of the surface conflict. Even though this conflict was largely dominated by army operations, it is highly unlikely that the Indian forces would have been successful without the timely and critical support provided by the IAF. The map of Kashmir would have been very different today if the IAF had not been able to produce the effects that it did in 1947–1948.

Growth in the 1950s

Since the IAF had been nurtured by the British from its inception, it was not surprisingly dominated by British equipment, doctrine, and concepts of operations. However, post-independence, Britain's reluctance to supply arms freely and the proclivity of the United States to attach political strings to its arms sales made India recognise the need to diversify its sources of military supply (Tanham and Agmon 1995). The Kashmir conflict had also convinced the Indian government to approve an increase in the IAF strength to fifteen squadrons, especially considering the modernisation being undertaken by Pakistan. The IAF diversified procurement by acquiring the French Ouragan, renamed the Toofani in IAF service, a hundred being inducted by 1953 (Singh 1974). The 1950s saw a minor arms race between India and Pakistan.

By the early 1960s, the IAF had started to build the Folland Gnat lightweight air defence fighter under licence, acquired 110 French Mystere IVA ground attack fighters, about 200 Hawker Hunters primarily for ground attack but also used for air defence duties, and 117 British Electric Canberra medium bombers. India's selection of the Gnat was based on ease of manufacture and it is doubtful whether the then universally prevalent concept of a lightweight fighter was a consideration (Lal 1986).

Sino-Indian War – 1962

Since 1959, when the Dalai Lama fled Tibet and was given refuge in India (Time 1959), relations between India and the People's Republic of China had continued to deteriorate. The Chinese had taken over Tibet and on 22 October 1962 crossed the border with India in an unprovoked invasion. This attack across the border was a direct response to India providing sanctuary for the Dalai Lama and his government in exile. The Indian Army, which had assumed responsibility for the borders only the previous year, was caught unprepared. Its logistic requirements in the mountains were being met through air supply since there were no roads to the outposts. The challenge was immense, because the army requirement for the Ladakh region alone in June 1962 was for 44,000 tons to be airlifted, whereas the IAF's total airlift capacity was less than half (only 21,600 tons) of this requirement (Singh 2011). The situation in the eastern sector was much worse.

The IAF undertook a herculean effort to supply the army from the air, despite shortages of aircraft and aerial delivery equipment. In the Himalayan mountain ranges a small number of light transport aircraft and helicopters performed far beyond their capabilities. However, the decision not to employ the combat air power of the IAF was the single most significant factor that led to the defeat of the Indian Army. Many reasons have been advanced for the non-use of IAF combat capabilities and it is difficult to determine the lessons that the IAF drew from it. However, the IAF started to lay emphasis on developing tactics for the conduct of close air support missions and on command, control, and coordination for the efficient use of close air support missions (Palit 1991).

Indo-Pakistan War – 1965

India started to increase the size, quality, and capabilities of its armed forces immediately after the debacle that it faced in 1962. The Pakistan military had been strengthened by US military aid and Chinese support and believed that it could make a successful attempt at taking over Kashmir. As a prelude it began to infiltrate forces into the Rann of Kutch to test the Indian government's will and the army's readiness and capabilities. Despite various indications

regarding Pakistan's intentions, the Indian government and army remained unconcerned even as late as August 1965. Further, the IAF was not even kept informed of the possibility of a war breaking out, although it had started to gauge the situation for itself.

The 1965 war was the first one in which the IAF was fully engaged. Eager as the young service was to prove itself, it was hampered by a number of factors. In the aftermath of 1962, the IAF was in the midst of a large build-up in both equipment and personnel. Experienced personnel were spread thinly across new squadrons; the fighter force consisted of six different types of aircraft from four different nations; and the older aircraft were continued in service to boost quantity. The IAF was concentrating on growth rather than on preparing for war (Tanham and Agmon 1995). The Pakistan Air Force (PAF) was numerically much smaller but equipped with more modern aircraft. Contrary to many accounts, the IAF had only twenty-five combat squadrons in September 1965 (although a force level of thirty-five combat squadrons had been authorised in 1963), of which ten squadrons were held in the east as a deterrent against Chinese intervention. The force ratio in the western theatre with Pakistan was 1.5:1 in India's favour, offset by the technological superiority of the PAF (Singh 2011).

The war started with the Pakistani armour crossing the line of control in the early morning hours of 1 September 1965. The initial IAF response was to send four and then four more Vampire fighters to support the hard-pressed Indian Army. Of the eight, four were lost to F-86 Sabres. What could be termed the air war was most intense up to 7 September and tapered off thereafter, with both sides conserving their aircraft strength. Official statistics about the war are unavailable even today and the claims of the two air forces remain contradictory and irreconcilable. Careful analysis available in the public domain tends to list IAF losses as sixty-five aircraft to all causes (with about twenty destroyed on the ground) and PAF losses at twenty-five aircraft. Indian sources have refuted the number of their losses as too high, as have Pakistani sources that claim only nineteen aircraft lost. The IAF claim of twenty-five PAF aircraft lost amounts to roughly one-sixth of the PAF's combat strength, giving credence to the Indian claim that had the war continued, the PAF would have become ineffective. The IAF claim that it could have sustained operations for a longer period is also in question since both air forces were facing increasing shortages of spares and ammunition. Although some IAF officers have argued that its performance in the 1965 war was praiseworthy, an unbiased analysis does not support this claim.

From an analysis of the conflict, the IAF senior leadership established six basic drawbacks that the force faced. They also recognised that these had to be remedied on priority (Kainikara 2005). The first was the lack of formalised procedures that would optimise the delivery of close air support to the army in combat. The second was the inadequacy of communications between the three services at all levels, which included the Navy. This led to failure of communications at critical phases of the campaign. Third, although inter-service cooperation was recognised as crucial to efficient application of military force, 'jointness' as a binding element in achieving this was almost completely absent. Fourth, the IAF did not have a sufficient number of operational bases with adequate infrastructure to sustain operations for the necessary length of time. Further, the available bases were in the interior, which restricted the combat radius of the fighter aircraft. The fifth was that the combat aircraft in the IAF's inventory were almost all obsolete and their logistical supply chain had not been carefully planned. This resulted in excessive loss in the conflict and also impinged on sortie-generation rates. Finally, there was agreement that the losses suffered by the IAF were not commensurate with the value gained in terms of the effect on the adversary and its combat efficiency.

Indo-Pakistan War – 1971

The drawbacks identified in 1965 made the IAF undertake an overhaul of its command structure, logistics and maintenance and operational readiness. The IAF also embarked on an acquisition spree and at the outbreak of the war had thirty-nine squadrons with some 700 aircraft, although a number of squadrons were still equipped with older aircraft. In contrast, the PAF had suffered from the US arms embargo and was in no better shape than in 1965. The reasons for the 1971 war and the formation of Bangladesh as an independent nation are superfluous to the discussion in this narrative and are not covered here.

The PAF launched a pre-emptive strike on 3 December, which was the harbinger of a full-scale war on both the eastern and western borders. In East Pakistan, the IAF established air superiority within the first few days (three days by some accounts, more probably two) and thereafter provided unfettered support to the army; used its helicopters to create 'heli-bridges' to facilitate the rapid advance of the army across numerous water obstacles and rivers; and carried out a limited parachute drop operation. The IAF demonstrated its high operational proficiency in a precision attack carried out during the eastern campaign. On 14 December, it carried out well-timed and accurate attacks on the East Bengal Governor's residence in downtown Dacca when a meeting was in progress, without causing any collateral damage and without using any precision-guided munitions. The aim was to break the will of the political and military leadership, which was achieved with the surrender of the Pakistan Army in the east on 16 December.

On the western front, the IAF was able to thwart a massive armour-led offensive. This was also an uncommon battle fought between fighter aircraft and tanks in the Rajasthan sector at a small place called Longewala. Hunter aircraft of the IAF decimated two regiments of Pakistani armour in a decisive demonstration of the potency of air power to dominate the surface domain. However, the efforts at counter-air operations by both sides were only partially successful. The IAF, in an effort to make up for the shortfall during the 1965 war, concentrated heavily on providing close air support and as a result suffered serious casualties. Neither air force was able to obtain air superiority in the western sector and both had to be content with achieving local superiority at different times and locations.

The IAF undertook a total of 6,604 combat sorties, and suffered a loss of fifty-six aircraft due to combat factors and another fifteen to flying accidents (Singh 2011). Compared to this the PAF carried out a total of 3,027 sorties and is reported as having lost fifty-five aircraft to enemy action and a further six to other causes (Official History of Pakistan Air Force 1988). The IAF had validated its altered concepts of operations and proved itself capable of securing the necessary control of the air, while actively supporting the ground offensive. This has been confirmed by the army commanders of the time (Lal 1986). Some points of contention still remained at the operational and tactical levels, but on the whole the services functioned in a reasonably joint manner. Of particular interest was the strategic campaign waged by the IAF in the west that concentrated on the destruction of Pakistan's energy sources and transportation system. Pakistan had not anticipated this campaign and it proved a successful foray into an independent air campaign by the IAF (Official History of Pakistan Air Force 1988).

Indicators of the post-1971 status of the IAF

As recently as the late 1980s the army remained the primary arbiter of India's defence, dominating thinking and conceptual development at the strategic level. The IAF therefore remained a peripheral service, called upon to deliver concentrated fire support when required.

The concept of 'jointness' was limited to battlefield support and did not encompass early planning. Even though the IAF now claims to have its own strategic air campaign plan, it is still hamstrung by the need to provide support for the developing ground war, the plans of which were not available to the IAF at the time. The strategic attacks on Pakistan's energy sources in 1971 therefore should be lauded as an exemplary case of moving forward with fundamental air power concepts.

The IAF clearly was not comfortable with being pushed into a largely supporting role and this discontent manifested itself in the developmental trajectory that it took from the late 1970s. Plans laid emphasis on gaining control of the air and the ability to mount a meaningful counter-air campaign: both roles that the IAF could undertake on its own within a planned air campaign. The Indo-Pakistan Wars were all of limited duration, and therefore the IAF was not able to leverage its greater resources and staying power. The need to achieve 'victory' in a short time span also influenced the acquisition of capabilities.

Only in the past two decades has the IAF moved away from a Pakistan-centric approach to capability development and started to factor in China as a more credible and significant threat. The altered force structure and the acquisition of long-range combat capabilities – with the necessary infrastructure for their efficacious use such as air-to-air refuelling aircraft and the Airborne Early Warning and Control System (AWACS) – are indicative of a definitive shift towards a China-focused strategic outlook.

Another aspect that has gained priority at the conceptual level is the absolute criticality of achieving jointness at all levels of war. Modern conflicts being waged across the globe have decidedly demonstrated that the employment of military forces can only be optimised with true jointness in their application. The IAF has absorbed this reality and has made considerable efforts in being the catalyst in achieving the necessary level of jointness with both the army and the navy.

Further, both the Indian Army and the Indian Navy have their own air arms. These are primarily rotary-wing assets in both cases, although the navy has acquired a minimal combat capability in terms of Mig-29 fighter aircraft that will be embarked on its aircraft carriers, as and when they become operational. Inter-service rivalry has plagued the true integration of the air power capabilities resident in the army and the navy with the dominant air power of the IAF. This situation makes battlespace management a complex issue because of the fractured command and control being exercised at the moment. A true 'joint' Air Operations Centre does not seem to have been envisaged in the planning for joint operations.

Kargil 1999 – 'air power at 18,000 feet'

In the spring of 1999, Pakistan infiltrated troops into the Kargil-Dras sector of the disputed state of Jammu and Kashmir, a provocation that would incite a war now called the 'Kargil Conflict'. The Indian Army was taken completely by surprise – at the strategic as well as operational levels – when the scale and density of Pakistan's intrusion into Kargil was discovered. The Indian Army thereafter went on the offensive, and in a 'no-holds barred' heroic operation dislodged the Pakistani Army from its protected bunkers. The IAF was called in to provide support for the army, employing fighter aircraft after a helicopter was shot down and a Canberra reconnaissance aircraft was damaged by a surface-to-air missile.

The IAF flew 1730 combat sorties during the Kargil conflict, generating more than forty sorties per day at the height of the conflict (Lambeth 2012). The clash also saw the first-ever use of laser-guided bombs by the IAF, when Mirage-2000H aircraft destroyed command and control bunkers of the Pakistani Army in the sector. The IAF was brought into the conflict only

after detailed discussion and analysis regarding the potential for the conflict to escalate as the result of using air power. However, once the IAF started its attacks, it was able to maintain complete control of the air and also deliver effective support to the army.

At the operational and tactical levels, the IAF adopted a number of innovations to optimise its application of concerted air power. Sources acknowledged, post-war, that the IAF's entry into the war 'immediately altered the nature of the conflict' (Major 2009). The innovations, carried out 'on the run', involved the fitting of commercially available Global Positioning System (GPS) equipment to the MiG-23 and -27 aircraft that not only improved accuracy, but also kept the aircraft outside the surface air defence envelope. At the strategic level the Indian government imposed a number of restrictions on the IAF to avoid conflict escalation. The IAF's ability to adapt to these severe restrictions, such as banning the crossing of the Line of Control, was exemplary and contributed to keeping the clash localised. The operational difficulties of the terrain served as a sobering wake-up call for the IAF, which had neither given such a scenario much thought nor trained routinely at such operating heights (Lambeth 2012).

Current status – future prospects

The IAF conducted studies to identify and remedy the shortcomings observed during the Kargil conflict, even if the finger-pointing by some of the biased army leadership is to be discounted. The contemporary IAF remains a shining example among the air forces of the world of organisational functionality and ambitious forward thinking. Its operational proficiency has been established over a period of years and is considered second to none. It is also worth mentioning that the strategic and operational leadership of the IAF has always been dedicated and exemplary. Today the IAF is a balanced force with full-spectrum combat capabilities operating as a competent fourth-generation air force. It fields conventional precision-strike capabilities, force multipliers such as air-to-air refuellers and AWACS aircraft, uninhabited aerial vehicles equipped with multi-spectral sensors and capable of long-term strategic surveillance and tactical reconnaissance, and an elementary, but developing space capability (Lambeth 2015). Over the years, the IAF has also acquired independent strategic missions, the most important being those of nuclear deterrence and retaliation.

India's nuclear policy, particularly regarding weapons, has enjoyed broad bipartisan support across the political spectrum. Over the years the nation has attempted to build a triad of nuclear response options, but continues to be reliant on the IAF for assured delivery of nuclear weapons if the need should ever arise. India has also proclaimed a 'no first use' doctrine regarding nuclear weapons, although some recent statements by senior security decision-makers in the government may be indicative of a nuanced shift in this policy. In either case, the IAF remains the mainstay of the nuclear option for the government. Accordingly, the combat arms of the Air Force are oriented towards the necessity to practice the delivery of nuclear weapons.

For all its demonstrated capabilities, a deeper analysis shows that the twenty-first century has not been kind to the IAF. Eighteen years after fighting its last battles, the IAF finds itself in challenging times. The troubles, tribulations and difficulties faced by the IAF are not of the air force's own making but foisted on it through a lack of understanding at the highest levels of decision-making regarding the criticality of air power to national security. The challenges facing the IAF can be divided into three interconnected constituents: an evolving threat environment, the declining combat aircraft inventory, and a failing modernisation programme due to procurement delays.

The evolving threat environment

Even though the Sino-Indian War of 1962, and the defeat suffered, have not been forgotten in Indian strategic thinking, it is only in the past two decades or so that India has started to consider China as the predominant threat to its security. Till then the threat perception focused almost completely on a land-centric conflict with Pakistan. With the articulation by the military forces of the need to be ready and able to fight a two-front war, two changes took place in doctrinal thinking and the development of concepts of operations. The Indian Armed Forces recognised first that these conflicts would not be land-centric and second that the current state of jointness may not be adequate to meet the requirements of a two-front war. As a result, decision-makers have accepted air power as a critical element in the planning of national security campaigns.

Arguably, the threat to India's national security, from a purely military perspective, will emanate from the activities of either Pakistan and/or China. This chapter does not discuss the domestic security challenges that India faces in terms of Maoist rebellions and minor terrorist activities, since the employment of air power and the IAF in countering these issues have so far been restricted to the provision of airlift capabilities on an as-required basis.

Chinese People's Liberation Army Air Force

The ongoing and rapid transformation of the People's Liberation Army Air Force (PLAAF) remains the most significant threat to Indian security – its airspace, military forces and strategic centres of gravity. Although the numerical strength of the PLAAF has declined over the past two decades, it is by far a more potent force in 2017. It now has a core of about 700 advanced, high-performance J-10 and Su-27/30 fighter aircraft, only a little less than the total combat strength of the IAF. This numerical shift creates a formidable advantage considering that traditionally the high-end capable combat platforms in the PLAAF were always fewer in number than those the IAF possessed. In 2012, these platforms exceeded the total numbers of combat aircraft that the IAF can field (Hallion, Cliff and Saunders 2012). The balance has definitely shifted in China's favour.

The PLAAF also possesses a large inventory of bombers, force multipliers, and uninhabited aerial vehicles. Although the bomber force may not have the capacity to penetrate Indian air defences, the bombers have cruise missile capabilities that can be employed effectively against selected Indian centres of gravity. India, by contrast, has tended to emphasise tactical theatre-level counter-air campaigns and does not have a bomber force (Tellis 2016). Its reliance on multi-role combat aircraft has the potential to become a strategic shortfall in a future conventional conflict with China. Similarly, the IAF does have force multipliers such as AWACS and air-to-air refuellers, but they are still too few in numbers to be able to support sustained operations. In comparison, China has built up sufficient strength to carry out prolonged combat air operations.

The contrast between the two nations in terms of aeronautical research and development is perhaps an accurate indicator of the real state of affairs in relative air power capabilities. China has moved ahead by leaps and bounds, producing two prototypes of fifth-generation fighters, the J-20 and J-31, while India has struggled for over thirty years to achieve operational status for its only Light Combat Aircraft (LCA), the Tejas (Bedi 2017).

Still, in the event of a conflict with India, the PLAAF is likely to be at a disadvantage because of two factors. First, regardless of its projected inventory, it will not be able to bring its entire combat air power capabilities to bear against India. It will have to keep reserves on hold to

respond to near-term threats: notionally from Japan, Taiwan and the United States. Second, the PLAAF faces infrastructure deficits in the Chengdu and Lanzhou Military Regions that adjoin the northern Indian borders (Tellis 2016). This could mean that it may be unable to employ all available combat assets for the necessarily high-altitude operations.

Pakistani air power

The PAF, with which the IAF has engaged many times previously, even though numerically inferior cannot be considered an inferior force. On the contrary, over past few decades, it has with US assistance eroded the IAF's margin of superiority both in capability and in numbers. The IAF understands that a two-to-one numerical superiority, which it currently has, is not a sufficient ratio to ensure victory when faced with a two-front conflict. The PAF has been proactive in creating a rationalised force structure and acquiring combat assets with sufficient force multipliers. It is also making all-out efforts to procure Chinese J-31 fifth-generation fighters (Tellis 2016). The PAF will not 'win' a war with the IAF, but it could prove a show stopper for the IAF if India envisages a two-front war. The IAF needs careful force structure planning and capability development calculations to ensure that shortfalls do not lead to jeopardising national security.

A two-front war contingency

India faces two potential adversaries who are dissimilar in all aspects of warfare. However, strategic planning within the Indian armed forces does not seem to have effective solutions to the challenges of a two-front war. The IAF particularly is hamstrung by constrained budgets and an impossibly delay-prone acquisition process. By 2020 it is estimated that the IAF would be faced with around 800 advanced Chinese fighters and more than 200 PAF fighters. The IAF will need a minimum of sixty combat squadrons to deal with a serious two-front challenge (Kapur 2014). Whether the primary theatre is Sino-Indian or the primary threat is Pakistan, a sixty-squadron force would provide the requisite air superiority needed for operational success. These calculations are based on achieving numerical superiority over Pakistan and maintaining parity with China. The challenge is for the IAF to grow to this stature, while at the present it seems to be heading in the opposite direction.

Declining combat aircraft inventory

In late March 2016, the then-Vice Chief of the IAF (subsequently promoted to Chief of Air Staff on 31 December 2016) courted controversy by stating baldly that 'Our [IAF] numbers are not adequate to fully execute an air campaign in a two-front scenario' (Singh 2016). Against an authorised strength of forty-two fighter squadrons, the IAF currently fields only thirty-three squadrons, which include obsolescent aircraft such as the MiG-21 Bison and a squadron of indigenous Tejas aircraft with only two aircraft on its strength. Mindful of the steadily declining combat strength, the IAF had embarked on an ambitious modernisation programme more than a decade ago. However, the programme has not yielded the desired results and continues to be plagued by bureaucratic delays in decision-making, complicated procurement processes, and declining budgets.

In December 2015, the IAF informed the Parliamentary Defence Committee that its combat assets would be reduced to twenty-five fighter squadrons by 2022 since ten squadrons of about 200 Mig-21 and Mig-27 fighters would start to be retired from 2017 onwards. The

mainstay of the IAF at this stage will be fifteen squadrons of Sukhoi Su-30 MKI multi-role fighters built under licence, for a total of 272 aircraft. Five SEPECAT Jaguar squadrons and three each of Mirage-2000H and MiG-29M fighters will complete the IAF fighter inventory for 2021-22 (Bedi 2017). Even the most cursory analysis will show a mismatch between the retirement rate and the introduction of light, medium and heavy combat aircraft to move the IAF towards being a strategic force. The situation is further exacerbated by a shortfall in fighter pilot numbers, revealed in April 2015 in a parliamentary report, which stated that the cockpit-to-pilot ratio was 1:1.08 rather than the mandated 1:1.25 (ibid.).

The continually declining inventory is a calamity by itself, and it is compounded by the unusually diverse inventory: the IAF fields seven types of fighters, four types of airlifters, three types of trainers, as well as air-to-air tankers and AWACS (Lambeth 2015). This is not only a logistical nightmare but also a definitive factor that will lead to operational inefficiency. Perhaps more important, the logistical burden will be a drain on an already constrained resource base. The diversity of equipment has also skewed the force structure of the IAF. Although some analysts tend to place the blame on the IAF itself (Karnad 2015), the situation is far more complex. Lacking a trustworthy domestic aerospace industry, the IAF's force structure is directly influenced by the global military aviation market, while the IAF cannot contain the fallout from the growth in unwanted directions. Considering that air power requires an abnormally long lead time to operationally field complex combat systems, the IAF needs to act now. Otherwise it is bound to fail in its primary duty of protecting the nation, especially when the nation is confronting a two-front war not as a probability, but as a distinct possibility.

Failing modernisation programme and procurement delays

A number of factors contribute to the 'non-progress' of the IAF's modernisation programme. The primary factor is the highly complex and time-consuming procurement process utilised by the Ministry of Defence. The current government has attempted to simplify it, but it remains cumbersome and opaque. The penchant for the civilian bureaucracy to refer even simple matters to committees adds to the inherent delay in the process. The prolonged wait for the induction of the medium-weight combat aircraft into service denies the IAF full-spectrum capability (Bedi 2017).

Another major factor is the weakness of India's higher defence management organisation that so far seems to be incapable of formulating unified priorities. Due to the combination of this fundamental flaw and the inability to articulate coherent responses to the demands of capability development, the IAF flounders in fielding a balanced and full-spectrum force. It is not an exaggeration to state that a disconnect exists between national security and IAF capability (Tellis 2016). The civilian mantra of self-sufficiency in producing military systems at the cutting edge of technology has eaten into the core of the IAF. The policies of successive governments have only very moderately succeeded in creating average and mid-level technologies. For an air force aspiring to function at the higher end of technology this is not welcome news.

The IAF realises that combat outcomes cannot be assured by catering to the need to foster domestic industry. However, the air force lacks strategic influence to make the political and bureaucratic leadership understand the urgency of introducing state-of-the-art equipment and systems. For the moment it seems that the IAF will continue to decline in numbers and capability, bedevilled by a civilian leadership that places national security on the back burner. Its modernisation programme remains a pipe dream, at least for the moment. The current government has not delivered on its promises to improve the procurement process: if anything,

the 'Made in India' slogan has further complicated the acquisition of much-wanted capabilities. Add the incompetence of India's domestic aerospace industry and the picture that emerges is not pretty.

Conclusion

The IAF has a distinguished record of service to the nation. It has fought and won wars over the years, adding to its lustre. It has also been at the forefront of providing humanitarian aid and disaster relief on a regular basis during times of natural calamities across the nation. Perhaps more important, the IAF has continually managed to improve its status as an air force, and is now considered one of the best forces in the world that encompasses a balanced, full-spectrum capability. Striving for operational excellence has become a byword in the IAF.

While discharging all its responsibilities, the IAF, like so many other air forces around the world, also faced some issues. Most of them can be overcome if they are addressed with understanding of the intricacies involved in creating and maintaining as complex a military service as an air force. However, particularly in the past decade or so, the IAF has faced increasing challenges from several directions. To ensure that it can perform at the requisite level, the IAF must mitigate these conditions sooner rather than later.

The challenges are many and varied. The geo-strategic environment in which the IAF operates is changing; air power capabilities are being improved and altered because of unprecedented technological advances; and the service confronts resource scarcity because of domestic political pressures, while air power capabilities are becoming increasingly resource intensive. These conditions apply to most air forces in the world. However, the IAF also faces a few challenges unique to its environment. India's domestic aerospace industry has time and again demonstrated its inability to deliver desired capabilities on time, despite promises to the contrary. The government's lackadaisical approach to the urgency of addressing national security issues exacerbates this situation. The most important challenge that the IAF faces is gaining acceptance at the strategic level of national security decision-making that India in the future will have to fight a two-front war. The stark facts reveal that the IAF at the present moment does not have the wherewithal to fulfil this momentous responsibility – a reality clearly brought out by the IAF leadership.

It is an unbiased assessment that the IAF today stands at a crossroads. The path that it traverses in the next five to ten years will determine whether it will continue to wear the mantle of a world-class air force with equanimity or whether it will falter, falling prey to decay brought on by the apathy of strategic civilian leadership and associated governmental agencies.

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28
PAKISTANI AIR POWER

Jamal Hussain

The Royal Pakistan Air Force (RPAF) came into being on 14 August 1947, the day British colonial rule formally ended and the subcontinent was partitioned into two independent dominions, Pakistan and India. Although the government assets of the undivided India were to be proportionately shared between the two countries, Pakistan's newborn air force received only part of its rightful share, comprising sixteen Tempest fighter-bombers, a few Halifax bombers, some DC-3 (Dakota) transport planes, and a handful of Tiger Moths and T-6G Harvard training aircraft (Shabbir 1982).

This chapter examines the seven decades of the Pakistani Air Force (PAF) as it blossomed from its *ab initio* stage with a handful of the Second World War-vintage aircraft and a motley bunch of aircrew and technicians to its present status where its professionalism and operational readiness are universally acknowledged and the service is considered the pride of the nation. Today it can lay claim to be a leading exponent of air power employment in a fourth-generation warfare setting. The story of an embattled service surviving and progressing against heavy odds as it struggled through severe resource constraints, crippling arms embargoes and the need to deter, and when called upon repel, an adversary over three times its size makes an interesting case study. There are key lessons to be learned for small and medium-sized air forces that like the PAF have to face and operate under similar challenges and trying circumstances.

The RPAF faced its baptism by fire within the first six weeks after its birth. A battle was raging in the Kashmir Valley between irregular forces supporting Pakistan's claim to the state of Kashmir and the entire military might of India. Civilians urgently needed supplies to be air dropped in the liberated zones where the Indian Air Force Tempest fighter-bombers were operating freely. Pakistan decided not to employ the Tempests in its inventory to avoid further escalation, and the unarmed, slow-moving, defenceless DC-3s were tasked to carry out air drops without fighter escort. In one such mission, the lone RPAF DC-3 was intercepted by a pair of armed Indian Tempests and was ordered to head towards India. The young DC-3 commander refused and the Tempests launched a series of gun attacks, damaging the plane. Skilfully dodging the marauding fighters within the confines of the narrow valley, the DC-3 managed to escape and land back at its home base. For his act of courage, Flying Officer Mukhtar Ahmad Dogar, the DC-3 captain, became the first Pakistani to be awarded a medal of valour, the Sitar e Jurrat (Shabbir 1982).

At independence, combat squadrons allotted to the RPAF were engaged in counter-insurgency operations as part of the British military action to subdue unrest in the north-west. The uprising in Waziristan against British rule in India, led by the legendary Faqir of Ipi (né Mirza Ali Khan), started in 1937. Air action against the Faqir proved ineffective and neither side could achieve decisive victory. The Royal Air Force and Royal Indian Air Force squadrons continued to operate on 'watch and ward' duties in Waziristan year after year until, in 1947, the task was handed over to the RPAF. On 15 August 1947, just a day after it came into being, the RPAF undertook its first operational mission in Waziristan. From 17 December 1947 on, the RPAF became a part of UK General Headquarters' Operation Curzon, aimed at extracting the Pakistan Army troops from Razmak in Waziristan, and air operations continued till June 1949. On 4 November 1954, the surrender of a key rebel leader and the notorious outlaw Meher Dil in effect brought the Waziristan insurrection to an end (Zafar 1988).

The founding fathers of the nation had recognised early that a modern and efficient air force was essential to the survival of the fragile state. Despite severe resource constraints Pakistan's fledgling government was determined to equip the service with aircraft and systems that would give it the wherewithal to safeguard the nation's airspace. The first four commanders in chief of the RPAF were British officers on secondment from the Royal Air Force. When it came time to replace the ageing Tempests and DC-3s, the service opted for British aircraft. The piston-engine Hawker Fury was introduced in 1948 as the air force's frontline fighter/strike aircraft and over seventy Bristol Freighters joined to form its transport aircraft fleet. To match the introduction of jet aircraft by the rival Royal Indian Air Force, Pakistan procured Supermarine Attackers, marking the beginning of jet aircraft operations in the RPAF.

Transition to the USAF model of air operations

For the first five years after its inception the RPAF continued to function in much the same way as its 'parent' service, the Royal Indian Air Force. In those early years, daredevilry and heroics were considered a virtue. The unofficial mantra 'kick the tyres, light the fires, whoever gets airborne first is the leader', a vague reference to the mass scrambles the Royal Air Force fighter pilots often underwent during the Battle of Britain, was often echoed in combat squadrons and coloured much of the ethos of the senior commanders. Violation of safety rules was considered a minor infringement, resulting in high accident rates and pilot fatalities. The first half decade of the RPAF may be summed up as being 'a fighter pilot's paradise and an aero-engineer's nightmare' (Zafar 1988).

The vision of the young Pakistani officers of the embryonic air force belied their youth and lack of experience. Faced with an adversary vastly superior in numbers, they understood well that the operational doctrine of the air force would have to be based on ensuring selective air superiority over critical areas while denying the same to the enemy. Lacking the mass to destroy the rival force with air strikes, besting it in air combat was considered the logical alternative. It was clear then that the RPAF needed to acquire air superiority fighters capable of inflicting unacceptable damage on enemy aircraft attacking Pakistan.

The signing of the Mutual Defence Assistance Agreement with the US in 1954 brought about a qualitative change in the composition and quality of the RPAF. Pakistan turned down the initial offer by the US to supply the ground attack F-84s and instead insisted on acquiring F-86 Sabres – the transonic, swept-wing jet fighter that had gained much fame in air combat against the Soviet MiG-15s during the Korean War. The service got its wish.

In the meantime, with Pakistan becoming a republic (from the status of a dominion in the Commonwealth of Nations), the Royal nomenclature was dropped and the service was renamed the Pakistan Air Force in 1956.

By the mid-1960s, the PAF combat elements had become an all-jet force. The fighter/strike units comprised the F-86 Sabres and a handful of F-104 Starfighters, the bomber fleet was made up of B-57s, while the T-37s and the T-33s respectively served as the basic and advanced trainers. The Bristol Freighters were similarly retired and replaced with the versatile turbo-prop C-130s to form the PAF's transport fleet.

Alongside the incorporation of US-origin aircraft, the PAF also adopted the USAF's operational philosophy, with flight safety as one of its key components. The cavalier approach to flying which marked the post-Second World War era gave way to a discipline that required the highest level of efficiency and had no tolerance for breaches in flight safety. This resulted in a dramatic reduction in accident rates.

1965 war

The first real test of the PAF came about during the India–Pakistan War of 1965. Notwithstanding the exaggerated claims and counterclaims by both air forces, a near consensus did emerge among neutral observers that the PAF had outperformed an adversary three times its size (Singh et al. 1991). This was especially true for air combat, in which the PAF established 2:1 superiority (Tufail 2003).

The air war in West Pakistan started on 1 September 1965, when the IAF was called in to support beleaguered ground forces of the Indian Army in the disputed Kashmir sector. The IAF launched Vampires to carry out air strikes against Pakistani ground forces and the PAF responded by scrambling a pair of Sabres. In the brief ensuing skirmish, four Vampires were shot down. This humiliating loss forced the IAF to immediately withdraw the entire fleet of Vampire and Ouragon aircraft from operational duties.

On 6 September, a strike formation of Sabres carried out a highly successful attack against IAF Base Pathankot, destroying about a dozen front-line fighter aircraft, including a few of the freshly introduced MiG-21s (Haider 2010). This Mach 2 fighter was not seen in action during the remainder of the war (Zafar 1988). The PAF effectively challenged the IAF's retaliatory strike against PAF Base Sargodha on 7 September. On that day Squadron Leader M. M. Alam of the PAF achieved the legendary status of a jet fighter ace when he was credited with downing five IAF Hunter aircraft in a single aerial encounter – an unparalleled feat in the history of jet air combat (Fricker 1979). The attacking IAF formations suffered high attrition, and by the end of the day the PAF had established a clear ascendency over its rival that lasted for the duration of the war.

While an all-out battle raged in West Pakistan, the eastern front (former East Pakistan) was relatively quiet. Offensive air operations were limited to twin strikes at IAF Base Kalaikunda by the lone PAF squadron based at Dhaka, which destroyed fourteen to sixteen aircraft and damaged another six to eight in the process (Zafar 1988). The squadron earned the sobriquet of the 'Tail Choppers'.

The US imposed an arms embargo on both countries upon commencement of hostilities, but this had a disproportionate impact on the PAF, as its entire combat fleet of aircraft and weapons systems was of US origin. In contrast, the embargo made little or no difference to the IAF, because the bulk of its aircraft were either of British or French make. Despite the embargo, the PAF had the capability to fight the war for a limited period because, over the years, it had assiduously built up a reserve in anticipation of just such an eventuality. However, it was clear

that with the supply chain for spares and munitions severed, the PAF's capability to continue operations for an indefinite period would be severely degraded. Pakistan reluctantly accepted the UN-sponsored ceasefire offer on 22 September 1965.

Post 1965

The PAF's reputation received a major boost because of its successes in aerial combat during the 1965 war. Several Middle Eastern states sought its assistance to establish their air forces *ab initio* or enhance the capabilities of existing air forces. PAF pilots and technicians were seconded to these countries in large numbers. In the Arab–Israeli Wars of 1967 and 1973, a handful of PAF pilots flew operational missions against the Israeli Air Force. No PAF pilot was shot down, while in separate aerial encounters – in Jordan in 1967 (Tufail 2003), and in Syria in 1974 (Zafar 2015) – they scored four confirmed aerial victories against one of the most professional air forces in the world. The PAF had demonstrated its authority and excellence in air combat, which were universally acknowledged.

The period between September 1965 and December 1971 was a real test for the service. After American military assistance had been cut off, the PAF had to find alternative ways to maintain its operational status. Not only did it have to make up the attrition from the 1965 war, but the rapid expansion of the IAF with advanced aircraft also made a major upgrade of the PAF's own weapon systems a matter of survival. The People's Republic of China came to the rescue and generously offered MiG-19s, which were immediately introduced and, after requisite modifications, dubbed the F-6. The first batch of these aircraft arrived in Pakistan on 30 December 1965.

The PAF also bought around ninety Canadian Sabres at a nominal cost from Germany in 1966 (Abbas 2010). In addition, it procured two dozen Mirage IIIE multi-role aircraft from France, fully paid for by Pakistan in precious, hard-earned foreign currency. Meanwhile, with Richard Nixon becoming the US president in 1969, the embargoes and sanctions started to soften, permitting limited import of critical spares. The freshly added planes had almost become operational when the 1971 India–Pakistan War broke out.

1971 war

A civil war erupted in the country's eastern portion (the former East Pakistan) in March 1970. Large-scale defection of Bengali pilots and technicians affected the PAF's operational readiness. In East Pakistan (geographically separated from West Pakistan by over 1,000 miles of hostile Indian territory) a lone squadron of the ageing subsonic workhorse, the Canadian Sabres, had the impossible task of fighting ten IAF squadrons, many equipped with the supersonic Mach 2 MiG-21s. By this time the native population had become actively hostile to Pakistan, with the result that the recovery of pilots who safely ejected over their own territory could not be ensured and some of them were presumably captured and killed by Bengali insurgents. The psychological effect of operating in such an environment added another sinister dimension to the near-impossible task of defending East Pakistan.

The bulk of the air action in the eastern theatre took place over just three days – from 3 to 5 December – when the IAF mounted a massive counter-air operation against the PAF's solitary operational airfield at Dhaka. PAF operations in East Pakistan finally ground to a halt on 5 December 1971, when the Dhaka runway was cratered beyond repair. The aircrew were evacuated to West Pakistan via a circuitous route to augment the PAF's pilot strength in the still ongoing battle against the IAF. The eleven Sabres that survived the IAF onslaught against Dhaka

were destroyed to prevent them from falling into enemy hands. During the brief aerial war in East Pakistan, the PAF lost five combat planes but in return destroyed at least three IAF aircraft, damaged two (half kills) in air combat, and shot down a further eight with anti-aircraft artillery (Tufail 2003). Considering the highly adverse operational and political environment and the immense numerical superiority of the adversary, the performance of the squadron was exemplary.

The land and air battles in West Pakistan were conducted at a comparatively slower pace than those waged in the eastern theatre and neither side could establish air superiority. The war in the west eventually ended in a stalemate as a ceasefire was declared once Indian military and political objectives in East Pakistan had been achieved.

Despite the military defeat in the east, the PAF's performance deserves credit. Independent sources have determined combat losses of the two air forces as twenty-seven for the PAF as against sixty for the IAF (Tufail 2003). In air combat in the west, the PAF enjoyed a kill ratio of 1.8:1 in its favour.

Post-1971 to the end of the twentieth century

The 1971 India–Pakistan War was a watershed both for Pakistan and the PAF. The eastern wing of the country was severed from the rest and the morale of the entire nation had sunk to a new low. But despite losing the war, the reputation of the PAF as a professional outfit had remained intact. As evidence of the esteem in which the PAF was held, requests from Arab countries to second Pakistani pilots, engineers and technicians to their air forces continued to pour in. The PAF willingly obliged, despite the difficult circumstances that prevailed after the nation had lost half its territory.

The peaceful nuclear explosion by India in 1974 acted as a wake-up call for the entire nation. Pakistan believed it had no option but to go nuclear, resolving to attain strategic parity to prevent a repeat of the 1971 disaster.

Pakistan's clandestine efforts to acquire nuclear weapons technology triggered the Symington (1976) and Glen Amendments (1977) to the US Foreign Assistance Act, which, in effect, imposed fresh economic and military sanctions on Pakistan. During the presidency of Jimmy Carter, an attempt was made to wean Pakistan away from developing a nuclear weapons capability. The US offered to provide the A-7 Corsair strike aircraft, which, besides allaying Pakistan's apprehensions of a rapidly modernising IAF, would have given the PAF the capability to carry out deep penetration strikes against India. The PAF declined the offer and instead recommended to the government not to accept any proposal that would compromise the country's ongoing nuclear weapons programme. The Carter administration did not accede to Pakistan's counter suggestion and the US aid package fell through.

The Soviet invasion of Afghanistan in 1979 altered the matrix of the US–Pakistan relation - ship. As a quid pro quo for agreeing to help defeat the Soviets, the US offered to provide Pakistan advanced military hardware, including sophisticated fighter aircraft. This was preceded by the enactment of the Pakistan-specific Pressler Amendment (1985), which required the US president to certify every year that Pakistan did not possess nuclear weapons, and to withhold all military and economic assistance to Pakistan if this presidential determination were not given. But in pursuit of its own objectives in Afghanistan, where Pakistan's sustained cooper- ation was critical, successive US administrations were happy to provide the required certification and thus ease sanctions against Pakistan. The PAF added forty F-16s equipped with state-of-the art avionics and weapons to its force structure. This acquisition restored the technological parity between the IAF and the PAF, albeit briefly. The IAF's response was

immediate: it introduced fifty-one high-tech Mirage 2000s; these planes, together with the over fifty advanced Soviet MiG-29s already in its inventory, increased the number of high-tech aircraft in the IAF to over a hundred.

With the powerful Soviet Air Force operating next door in Afghanistan, safeguarding the country's western border became a daunting task and required the PAF to remain on constant alert. The Afghan Air Force, supported by the Soviets, was carrying out unchallenged operations against the Mujahideen fighters across Afghanistan, right up to the country's border with Pakistan. Frequent incidents of airspace violation by both Afghan and Soviet aircraft presented a dilemma: to allow such violations to go unchallenged would have been taken as a sign of weakness, while an aggressive response would be equally problematic because that could give the Soviets an excuse to launch full-scale aggression against Pakistan. The PAF therefore instituted very stringent rules of engagement, stipulating that pilots should engage an intruder only on condition that if the aircraft were shot down, the debris would fall clearly within Pakistani territory.

Pakistan's air defence orientation was primarily designed to counter the threat from the east, with very limited capabilities to detect and intercept low-flying intruders from the west. The nation therefore undertook a major realignment of air defence assets and deployed a sophisticated Air Defence Ground Environment in the north-west of the country. Along with the newly introduced F-16s, the PAF now had the assets in place to respond to the threat from the west.

This redeployment had the desired effect because it soon became evident that Afghan and Soviet aircraft and gunship helicopters were exercising caution when operating close to the Pakistani border. But in some instances they did stray into Pakistani airspace, and while usually they would be forced to flee across the border there were occasions when intruding aircraft were engaged and shot down by PAF interceptors. During the period of Soviet occupation of Afghanistan, PAF pilots were credited with eight confirmed aerial kills, which included the shooting down of an SU-25 Frogfoot flown by Colonel Alexander Vladimirovich Rutskoy – a renowned Russian pilot who held the high professional status of an 'inspector of SU-25s' (Rashid 2000). To its credit, the PAF did not lose a single aircraft to enemy action, which reaffirmed the combat skills of its pilots. However, because the PAF had to maintain a continual high state of alert for over six years, the meagre resources of the service became severely overstretched.

By 1990, the Soviet Union had been forced to withdraw all its forces from Afghanistan and keeping Pakistan as a key military ally for the US was no longer an imperative. The US again imposed embargoes in 1990 because, it was charged, Pakistan had acquired nuclear weapons. US officials must have been aware as far back as 1985 that Pakistan had succeeded in manufacturing a uranium-fuelled, implosion-type nuclear bomb, but successive administrations thought it expedient to conceal this knowledge from the US Congress for as long as Pakistan's role in defeating the USSR in Afghanistan was considered essential.

The period from 1990 to 2002 presented a challenge for the PAF. It suffered a double blow: a national economy that could not support the PAF's modernisation plans and a stifling embargo that prevented acquisition of weapons essential to match the IAF's increasing offensive potential.

By the mid-1990s, the F-16 fleet was more than a decade old, while the Mirages and the F-6s that formed the bulk of the PAF's inventory had already been declared obsolete by other countries. The introduction of the Chinese F-7 fighters (a variant of Russian MiG-21s) allowed the PAF to finally retire the aging F-6s, but this was only a partial solution. The PAF was urgently seeking to modernise its fleet but the US embargo made it impossible to acquire additional F-16s, whereas later generation fighters (possible candidates being the French Mirage 2000-5, Rafale, and the Swedish SAAB JAS 39) were either unaffordable or not obtainable

because of the embargo. The PAF had to find a way to remain a viable force. It therefore upgraded the Mirages and F-7s with improved airborne intercept radars and suites for electronic countermeasures. Incorporation of forward-looking infrared (FLIR) and night vison goggles in a specific number of Mirages upgraded them to all-weather strike platforms. The F-7 fleet was similarly retrofitted with basic airborne intercept radars, defensive electronic suites, and more effective air-to-air missiles. These improvements notwithstanding, the lack of beyond visual range (BVR) air-to-air missiles remained a handicap – one that the PAF was unable to redress during this period.

The PAF in the twenty-first century

The events following 9/11 were a watershed in world affairs which had a profound impact on Pakistan. When the US invaded Afghanistan in October 2001, Pakistan once again became an ally, albeit a reluctant one. The US resumed economic and military assistance and the supply chain for the F-16 fleet gradually reopened. Pakistan's request for additional F-16s, especially the Block 52 version, was hotly debated within the US government and after nearly a decade of stonewalling approval for their release was at last given in 2011.

The post-9/11 conflagration in the west assumed perilous dimensions for Pakistan and the possibility of a genuine two-front threat started to emerge. US Operation Enduring Freedom swiftly ousted the Taliban government from Kabul but could not eliminate the Taliban force, which melted away into the mountains and took refuge in Pakistan's tribal belt, with the largest concentration in South Waziristan. Exploiting their ethnic affinity with the Pakistani Pashtuns, the Taliban were soon able to regroup and prepared to launch an offensive against what they deemed as 'foreign occupation forces' in Afghanistan.

The attack on the Indian parliament in December 2001 by a group of non-state actors created war hysteria in India. The Indian armed forces were mobilised and positioned on the Pakistani border, poised to launch an offensive. The PAF response was swift: it went on a war footing. The eyeball-to-eyeball confrontation lasted for more than nine months and eventually India backed down. The operational readiness and the total commitment of the PAF, the Pakistan Army and Pakistan Navy to meet any military aggression head-on was one of the factors that deterred India from initiating military aggression.

When the US military focus shifted from Afghanistan to Iraq in 2003, the Taliban seized the opportunity and launched offensive operations in Afghanistan from its base in South Waziristan. To deny sanctuaries to the Taliban, a land/air campaign codenamed Operation Al Mizan was launched in South Waziristan in 2004. But this type of warfare – variously termed sub-conventional, asymmetric, irregular, or fourth-generation warfare – was unfamiliar to both the Pakistan Army and the PAF. Their training, composition and strategy until then had been structured to fight a conventional force. For the PAF it was a steep learning curve. It became clear that counter-insurgency (COIN) operations must not be viewed as a 'dumbed down' version of air operations in a conventional war. The lessons helped the service develop a doctrine and strategy for future COIN operations.

The campaign ended in a stalemate, but it did precipitate the creation of the Tehreek-e-Taliban Pakistan (TTP), a syndicate of militant groups that since then has engaged in a full-scale insurgency against the Pakistani state. The PAF conducted some relatively small-scale air operations – Operations Tri Star, Falcon Sweep and Rah e Haq (2008) – against the insurgents in which these new concepts were tried, tested and further refined. By the time another major operation in the Swat Valley became necessary in 2009, the PAF had acquired a fair degree of competence in conducting sub-conventional warfare (Hussain 2012a, 2012b).

Pakistan launched Operation Rah-e-Rast (the Righteous Path) in May 2009 to evict militants from the Swat Valley after the area had been virtually occupied by the TTP and its people made hostage. The PAF provided critical support to the Pakistan Army in achieving mission objectives in record time and with minimum casualties. Helped by accurate intelligence and effective aerial reconnaissance, the PAF could reliably fix position of the elusive TTP elements. Air attacks using precision-guided bombs paved the way for the ground troops to advance. Specially modified aircraft streamed live video coverage of the battle zone to the land commanders and combat planes maintained a continuous presence over the battlefield to provide instant close air support. The F-16 fleet undertook the bulk of these operations and proved invaluable in uprooting and eventually defeating a mobile and well-entrenched enemy. Pakistan's armed forces adopted extreme measures to avoid collateral damage or keep it to a bare minimum; whenever they learned that militants had taken shelter among civilians, air attacks were called off. In such situations, it was jointly agreed that ground forces would assault militant positions without air support, accepting higher casualties but avoiding collateral damage (Hussain 2012a, 2012b).

A similar operation became necessary in South Waziristan and Operation Rah-e-Nijat (Path to Salvation) was launched in October of the same year. The PAF again played a key role in the success of the campaign. After Rah-e-Rast and Rah-e-Nijat, the PAF continued to maintain its war readiness by carrying out aerial reconnaissance, surveillance and quick-reaction ground attack missions against time-sensitive targets (Irfan 2009).

Successes in Operations Rah-e-Rast and Rah-e-Nijat helped ease some US criticism of Pakistan for not doing enough against the Taliban forces. The older F-16s, the mainstay during COIN operations, had performed well, but these aircraft lacked night ground attack capability, which allowed the Taliban a small window to move forces in the dark. To offset this handicap, the PAF requested the US to release the all-weather Block 52 model of the F-16. After much debate and deliberation, a batch of Block 52 F-16s was released in 2011, while the older Block 15s in service with the PAF were given a mid-life upgrade and brought up to par with the Block 52 models.

The long-standing need of the PAF to equip its fighter aircraft with BVR missiles was finally met with the delivery of Advanced Medium Range Air-to-Air Missiles (AMRAAMs), thus giving a qualitative boost to the PAF's air combat capability. In the meanwhile, the first lot of JF-17 Thunder multi-role fighter aircraft, jointly developed with China, was introduced into the PAF's operational fleet in 2010 (Hashmi 2014). These aircraft initially replaced the ageing A-5 Fantan strike platform; increased JF-17 production has enabled the PAF to replace five of its F-7P squadrons with the far more capable JF-17s.

The limited range of its ground-based radars had always been a weak link in the PAF's Air Defence Ground Environment. Critical lines of communication and vital assets situated close to the border were always vulnerable to shallow penetration attacks because the PAF had little or insufficient early warning of intruding enemy aircraft. This shortcoming was finally redressed with the acquisition of Airborne Early Warning and Control (AEW&C) airplanes that made it possible for the PAF's air defence system to look deep inside enemy territory. A combination of AMRAAM-equipped F-16 interceptors and BVR-capable JF-17s operating in coordination with AEW&C platforms and air-to-air refuellers, along with improved surface-to-air missiles and the experience gained in countering the Soviets (in Afghanistan) and suppressing the TTP insurgency, has given a significant boost to the PAF's operational capabilities. The service is battle hardened and ready to face any future eventuality with confidence.

Pakistan launched Operation Zarb-e-Azb (Sharp and Cutting Strike) in North Waziristan in 2014 to eliminate the residual terror network. The PAF was once again at the forefront,

achieving remarkable success in destroying militant positions and heavily fortified hideouts deep inside mountainous terrain. The bulk of these missions were flown by the Block 52 F-16s, but with the older F-16s returning to operational status following their midlife upgrade the workload is now being proportionately shared by both versions of the aircraft. While Pakistan has achieved the major objectives of Zarb-e-Azb and effectively expelled the insurgents from the area, the militants have taken shelter in neighbouring Afghanistan and continue to pose a threat to Pakistan's national security.

Efforts towards self-reliance

In its formative stage the PAF was totally dependent on foreign sources to fulfil all its operational needs. The first tentative step towards self-reliance in the PAF was the founding of the Pakistan Aeronautical Complex at Kamra in 1971. Initially the PAF undertook engine and airframe overhauls and major inspections of the service's combat fleet (F-6s and Mirages). The scope was subsequently expanded to include aircraft manufacture when Pakistan undertook the production under licence of an improved version of the Swedish SAAB Safari, a piston-engine, fixed-gear, fully aerobatic basic trainer, launched as Mushak MFI-17. Subsequently the basic model was redesigned with a more powerful engine, a glass cockpit, and other advanced features and renamed the Super Mushak MFI-395 (Hussain 2012a, 2012b). Super Mushaks currently form the backbone of the basic flying training wing at PAF Academy Risalpur. Many have been exported to several other air forces.

Building on the Mushak experience, Pakistan Aeronautical Complex Kamra in conjunction with China designed and co-produced a jet trainer (K-8) that currently complements the T-37 fleet at the PAF Academy and has replaced the ageing MiG-17s as an advanced jet trainer. Pakistan initiated steps to manufacture a modern fighter plane in the 1990s, again as a joint venture with China, and within two decades JF-17 Thunders were designed, tested and declared operational. The introduction of JF-17s is in full swing to replace the A-5s and the F-7s. Plans for co-production of the next generation of fighters are already on the table.

Nation-building role of the PAF

While military power safeguards a nation's present, literacy and quality of education determine its future. Besides fulfilling its core duty to defend the aerial frontiers, the PAF has been actively pursuing projects that directly contribute to nation building. Vocational and technical training, health, education and integration of youth from under-developed regions are a few areas, among others, on which the service focuses.

The PAF's sound technological base and high standards of training enable it to support and promote government technical and vocational training programmes. The PAF does so by providing qualified instructors, materials, equipment and training assistance, in addition to establishing new institutes in small cities and remote areas of the country such as Badaber, Nawabshah, Jacobabad and Gilgit Baltistan. It is also extending full support to highly reputed organisations in developing extensive welfare projects that include establishing boarding/day schools as well as health and vocational training facilities. Besides serving the basic needs of the people living in nearby underdeveloped areas, these projects help promote national harmony and a sense of patriotism.

The PAF is also pursuing establishment of an 'Aviation City' with an aim to enhance Pakistan's national capacity in cutting-edge technology related to the field of aviation and other

sciences, along with providing strong linkages to public- and private-based avionics- and electronics-based industries in the country. The effort would serve to strengthen the aviation industry while creating opportunities for the private sector to contribute in this important domain. The PAF has extended its role in nation building by selecting candidates from rural and remote areas and providing them with requisite awareness and training for their induction into the service.

Conclusion

Ever since its inception in 1947, the PAF has been nurtured and configured to counter threats from India. Its doctrine, strategy and training were driven by an India-centric approach. The centre of gravity of the service has always been its fighter fleet and its doctrine was formulated with the objective of developing a capability to create and maintain superiority in air combat (Hussain 2005). Recognising that it would always be heavily outnumbered in future conflicts with its principal rival India, the PAF evolved a strategy to establish and sustain air superiority over the battlefield and its own territory. Ignoring the Douhet/Trenchard/Mitchell air power doctrine that gave primacy to bombers, the PAF drew inspiration from the lessons of the Battle of Britain in which the RAF fighters saved the day and won the battle (Hussain 2005).

Although achieving and maintaining air superiority in defined areas remains the cornerstone of the PAF's doctrine, ground attack operations have become an integral part of this doctrine, although they are limited to interdiction, airfield strikes and close air support missions for the army and navy. With the introduction of nuclear weapons in the region, strategic strikes are now a part of the full-spectrum nuclear deterrence in which the PAF has a key role.

The nature of the threat in the region experienced a major transformation near the end of the twentieth century. Although the nuclearisation of South Asia introduced an extremely dangerous element into an already volatile threat environment, it also altered the balance of power, to an extent negating the numerical disparity Pakistan faces against India, its arch adversary. While strategic parity between South Asia's traditional rivals reduced the possibility of a full-scale war, sub-conventional war waged by non-state actors emerged as a new threat to global peace. An insurgency perpetrated by religious extremists such as the TTP is essentially based on a toxic ideology that enjoys some sympathy among a section of the population. The PAF is fully aware that the task of defending the country against threats from groups such as the TTP is far from over, and well understands the imperatives of being prepared to continue COIN operations over an extended period.

As the PAF approaches completion of seventy years, it can justifiably take satisfaction from knowing that it has developed into a battle-hardened and well-trained tactical air force. For over a decade now the service has been fully committed to the war against the TTP and its affiliates without compromising its deterrence posture against the traditional threat from the east. But it has paid a price as COIN operations use much of the valuable air assets essential for maintaining conventional deterrence. Given the size of the national economy, and the many competing demands on the country's limited budget, replenishing resources expended during COIN operations is often a difficult and slow process.

With regard to the future, the F-16 and JF-17 fleets will probably remain the mainstay of the PAF for the next five years. The threat environment is not expected to change, which means the service is likely to maintain its current operational doctrine. Indigenous production of armed drones of the Predator/Reaper class is a much-anticipated development, as these would prove to be an invaluable asset in COIN operations and would also help to reduce the current

burden on the F-16 fleet. Finally, the service would continue striving to attain the highest degree of professionalism in all aspects of air operations, especially in the art of air combat, by implementing a realistic and robust training regime. The survivability of the PAF against an adversary vastly superior in numbers will largely depend on its ability to out-think the enemy in strategy and to out-fight the enemy in the air. This is the creed by which the PAF swears and lives.

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29
BRAZILIAN AIR POWER

Carlos Eduardo Valle Rosa

This chapter introduces some major themes about the Brazilian Air Force from its origins to the present day. It focuses on the technological background obtained since the creation of the Air Force and on the build-up of a reliable national aeronautical industry. One of the important themes covered in the essay is the meaningful defence restructuring that Brazil underwent during the 1990s. At that time, Brazil united all of its armed forces under a single government ministry. This demanded some internal reorganisation of the Air Force that is still in progress. Most of the benefits from the resulting joint mentality came from exercises and operations, both producing new understanding of professional military education and, especially, of airspace doctrine. These events, coupled with a low defence budget, generated challenges for the Air Force: not only to development of new capabilities, as expressed in the defence and doctrine documents, but also to the adaptive characteristics required for airmen, who truly represent the 'force' inside the Air Force.

Historical context

On 23 October 1906, a Brazilian-born engineer and inventor, Alberto Santos-Dumont, took off from Bagatelle Field, in the suburbs of Paris, in the '14-Bis' – a tiny wooden and silk-made airplane, flying just about sixty metres. This scene was witnessed by no less than a thousand spectators. On the following 12 November, another flight of 220 metres, at a height of approxi - mately six metres, lasted for twenty-one seconds and reached a top speed of 41.3 kilometres per hour (INCAER 1988: 325), definitely perpetuating the achievement in the history of flight.

Although Santos-Dumont was Brazilian, the first self-propelled and heavier-than-air machine did not take flight in Brazil until 1910. In 1915, Brazil made its first attempt to use an airplane as an instrument of air power in military operations, during a seditious movement in one of the states of the Federation. Lieutenant Ricardo Kirk armed three Morane-Saulniers with bombs in order to fight the separatists (ibid.: 425–427).

During the First World War, the Brazilian Army and Navy took different approaches in dealing with air power. In 1917, the Brazilian Army sent two lieutenants to the French Aéronautique Militaire to learn how to start its aviation branch in Brazil. The Navy, by contrast, assigned some pilots to train with the Royal Naval Air Service. Subsequently, they flew maritime patrol missions with the Royal Air Force 10th Group in Plymouth (ibid.: 433–434).

In the 1920s and 1930s, aviation expanded in Brazil, and aircraft started flying inland, connecting the cities on the coast with smaller villages in the countryside. This task became the *raison d'être* of military aviation. Nevertheless, in 1932 another seditious movement saw air power used as an instrument of political force on both sides. At that time, the number of available aircraft was larger, and aerial combat, reconnaissance, photography, air–ground attacks, and even the dropping of propaganda leaflets were the main missions carried out by both belligerents.

In January 1941, the Brazilian government decided to unite Army and Navy aviation into one organisation, thus creating the Brazilian Air Force (BAF). This was not an easy task, due to divergent previous experiences, doctrines, equipment, purposes, training, and logistics. In 1942, facing political pressures from both the Americans and the Germans, Brazilian President Getúlio Vargas decided to join the war effort on the side of the Allies. Therefore, in August, the country declared war against the Axis, amidst a submarine campaign that sank cargo ships along the coast of Brazil. In less than two years, the BAF had to deal with all the problems of integrating the Army and Navy cultures of flight, fighting against submarines, and fighting on the Italian Front.

The Second World War saw the BAF's baptism of fire in three different contexts. The first and most famous was the 1st Fighter Squadron (1st FS), the 'Senta a Púa'. The unit flew P-47 Thunderbolts during 1944 and 1945, supporting the North American 5th Army in its fight against German forces in Italy. The squadron flew 2,550 individual missions, without pilot turnover, reaching a total fighting time of 5,465 hours and destroying roads, railroads, bridges, vehicles, military buildings, and related installations in an effort to interdict German supplies to the front.

Along with the 1st FS, Brazil sent the 1st Observation and Liaison Flight, the 'Olho Nele', assigned to the Brazilian Expeditionary Force, which focused mainly on artillery fire control but also observation of battlefields and liaisons. The third real action the BAF saw during the war consisted of hunting for Italian and German submarines along the Brazilian shoreline in a combined operation with the American Navy maritime patrol aircraft. From 1941 until Brazil's official engagement in the Second World War, records accounted for about fifteen actions against ships throughout the area of operations (Lavenère-Wanderley 1975: 253–254). During the war, enemy actions continued, and more than one thousand Brazilian sailors died due to torpedoing by enemy submarines.

All of these experiences triggered the need for a drastic change in doctrine after the Second World War ended. As a huge country, with insufficient roads or railroads, Brazil has needed airplanes since the 1920s to reach the immensity of the mid-western and Amazon regions, which were totally isolated from the main cities and the capital. At that time, airplanes played the main role in transporting supplies, medicine, mail, injured people, and all kinds of logistics to the villages and tribes inland. They landed on rivers and rudimentary airstrips, flying without any navigation devices except for a compass. Sometimes the pilots had to perform the same journey by land first in order to build the facilities to make aircraft operation possible.

The war experience also resulted in the improvement of crew operational readiness. Brazilian pilots gained a new perspective on air power. Flying the best aircraft available, operating on-board equipment never seen before, dealing with state-of-the-art techniques, fighting enemies with advanced military material, and flying real war missions alerted them to the importance of technological advantage in war. Therefore, immediately after the Second World War, officers with this insight took the initiative to share their experience, created a school to disseminate doctrine, and developed a technological centre to conduct research on air power. In 1950, the Aeronautics Technical Centre started what would be the embryo of

today's largest airspace complex in Latin America, hosting aircraft factories, research institutes, and universities focused on air- and space-related curricula.

Since the end of the 1960s to the present day, the BAF has acquired foreign aircraft and simultaneously operated indigenously produced aircraft, such as the EMB-326 Xavante and the EMB-110 Bandeirante, products of Aeronautics Technical Centre initiatives. The Brazilian Aeronautic Company EMBRAER began its successful route towards becoming one of the leading aerospace companies in the world. Recently, a volatile economic situation, ranging from two-digit inflation to moderate stability and, once again, to times of uncertainty, as seen in late 2015, brought financial instability to the military budget, especially to projects and investments.

Due to all of the above-mentioned conditions, Brazilian airspace power has assumed the distinctive characteristics of research and adaptability as priorities in its development. Santos-Dumont, who made aircraft a synonym for science, was the inspiration with his technology-driven personality. Through the need to master creativity to adapt to many circumstances, as in the Second World War, and because of budgetary restrictions, the BAF still fights to consolidate itself as an Air Force with high performance standards, operating indigenous products and with the prospect of being a peer to the leading air powers of the world. To better understand these issues, the next section analyses the present and near future of defence and the BAF's organisation.

Ministry of Defence

In 1999, the creation of the Ministry of Defence placed the Brazilian Armed Forces under the direct control of a civilian authority in charge of the defence budget, joint operations, joint doctrine, and strategic programmes. Until then, the BAF had to deal with these matters independently. From then on, the BAF needed to improve its political connections and policies while narrowing its differences with the Navy and the Army.

The Ministry of Defence brought positive changes, which resulted in the issuance of political and joint documents for the first time. This was the case of the National Defence Policy (NDP), the National Defence Strategy (NDS), and the National Defence White Book. In the doctrine field, the Ministry of Defence released manuals about joint employment of the armed forces, such as the Defence Military Doctrine and the Joint Operations Doctrine.

The NDP and the NDS appeared after a change of concept stemming from the increase of the Armed Forces' roles in internal security during the insurgencies of the 1960s and 1970s. The NDP now connects defence with development, defining Brazil's surroundings as a 'relatively pacific' area (BRASIL 2013a: §4.1). According to the policy document, air power's task is to maintain the capacity to survey, control, and defend jurisdictional airspace (ibid.: §7.5). The NDS details the topics covered by the NDP, declaring Brazil as a non-belligerent country and relating economic and social growth to solid preparation of its defence capabilities, following the trend of a concept change in defence. Beyond that, the NDS only saw meaning in a strategy for defence if that strategy were directly connected to a strategy for development (BRASIL 2013b: 1). This should be regarded as a key distinctive characteristic because the country always relates project development to technology transfer, some kinds of spin-offs to national industry, or indigenous participation in the engineering phases of product build-up.

Airspace became one of the priorities in the NDS, along with the cybernetics and nuclear sectors. The document advises the Armed Forces to focus on certain capabilities, such as operational readiness, interoperability, 'jointness' and projection of force (ibid.: 33). The NDS

directed the BAF to take charge of pursuing four strategic objectives: improvement of airspace surveillance, achievement of some desired control of the air, provision of mobility to support surface forces in need of deployment, and development of a strategic strength not focused on a specific enemy but on established capabilities (ibid.: 16–17).

The National Defence White Book follows the traditional defence white papers of other nations, describing the strategic environment, the Armed Forces as a national instrument of military power, their relationship to society, and defence budget expenses. It serves as an exhaustive source of information about defence in Brazil never before seen in an official document. According to the White Book data, Brazil is among the ten largest countries in the world in terms of its gross national product (GNP) versus defence expenditure relationship, with a rate of 1.5 per cent (BRASIL 2013c: 226). Importantly, this rate includes 75.3 per cent of salaries and annuities, leaving only 10.6 per cent to investments (ibid.: 229). The BAF accounts for 25.1 per cent of the total defence budget, with an average of US$739 million available for investment from 2006 to 2011 (ibid.: 228, 232).

The other category of important documents generated after the creation of the Ministry of Defence consists of doctrine manuals. The first one that deserves mention is the Defence Military Doctrine, first issued in 2001. Since the BAF's creation, the Armed Forces had operated without a common doctrine. After the issuance of the doctrine, this problem was greatly reduced. Perhaps the Defence Military Doctrine's greatest contribution was the clear subordination of war to politics (BRASIL 2007: 22), following Clausewitz's tradition. Given the BAF's history as a protagonist in military interventions to stabilise situations of socio-political turmoil, this presented a great challenge to the institution, now under civilian political control.

The Joint Operations Doctrine (BRASIL 2011a) explains how the Brazilian Armed Forces deal with joint operations. The three-volume document describes all the processes of planning and conducting military operations, from the strategic to the operational levels of decision-making. With fundamental guidelines provided by the documents discussed above, the BAF could follow the path to its organisation and capability building.

Brazilian Air Force

BAF activities fall into two main categories: preparation and actual force employment. They are coordinated in order to avoid continuity problems when peace deteriorates into a crisis or even war. Preparation comprises 'permanent planning activities, budget, intelligence, logistics and mobilisation, research and development, education and training, doctrine and operational evaluation', and employment involves 'command and control during a campaign or military operation' (BRASIL 2012a: 40–41).

According to the BAF's basic doctrine, 'airspace power' must have some 'essential capabilities', following a connection with the NDS. Therefore, it must 'dominate the airspace environment', be able to 'control the information in the battlefield', act with 'readiness, mobility and precision', provide 'appropriate logistics and timely sustainment', and 'protect combat power' (ibid.: 42–44).

To develop these capabilities, the BAF's squadrons follow specific flight programmes, allowing pilots to acquire the skills necessary to be declared combat ready in their respective fields of specialisation. Air bases have the function of supporting the squadrons stationed at and possibly operating in the aerodrome. Their area of responsibility should include force protection, anti-aircraft defence, air traffic control, engineering, transport, and all kinds of aerial operations support. In 2016, the BAF started a major restructuring programme, creating 'wings' to coordinate the squadron's activities and a 'Preparation Command' with higher level

responsibilities for issuing doctrine, evaluating performance, and planning for the long term (Rossato 2016: 8–11).

Whenever a crisis escalates and the necessity to employ air power arises, the Brazilian Airspace Defence Command, which will be called Airspace Operations Command after the restructuring programme, exercises authority in planning and conducting airspace operations, acting as a 'Combatant Command'. The Brazilian Airspace Defence Command constitutes the core of the Brazilian Airspace Defence System, which is responsible for providing twenty-four-hour quick-reaction alert on surveillance, air interception of non-cooperative flights into or throughout the country's airspace, and anti-aircraft artillery defence in sensitive points or areas. As part of the Brazilian Airspace Defence Command structure, the Joint Air Operations Centre is responsible for delivering 'essential capabilities' in the context of combined, joint, or independent military operations. The Joint Air Operations Centre holds the authority to plan and conduct air warfare and, in times of peace, to execute air policing measures against illicit traffic, mainly small aircraft smuggling contraband across the borders.

The Brazilian Airspace Defence System is not a typical airspace defence system, because it operates alongside another system: the Brazilian Airspace Control System, which ensures safe navigation to all civilian flights inside the country's jurisdiction areas. This structure is unusual, demanding an adaptive process to promote full integration between the Brazilian Airspace Control System and the Brazilian Airspace Defence System. To achieve this, the concept of operations encompasses both systems operating in the same physical structure, with common procedures and intensive partnership in training and employing personnel with the same levels of experience.

Recently, the BAF established the Space Operations Centre, designed to operate satellites and gather information from devices in outer space. The Space Operations Centre has not only 'satellite pilots' but also the capability to provide situational awareness, trustworthy communications, and timely intelligence to the Joint Air Operations Centre in times of war. The Space Operations Centre will probably have to integrate itself with both previous systems in order to exploit all available functionalities. Adapting to achieve such capabilities in its daily routine, the BAF prepares itself to employ air power in some exercises and operations, keenly aware that this is the best way to meet its goals in the context of the peaceful Brazilian environment.

Joint and combined exercises and operations

Due to the national economic crisis of 2015, the BAF's budget suffered a dramatic cut. Indeed, since 2000 the BAF has been reducing flight hours from 150,000 to an average of 100,000 hours per year (Monteiro 2016). From 2000 to 2011, the BAF's total expenditure of government funds oscillated around US$728 million (BRASIL 2013c: 231). To respond to such a reality, meticulous application of resources and carefully planned training must be aimed at acquiring the needed 'essential capabilities'. The operations and exercises represent one way to reach this objective. In doing so, the BAF and the air power available in the Army and Navy must work together to improve interoperability towards creating a synergistic way of increasing strengths and reducing weaknesses.

The Brazilian Navy is trying to increase its aviation operability. The AF-1 (McDonnell Douglas A-4 Skyhawk) can operate from an aircraft carrier, providing the fleet with air defence and anti-surface capabilities. The Navy is seeking to expand fixed-wing carrier aviation (although it recently decommissioned its only aircraft carrier), focusing on one platform capable of airlift, airborne early warning, and air refuelling. The helicopter force, a more developed branch of Navy aviation, comprises aircraft such as the Sikorsky SH-16 Sea Hawk and the

Westland Lynx Mk.21 to perform anti-submarine warfare, naval surface attack, and search and rescue tasks.

Until now, the Army has only had helicopters devoted to air-mobile operations, infiltration of hostile territory, and support to ground operations such as close air support. For those purposes, the main equipment includes the Eurocopter AS365 Panther and the AS532 Cougar, alongside the Sikorsky S70A Black Hawk. According to the Army strategic perspective, the Army needs to acquire fixed-wing aircraft (BRASIL 2014: 53), possibly to airlift supply and personnel in the Amazon region.

Recently, the Brazilian government signed a contract with HELIBRAS (the Brazilian helicopter industry) to provide the EC725 to the Armed Forces in specific versions. Since 2010, some units, from the fifty originally requested, are operating in the Navy, Army, and Air Force. From the total purchased, Brazil will produce forty-seven, with the technology transferring to the national helicopter industry.

Joint exercises

Since the creation of the Ministry of Defence, joint exercises have become routine for Brazilian Armed Forces training. This process in theory starts with strategic-level planning, under Joint Chief of Staff coordination, following the political guidance issued by the President of the Republic for a predetermined hypothesis of conflict. These exercises can create a strategic plan to deal with a humanitarian crisis or even a major event such as the FIFA World Cup. The Joint Operations Doctrine provides the methodology for the planning cycle. Later on, the President of the Republic designates a Joint Command to execute the operational-level planning, focused on achieving the course of action that will reach the desired end state with least cost and risk (BRASIL 2011a). During the process, air power generates its air campaign, integrating itself into the joint campaign. Usually in the subsequent year, real-life exercises centred on the hypothesis take place to check the planned solutions and improve the plans. Following this methodology, air power participates in all of the joint exercises. Each scenario raises specific problems for the BAF to deal with. The main scenarios take place in the Amazon and the Atlantic – both enormous areas that contain natural resources of great economic value.

The 'Amazon exercise' covers a huge area with limited support and infrastructure. Thus, since the 1980s the BAF has installed two new air bases, built three deployment aerodromes, and performed engineering work on some rough runways, giving them the capacity for jet airplane operation. In keeping with this effort, the reallocation of some squadrons to the area, especially fighters, complemented the airlift and helicopter presence in the region, both historically operating in the area in support of the Army's deep and isolated jungle battalions.

The 'Atlantic exercise' presents very different air power challenges. Brazil has a shoreline of more than 7,000 km and some clusters of islands, such as Fernando de Noronha. Air power provides maritime patrol capability with the P-3M Orion, equipped with sensors of all kinds and armament such as the Harpoon air–surface missile and torpedoes. One challenging demand on the BAF is the search and rescue mission throughout the Atlantic Ocean, an area of responsibility that encompasses more than 13 million km^2.

Joint operations

The BAF naturally delivers capability improvements from exercises to operations. The hypothesis posed at the strategic level sometimes becomes real, and the government calls upon the BAF to apply its capacities in the context of a joint operation. The 'Ágata Operations',

conducted since 2011, have the objective of obstructing drug trafficking and the smuggling of guns and all kinds of illegal products. While trying to prevent and impede transnational crimes along the extensive dry land international borders, the BAF increased its participation in these operations. The number of Air Force personnel grew from hundreds to thousands. Involvement of aircraft, such as the A-29 (EMB-312), the E-99 (EMB-145 AEW), and the R-99 (EMB-145 Multi Intel), and the unmanned aerial vehicle RQ-450 (HERMES 450), among others, is increasing. Although guaranteeing law and public order is a subsidiary action, 'Ágata Operations' gave the BAF some opportunities to achieve goals such as improving airspace dominance by executing real air policing missions through the bombardment of illegal airstrips in the Amazon jungle, and testing the investments made in deployment airbases and runways during real operations. Particularly in these types of operations, the A-29 and the AH-2 Sabre (Mi-35M) have proven superb platforms to gain air superiority against small aircraft and undertake interdiction missions.

The United Nations Stabilization Mission in Haiti (MINUSTAH), another real operation, demanded an unprecedented airlift effort by the BAF. Especially after the 2010 earthquake, C-130 and KC-137 aircraft flew extensively to Port au Prince. Over several months, the BAF flew more than 4,000 hours, an amount sometimes planned for an entire year of operation.

The large international events hosted by Brazil, such as the FIFA World Cup and the Olympic and Paralympic Games, represented another kind of real operation, and offered special occasions to improve the BAF's capabilities. In 2016, with the integration of the Brazilian Airspace Defence System and Brazilian Airspace Control System, the BAF created aerial clusters above the game arenas in Rio de Janeiro. In these restricted areas, flights occurred only under special procedures, with the purpose of achieving full airspace environment dominance. Over the months of the games the BAF gained some experience in a difficult environment constantly scrutinised by the international media.

Both 'Ágata' and the games gave the BAF opportunities to improve interagency operations, due to the need for coordination among aerial services, from Federal Police, State Police, civil defence, and many event-related agencies. Interaction among the agencies occurred through coordination of the use of airspace and intelligence support. With the Federal Police, the BAF conducted aerial surveillance to provide information about smuggling along the land frontier and about the terrorism threat. With the State Police, the BAF collaborates in actions against common urban crimes.

BAF combined exercises

The BAF's main reason to conduct international exercises is to develop Air Force capabilities. The BAF hosts and is invited to participate in some important air power training activities. Among the hosted ones, the most significant is the 'Cruzeiro do Sul Exercise' (CRUZEX). This exercise, indeed, represents a change in the BAF's doctrine towards a NATO way of aerial warfare. The command and control process, encompassing air missions, air tasking orders, effects-based operations, centres of gravity, John Boyd's OODA loop, and John Warden's Five Rings system, among other concepts, has become common since the 2004 CRUZEX edition. Not only Brazil's South American neighbours but also air forces from France, the United States, Canada, the United Kingdom, and Sweden joined command post and real flight exercises. The exercises centre on scenarios involving aerial exclusion zones, land and maritime surface attacks, aerial combat, air refuelling, air early warning, combat search and rescue, and airlift infiltration, not to mention staff duties such as planning, issuing of air operations directives, psychological operations, and day-to-day interaction with the media.

The BAF also participates as a guest in international exercises such as 'Salitre', 'Cooperación', 'Red Flag', 'Maple Flag', 'Joint Warrior', and 'Air Mobility Rodeo'. The lessons learned from these experiences became essential to improving BAF pilots' basic skills, flight procedures, and air tactics. Flying with air forces that have real combat experience, as happened during the Second World War, became an extremely valuable tool to improve professional military education (PME) and doctrine, which will be discussed in the next section.

Airspace power PME and doctrine

Enrolment in the Air Force Academy is the only way to become a BAF pilot. Candidates must pass a nationwide exam and a specific pilot evaluation test. Predominantly people from the south-eastern region enter the Air Force Academy. This results from the economic and social development of that region, and because of a large historical concentration of military personnel in air bases, squadrons, and other BAF organisations in the area, making it easier to spread aeronautical culture. Women have been permitted to fly combat aircraft since 2003. Over four years, cadets study management to obtain a Bachelor's degree. They fly indigenous aircraft – the T-25 Universal (made by the Neiva Aeronautical Industry) and the T-27 Tucano (EMB-312) – gathering around 150 hours of flight experience in all kinds of basic exercises, such as instrument flight rules, aerobatics, formation flight, and high- and low-level navigation.

After the Air Force Academy, pilots enter one of the operational specialisations in fighter, helicopter, maritime patrol, airlift, or reconnaissance aviation. In the first years, as lieutenants, they pass through progressive adaptations to new and more complex missions. During this phase, pilots have the chance to fly in one of the combined or joint exercises and operations. As captains they study at the Squadron Officer Course, developing not only operational curriculum but also higher level managerial skills. As majors they study 'jointness' and the planning of war in the Command and Staff Course. This stage also includes aerial strategy studies and some areas of strategic-level planning. The climax of the Command and Staff Course is a joint war game, played in selected scenarios with Navy and Army colleagues from similar courses. Since the 1990s, the BAF has increased the number of officers who have the opportunity to study abroad. The experiences brought back by these students, most of whom later become instructors at the schools, improve doctrine and the training curriculum.

During the PME process, one of the main subjects is the Air Force Basic Doctrine (AFBD). A brief analysis of the six versions already published during the BAF's history is worthwhile because of the influence they had when they were written and because of the way they direct how the Air Force should fight.

The first edition of this document appeared in 1958. In it the term 'air power' encompasses civil aviation, infrastructure, the aeronautical industry, and research institutes, which would progressively become a tendency in the following AFBD documents until the final shift to the concept of 'airspace power'. The content reflected the country's economic situation, industrial capacity, cultural level, aeronautical mentality (a clear influence of Alexander de Seversky), and geopolitical factors (such as Halford Mackinder's 'heartland' construct). The impact of technology on aviation, another topic in the 1958 edition, follows the perception of those Brazilians who fought in Italy and over the Atlantic Ocean. Air Force operations were classified as 'strategic', 'air defence', and 'aero tactical'. The first type of operation aims to gain control of the air and to neutralise and destroy the enemy's vital elements (following William Mitchell's propositions), including the enemy air force. The second type focuses on self-protection, and the last one on accomplishing theatre-of-operations objectives. The edition, largely a product

of the Second World War experience, exerted wide influence in generations of PME-trained officers, and another AFBD appeared only after seventeen years.

The second edition was issued in 1975. Air power now became 'airspace power', comprising the same elements as the latest version plus air and space installations and equipment. 'Space' became a new topic because of international influences, mainly the Cold War, and because of the first steps the BAF was taking in space exploration. The document covered distinctions among classical, revolutionary, conventional, and nuclear war. The 'revolutionary' war topic probably arose because of the Brazilian context of insurgency, not to mention the recent Vietnam War, and the logic of an operation to support police actions and military forces against irregular forces.

After a fifteen-year lapse came the 1990 edition, the simplest version of the AFBD so far issued. It contains fewer considerations about politics and war and omits the concept of airspace power. Matters regarding insurgency also vanished from the document. This edition established a new military structure but not yet the joint concept.

In 1997, the concept of airspace power re-emerged in the largest document, which was also the last one published before the creation of the Ministry of Defence. The AFBD linked the country's new constitution and other laws related to employment of armed forces. The concepts of 'centre of gravity', the levels of war (political, strategic, operational, and tactical), and joint operations appeared for the first time. The document gave importance to intelligence, logistics, and leadership in war, and introduced the concept of 'air warfare'. This edition also contained a detailed description of Air Force tasks and missions, as well as rules for operational planning.

The AFBD of 2005 was largely a revision of the prior version. For the first time, the document explicitly stated the 'mission' of the BAF. The document contained some new elements, including command and control, and a more detailed consideration of electronic warfare, information warfare, cyber warfare, and supporting activities, such as media relations, force protection, and air traffic surveillance. This edition was published after some feedback from joint exercises with the Navy and Army.

Finally, the current edition, issued in 2012, demanded some adaption to the changes that had taken place in the Ministry of Defence's related doctrines. It was also influenced by the BAF's international experience in exercises and PME. Now, airspace power became something war cannot disregard, especially given the political dimension of decisions in war. A clear evolution came when the traditional land-centric principles of war were debated through the airspace power perspective. However, the major change in this version was the new approach to air force functions: they became airspace power 'essential capabilities, tasks and actions', clearly linking the National Defence Strategy to the AFBD, the strategy-to-task continuum. The approach to 'essential capabilities' demands some refinement, and time to better understand the present and near-future contexts of the BAF's challenges.

Challenges

To keep moving technological and adaptive-driven efforts forward, the BAF is trying to reinforce the connections among the NDS, basic doctrine, and training in order to develop the capabilities required to deal with the realities of a 'peaceful environment', a huge landmass and extensive natural resources to protect, and budget limitations.

The first challenge is to acquire a credible capacity in airspace dominance. Recently, platforms such as the F-5E and the A-1 (EMB-AMX) underwent modernisation of avionics and weapon systems. The Mirage 2000, now decommissioned, substituted for the 1970s Mirage

III. With the former French aircraft, the BAF became familiar with the beyond-visual-range missile arena. Thus, the development of the A-Darter fifth-generation long-range air-to-air missile will give the BAF a differentiated capability. Along with this weapon, some others are in the final stage of assembly, including the MAR-1, an anti-radiation air-to-surface missile; the MAA-1, a short-range air-to-air missile; and the ACAUAN, a kind of GPS 'dumb bomb' guiding kit. Although some products are being developed in partnership, all of them will be produced entirely in Brazil.

However, the biggest capability in this area, improving both readiness and precision, will come with the Gripen NG contract. Swedish SAAB Corporate and Brazil signed an agreement for thirty-six units, with the first ones expected to become operational in 2019 (Fernandes 2016: 34–39). The new project will follow the BAF's specifications regarding weapon systems and will be produced, in a second stage, by EMBRAER. The BAF intends the multi-role fighter to replace all of its current fast jets. Together, these new platforms and armaments will permit the BAF to fight at parity for air superiority in highly demanding aerial scenarios with the capacity to strategically dissuade the enemy.

Another area of interest is control of information in the battlefield. An E-99 update is currently in progress. Changes will occur in the electronic warfare system, airborne command and control functionality, and aerial surveillance radar modernisation. To achieve full operational status, the BR-2 data link, developed indigenously, is in the final assembly phase. The link will connect all main combat aircraft with data exchange capacity. Recently, the BAF started to operate the RQ-900 (HERMES 900), a unmanned aerial vehicle with sensors and payload capacity, as a surveillance platform controlled by satellite. Some units are undergoing analysis on how to introduce weapon delivery systems on board this unmanned aerial vehicle.

The launch of the Strategic Communications and Defence Geostationary Satellite represents another major step in battlespace situational awareness. The satellite will use the 'Ka' band for government strategic communications and the 'X' band for the Armed Forces exclusive access (Plavetz 2016). Although the first Strategic Communications and Defence Geostationary Satellite will be launched by Arianespace, Brazil intends to have its own launch vehicle and space control centre. The 'Cruzeiro do Sul' programme presents a great challenge to Brazilian airspace power. The rocket launch vehicle Epsilon, already in the research phase, is projected to transport a payload of 4,000 kg into geostationary orbit (BRASIL 2011b: 136). Currently, the launch facility and the Space Operations Centre are undergoing final adjustments to become operational. Notwithstanding, to completely accomplish the space programme objectives, Brazil will need around US$3 billion in the next ten years to fund satellite development and manufacturing, building-related infrastructure, and space access projects (BRASIL 2012b: 16).

Mobility, one of the conditions for logistically appropriate and timely sustainment capability, is considered essential in Brazil because of the country's large dimensions. This will come with the acquisition of a strategic airlift fleet, which will be a heavy cargo aircraft ready for aerial refuelling, giving the BAF global reach. To provide an intermediate solution, one Boeing 767 is already in operation. But the real 'star' in cargo proficiency will be the EMBRAER KC-390. Designed entirely to meet a wide range of demands, especially the BAF's needs, this multi-mission transport aircraft is already in the second prototype stage. The concept of operations is to penetrate into enemy territory, drop paratroops, resupply them, and later exfiltrate combatants, support material, and non-combatants from an endangered area. To do this, the KC-390 will have all electronic countermeasures available, chaff and flare, night navigation equipment, and the capability to land on short, unprepared runways, provide air refuelling, and be refuelled in the air, among other characteristics.

Among the other challenges facing the BAF, aside from the budget restrictions and the linkage of defence expense to national industry development, one of the greatest stems from the change of focus from war (or national defence) to subsidiary duties. The Armed Forces of Brazil still carry the burden of conscription, which is understood as a social contribution to the population. Employment in internal security affairs, such as those connected with transnational crime or against drug dealers in main cities, demands remodelling from traditional war training to police actions. Certain isolated villages in the Amazon can still only be reached readily by airplane. Airlift to these places and people is a constitutional responsibility of the Air Force. These missions also present an excellent opportunity to spread positive feelings about the importance of the Air Force among the society at large. Some BAF aircraft are always present to assist during natural disasters or calamities, and they also fly to deliver organs for transplant, participate in vaccination campaigns, transport election teams to remote populations to allow those populations to vote, or cooperate in the fight against common crimes.

Conclusion

Despite all these challenges, the BAF must remember some important points. Since the pioneering flight of the '14-Bis', the BAF keeps pursuing a technological focus. This is profitable given the nationally established airspace technology complex. Around the city of São José dos Campos rose small airplane factories, maintenance yards, space research institutes and related products manufacturing, a flight-test school, aeronautical engineering universities, private airspace product companies, departments to study atmospheric and climate phenomena, and other establishments to improve the knowledge of aeronautics.

The teachings of war pointed towards this focus, and the doctrine evolved from the basics of the air power concept to an inclusive and all-embracing concept of airspace power. This concept spans not only technology but also the art of airspace warfare, which was learned after the BAF's honourable participation in the Second World War. With the advent of joint and combined experiences and the Ministry of Defence came a new way of force structuring, leading to new policy documents and doctrines. PME enlightened the BAF's officers regarding themes of modern air warfare, thus enabling peer participation in real operations.

All of this did not come about easily, but through hard study, scarce but well-applied financial resources, the need for internal changes, and prioritisation of objectives. Because of the formulated national strategy, the BAF directed its efforts towards gathering capacity and inter-national cooperation, which enabled the development of indigenous products. In a final synthesis of the ideas in this chapter, one can conclude that airspace power in Brazil, more than ever, projects an Air Force that is still technologically and adaptively driven, not only because of the machines it has but also because of men and women entirely dedicated to their profession.

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JAPANESE AIR POWER

Tomoyuki Ishizu

More than a century has passed since the Wright brothers made history with the first powered flight in 1903 and since, in 1910, two captains in the Imperial Japanese Army successfully completed Japan's first flight to catch up with the Western powers. In the intervening years, air power has gradually developed into a core element of military power, demonstrating its dominant capability in the Gulf War of 1991 and the Iraq War of 2003. Indeed, anyone discussing air power at present could hardly deny its value. It is not, however, a 'panacea': a number of problems and limitations constrain its use. More important, anyone concerned with the value of air power must ask what grand strategy should support it to ensure effective utilisation of its abilities. After all, it is impossible to assess the utility of air power outside the political and strategic framework within which it must function.

This chapter first summarises the development, history and characteristics of air power, Japanese air power in particular. It then sketches the present-day as well as future utility of air power. Finally, it examines the characteristics of effective air power employment from the perspective of Japan's present and future grand strategy. In this context the chapter emphasises integrating military power as well as forming an integrated strategic culture.[1]

Evolution of Japanese air power before 1945

The Second World War first clearly demonstrated the value of air power as a tool for implementing grand strategy. As the German Blitzkrieg, Allied strategic bombing, Japan's surprise attack on Pearl Harbor and the US atomic bombing of Japan demonstrated, air power had developed into an indispensable element for war at all levels.

The evolution of Japanese air power before 1945 can be viewed through the lens of four phases. In the first period Japan produced foreign aircraft models domestically using imported airframes. However, Japan lagged behind the rapid progress in the utilisation of air power and development of an aeronautical industry occurring in the West. The second period involved introduction of foreign air power expertise into Japan and intensive learning about the uses of air power and aeronautical technology as a result of inviting military personnel and engineers from the West to Japan. The third period witnessed an abrupt change in Japan's grand strategy with a consequent reformulation of the nation's military strategy, including air doctrines. The fourth period saw Japan display its air power to the world. From the technological perspective,

Japan in this period could not rely on the adaptation of foreign technology and found itself obliged to address technological issues using its own resources.

Although Japanese air power brought about spectacular achievements in the initial phases of the Pacific War, once the allied powers initiated a counteroffensive, its limits quickly became apparent. In this context, strategic bombing warrants special concern.

Japan carried out a series of strategic raids against Chungking and other cities in China from 1938 to 1941 during the Sino-Japanese War. However, in discussions of the war, the Japanese air offensive has received virtually no attention (Ishizu and Murray 2006). Nevertheless, Japan's strategic bombing of Chungking should be one of the most controversial subjects of the Sino-Japanese War. The doctrine advocating use of aircraft to deliver direct blows against the political, economic and industrial heart of the enemy made the enemy's civilian population a legitimate target, and, indeed, a prime target in the case of the Japanese bomber offensive.

Recent years have seen a growing renewal of interest in Japan's strategic bombing campaign against Chungking. This interest has centred mainly on two points: ineffectiveness and immorality. Regarding the ineffectiveness of the bombing, many argue that Japan's strategic bombing attacks represented, by and large, a strategic blunder or a waste of effort and time for Japan, because the bombing demonstrably failed to destroy either the ability of Chiang Kai-shek's Nationalist government to wage war or the will of Chinese civilians to continue its fight. Even while the air attack on Chungking was ongoing, one of the commanders in charge of the air campaign himself considered the bombing campaign useless and unnecessary (Endo 1974: 194–196). Regarding the immorality of the bombing, Japan's avowed policy of brutal and indiscriminate bombing directed against innocent Chinese civilians has fallen into disrepute.

It is difficult to determine what the Japanese air offensive in China, especially the bombing of Chungking, actually achieved. From a political standpoint, it achieved nothing. In fact, the bombing campaign undermined Japan's attempt to attain a political settlement with the Nationalists. Obviously, it was a contradictory policy to make overtures to Chiang Kai-shek while dropping bombs on his capital.

From an economic standpoint, it is unclear whether Japan's bombing offensive caused a substantial decline in China's overall war-making capacity, because of the lack of reliable Chinese records. Given that China did not possess a modern industrial infrastructure that could suffer significantly from bombing, it is understandable that Japan did not seriously develop elaborate air doctrines such as the 'Industrial Web' theory that emerged in the United States.

From a psychological standpoint, the resistance of Chinese population in Chungking invalidated the widely held belief that bombing could easily break civilian morale so that defeatism would prevail. Bombing did not bring about the collapse of Chiang Kai-shek's government. Nevertheless, it would be misleading to suppose that the bombing failed to shake civilian morale in those areas exposed to intensive air raids, such as Chungking. The persistent bombing of Chungking indeed led to widespread fatalism, apathy and absenteeism from factories, all of which militated against political cohesion and economic production (Maeda 2006: 327–353).

From a military standpoint, the Japanese air offensives against China achieved modest positive results. First, China provided an ideal training ground for Japanese air power, as Spain in the Spanish Civil War had done for the Luftwaffe in the inter-war period. The Luftwaffe confirmed from its experience of raids on Guernica that long-range air bombardment required substantial technological support. The Japanese, on the other hand, gained considerable combat experience from the war in China not only in tactical air support, but also in land-based and carrier-based long-range air bombardment, before the beginning of the Pacific War.

Furthermore, the Japanese air offensives against China made a considerable contribution to Japan's gaining command of the air over central and southern China.

To sum up, the Japanese air offensives against China achieved some modest results from a military standpoint, but failed to achieve political or economic advantages. Moreover, Japan's strategic bombing against Chungking failed to bring about the collapse of Chinese civilian morale, let alone the overthrow of Chiang Kai-shek's government, primarily because of Japan's lack of industrial and economic capacity to maintain a large-scale air effort. Similarly, Japan did not realise what an air war in the age of total war would truly involve.

Air power today: a panacea?

As noted, the Second World War as a whole marked a turning point in the history of air power. Of course, legal and ethical dilemmas lay in wait during the development of air power, as the strategic and atomic bombings underlined. By the end of the Second World War, however, no one could deny that air power would play a more significant role in the future. It was obvious that the latent abilities of attack from the air were coming into bloom, backed by technological advances. The constraining factor of technological feasibility was apparently disappearing.

In the years after the Second World War, air power developed steadily through trial and error up to the Gulf War in 1991. This represented another major turning point in the utility and effectiveness of air power, since its emerging characteristics appeared in full during the Gulf War. In the 1970s and 1980s, the term 'strategic' had generally referred to nuclear weapons within the framework of the Cold War, but the Coalition air forces in the Gulf War employed conventional weapons, previously considered 'tactical', to achieve truly strategic objectives. In fact, John A. Warden's major accomplishment lies in having brought the US Air Force back to a belief that conventional weapons can achieve strategic objectives by using the products of information technology: stealth and precision weapons. The most important success of air power in the Gulf War was nothing other than the war's outcome (Kuehl 1995: 250–251).

During the Gulf War, air power achieved less than some had expected. However, the United States and its allies could not have crushed Iraq's military power at such small cost in human lives without air power. Previously, air power had served mainly to support land power, but in the Gulf War air power not only defined the combat theatre (battlespace), but also gave the impression that it could bring an end to the war by itself.

Since the Gulf War, air power has become almost synonymous with the 'Western Way of War', and particularly with regard to the United States, the 'American Way of War'. Certainly, although disputes remained over the necessity of major army and navy forces after the Cold War ended, no one questions the necessity of air power. Today's disputes centre not on whether or not air power is of value, but rather on which service should exercise its abilities. In fact, the air power capability represented by the United States comfortably fits with today's zeitgeist, symbolised by the term 'post-heroic war'.

In the future, governments may come to think that air power will allow even the staged input or use of military power considered dangerous in the case of land power (Cohen 1994), since air power possesses the ability to attack targets selectively. In addition, even though the ultimate goal of war is to impose one's will on the enemy, the means to achieve this has undeniably shifted from 'brute force' to 'coercion', at least for Western nations. Since 'coercion' involves influencing the enemy's policy-makers, the value of air power, which allows the selective use of military force, must further increase (McInnes 2001: 41–44). Actually, cruise missiles (an aspect of air power) have found their use as a means for coercion: now the term 'Tomahawk Diplomacy' has appeared on the scene.

Moreover, air power represents the best means of embodying the idea of pre-emptive attack, as suggested by recent US and Russian guidelines for the use of military power. Thus, air power did fit the twentieth century's zeitgeist, a trend that continues to strengthen even in the twenty-first century. Air power (more precisely, aerospace power in the domain that includes outer space) will likely become a concept symbolising the twenty-first century to a greater degree than in the previous century. The shift in terminology from the traditional 'battlefield' to 'battlespace' plainly attests to war's three-dimensional nature.

Problems and limitations of air power

The United States can employ air power at will, similar to the old British Empire's 'Imperial Policing', partly because the present strategic environment permits it to do so. More specifically, this freedom has resulted from the position of the United States as an unparalleled hegemon on the international stage.

If the present strategic environment should change, allowing the appearance of a rival air power state, air war might return to its former form of a 'dogfight'. It is also necessary to consider a paradox inherent to wars: if a state or non-state insurgency were to appear on the scene to challenge the United States, using new means to avoid air war, could the United States operate its own air power effectively enough to wage and win such 'asymmetrical wars'?

In truth, it is dangerous to expect too much from air power. For example, those who over-value present-day air power seem to believe that air power will allow a return to the 'limited war' of the mid-eighteenth century in Europe. This idea of bloodless wars and victories at little cost is only an illusion.

Air force supremacists tend to develop an unproductive argument that overemphasises the value of air power, whereas history suggests that the 'synergistic effect' of each service/branch brings about victory in war. For example, the Kosovo conflict of 1999 successfully demonstrated that air power, under a grand strategy that expected no input from land power, can produce only limited effects (Lambeth 2005).

Even today, strongly supported by technological development, air power cannot completely eliminate its inherent flaws, such as intermittency of limited temporal/spatial 'staying power' and dependence on ground bases. The phrase 'boots on the ground', often quoted in the Iraq War, suggests the importance, even today, of ground forces, not only at the military level but also in a political sense. The higher importance of air power in war is only relative to the end.

From a political point of view, the United States can almost never use military power by itself. It must establish a cooperative relationship with allied as well as friendly nations. For example, even during the alliance between Britain and the United States during the Second World War – the so-called 'Special Relationship' – it was not easy to carry out combined operations. Is the United States willing to carry out combined operations including Japan that might not be considered militarily valuable? On the other hand, can allied and friendly nations secure the technological capability or interoperability that would allow them to perform combined operations with the United States?

Furthermore, as a major premise for addressing these problems, is it necessary to secure interoperability? In other words, Japanese decision-makers must give consideration to more fundamental problems in Japan's grand strategy, for example, in considering the future of the Japan–US alliance.

Meanwhile, if adhering to the narrow definition of air power – namely, 'air power equals air force' – nations must answer such questions as why the air force must exist as an independent actor when military power is developing as a whole to conduct integrated joint operations.

Needless to say, the value of air power and the retention of an air force as an independent service are separate issues belonging in different categories.

Moreover, it is still open to question whether or not Japan's attention is attracted by the results of air power's ability alone or by a highly networked military force based on information technology, in which all elements rely on the Global Positioning System and air power is only a part. In short, Japan must realise the value of military power in the future depends on the level of integration. During the military operations in Afghanistan and the Iraq War, US air power operated with unprecedented effectiveness with guidance by the ground 'special forces' which had infiltrated into the areas in advance. Similarly, leaders must not undervalue the significant role played by naval platforms, including the launch of air strikes and cruise missiles, as well as in transporting aircraft and naval vessels as a transport means. Furthermore, considering air power specifically, its unified command may have been a major contributor to victory in recent wars: that is, the crucial issue may be the method of command or organisation.

Leaders must also consider the interrelationships among wars, as well as the use of military power and the zeitgeist. Assuming further dramatic developments in air power, backed by technological advances, will its potential abilities ever be fully used, given the severe limitations imposed by political, social and ethical constraints? In all likelihood, these constraints may well become tighter, as if inversely proportional to the technological development of air power. If so, such a trend could substantially restrict air power's potential, particularly in Japan, where pacifist sentiment still dominates.

Finally, is air power effective as a tool to achieve a state's political objectives? As one commentator has pointed out, concern over air power has become complicated by a reality in which 'technology itself is the present day's leading theorist of air power and, for the time being, invention is the mother of adaptation' (Cohen 1994). Looking towards the future, is it possible to develop air power and military strategy based on insights into the objectives of a war? With these problems and limitations in mind, let us now review the development of Japanese air power after 1945, and its future and possibilities.

Japanese air power in national defence policy

Determined never to relive the miseries of war, Japan has made every effort to build itself into a 'peace-loving nation' since the end of the Second World War (Defence Ministry of Japan 2016: 164–168). Indeed, pacifism is enshrined in the current Japanese Constitution, of which Article 9 explicitly renounces war, possession of war potential, and the right of the state to resort to war. Nonetheless, as long as Japan remains an independent nation, the Constitution recognises beyond doubt that these provisions do not deny that Japan as a sovereign state has the inherent right to self-defence.

Because the right to self-defence is thus accepted, successive Japanese governments after the Second World War have interpreted this to mean that the Constitution allows Japan to possess the minimum level of armed strength needed to support the exercise of that right (Defence Agency of Japan 2005: 18). Even so, the use of armed force is permissible as a means to exercise the right to self-defence only when the situation meets the following three conditions:

- Japan foresees an imminent and illegitimate act of aggression against Japan;
- Japan has no appropriate means to deal with such an act of aggression other than by resorting to self-defence; and
- the use of armed strength is confined to the minimum necessary level.

Under the 'Basic Policy on National Defence' adopted by the National Defence Council and approved by the Cabinet in May 1957, Japan has been making efforts to build a modest defence capability in accordance with the fundamental principles of maintaining an exclusively defence-oriented policy and not becoming a 'military power' that might pose a threat to other countries, while adhering to civilian control of the military and firmly maintaining Japan–US security arrangements (Defence Ministry of Japan 2016: 170).[2] Japan also observes three non-nuclear principles: not possessing nuclear weapons, not producing nuclear weapons, and not permitting the introduction of nuclear weapons into the country (Defence Agency of Japan 2005: 19).

This exclusively defence-oriented policy means that Japan may not employ its defensive forces unless and until another country mounts an armed attack on Japan, in which case use of those forces must be limited to the minimum level necessary to defend the nation. Furthermore, the extent of the defence forces retained and the use of these forces should be kept to the minimum level necessary for self-defence. This policy thus leads to a passive military strategy consistent with the spirit of the Japanese Constitution.

These domestic political priorities have governed Japanese defence policy since 1945. The policy is also shaped by the geostrategic features of Japan. Japan is located at a strategically important position close both to the major powers of the Eurasian continent and to the narrow exit points of maritime traffic extending from the north-eastern part of the continent to the Pacific Ocean. Its territory consists of a thin, crescent-shaped archipelago with long coastlines and numerous small islands, which allows little space for defence in depth (Defence Agency of Japan 2005: 21). Moreover, Japan's large population is confined to a very narrow territory, its industries and population are concentrated mainly in urban areas, and a large number of important facilities essential to economic development are in coastal areas. In terms of topology, all of these factors can be considered vulnerabilities. Under such geostrategic as well as domestic political constraints, the national leadership has considered effective employment of Japanese air power and will continue to do so in the future (Ishizu 2008: 72–76).

Not surprisingly, Japanese air power as represented by the Japan Air Self-Defence Force (JASDF) until recently has been modest both in scope and scale, because

> … among such armaments, possession of those that are characterised as offensive weapons that, by the nature of their performance, are intended to be used only for the mass destruction of another country, would in any case mean that the parameters of the minimum necessary level were exceeded by definition; thus, under no circumstances are these weapons permissible. The Self-Defence Force (SDF) is therefore, for example, not allowed to possess Intercontinental Ballistic Missiles (ICBMs), long-range strategic bombers, or attack aircraft carriers.
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> *(Defence Agency of Japan 2005: 103)*

The future of air power in Japan's grand strategy

First, in discussing the larger conceptual framework, will Japan, assuming its freedom to use the technologically latent ability of air power fully, be able to develop its own defensive power based on air power's intrinsically offensive nature? In contrast to the 'United States as an air power' (de Seversky 1942), Japan has historically far more resembled a continental power. Thus, it is unlikely to develop into an air power state. When considering the Japanese government's policy on air power, the narrow base of Japan's defence and aircraft industries, and, above all, public perceptions of air power, the differences from the United States become clear.

Of course, 'like a continental power' does not truly capture the history and present status of Japan: Japan is not a continental power in the true sense. Yet at the same time, despite its dependence on the sea for food and industrial resources, Japan is not a sea power similar to ancient Athens or the United Kingdom. What is important in considering these problems is the element of government and public perceptions, namely, of desirable *Weltanschauung* and willingness.

Alfred Thayer Mahan cited six basic factors affecting the sea power of a nation and, with regard to two of them – 'number of population' and 'national character' – he placed special importance on the population engaged in activities on the sea such as marine transport and fishery (Mahan 1987 [1890]). He also argued that policies that actively support activities of the nation's people on the sea or in colonies constitute the greatest factor in gradual enhancement of a nation's global power. This is the 'character and policy of governments' referred to by Mahan. It seems that these factors apply directly to air power as well.

As Rome was a land power and the United Kingdom a sea power, so the United States is an air power, and these three nations have each ruled the world and sought to bring peace or order, taking advantage of their inherent military power. Is it possible for Japan's air power to develop dramatically and for Japan to become an air power state in the future? Moreover, the United States has as its grand strategy the aim of maintaining the balance of power and acting as the protector of last resort, organiser and leader of collective security, and defender of humane values (Gray 1996: 118). The United States has its highly respected air power as a tool to carry out these aims, but could Japan prepare a grand strategy for the effective use of air power? Fundamental discussion of Japan's grand strategy would be the first step in positioning air power clearly in Japan and developing specific military strategies.

In December 2004, the Japanese Cabinet adopted a resolution about the 'National Defence Program Outline in and after 2005' (hereinafter referred to as 2005 NDPG because the next one was adopted in 2010 and the current one was adopted in 2013 respectively), which advocated a stance placing importance on 'effective responses to the new threats and diverse situations' (Defence Agency of Japan 2005: 121–124).[3] More specifically, the document covered the topics of ballistic missile attacks, attacks by guerrillas and special operations forces, the invasion of Japan's offshore islands, patrol and surveillance in the sea and airspace surrounding Japan, the violation of Japan's airspace and the intrusion of armed special-purpose ships, and large-scale and/or special-type (nuclear, biological, chemical and radiological) disasters. In crafting responses to these situations the Defence Agency of Japan found it necessary to consider the role of air power and even the importance of integration. In this respect, the 2005 NDPG marked an important turning point in Japan's defence policy after 1945.

As mentioned before, Japanese air power developed during the Cold War with air defence and anti-submarine warfare as its premier missions. Since the 1980s, it has also played an important role in carrying out sea lane defence. However, due to the change in strategic environment with the end of the Cold War, the importance of the roles so far played by Japanese air power has declined. Instead, various roles in the new strategic environment have gained higher priority, together with tasks such as providing transport in aid of international security. Among these latter roles, along with a variety of relief activities that fall into the category of 'International Peace Cooperation Activities', Japanese aircraft carried US military commodities since the terrorist attacks on 11 September 2001, in accordance with the 'Anti-Terrorism Special Measures Law'. Moreover, Japan conducted humanitarian/reconstruction assistance and other activities after the Iraq War in 2003 under the 'Special Measures Law for Humanitarian and Reconstruction Assistance in Iraq' (Defence Agency of Japan 2005: 272–274).

As two objectives for security in the 'Basic Principles of Japan's Security Policy', the 2005 NDPG had proposed preventing any threat from reaching Japan, and, in the event that a threat should do so, repelling it while minimising damage, while at the same time improving the international security environment so as to reduce the chances that any threat would reach Japan in the first place. This 'international security environment improvement', along with 'territorial defence', represented a major task carried out by the Defence Ministry/SDF (ibid.: 119, 324). Again, the current spectrum of issues that require the use of military power has widened. Moreover, such contingencies are becoming hard to anticipate. In this sense, dependence only on traditional deterrence and defence has its limits, while efforts to stabilise international security are becoming increasingly important.

These circumstances offer the real possibility of Japanese air power taking a more active part in military operations. The 2005 NDPG provided for the enhancement of transport capacity to allow involvement in international peace cooperation activities, such as 'Subjective and Proactive Activities to Improve the International Security Environment'. This represented a persuasive policy for using manoeuvrable and flexible air power, while securing Japan's national interests under the framework of its present grand strategy (ibid.: 123). The policy brought strategic or long-range air transport capacity into consideration. Japan does not appear to need functionally self-contained air power in the foreseeable future; therefore, Japan may find it proper to place greater importance on the transport capacity of its air power.

The 'Mid-Term Defence Program (FY2005–2009)' instituted under the 2005 NDPG set forth a specific future defence build-up plan.[4] The first change of note concerning air power-related equipment was the decision to adopt tanker transport aircraft (KC-767 or other aerial refuelling capabilities), while reducing the number of fighter aircraft and procuring new transport aircraft (Defence Agency of Japan 2005: 138). Following this line, Japan established the Aerial Refuelling/Transport Unit. Second is the decision to install the Ballistic Missile Defence System, based on the Aegis and Patriot systems. This system is now backed by ground-based command and control and JADGE (Japan Aerospace Defence Ground Environment), and will be joined by unmanned aerial vehicles (UAVs).

In accordance with the second previous Mid-Term Defence Program, the Japan Ground Self-Defence Force (JGSDF) formed the 'Central Readiness Force' composed of airborne troops, the Special Operations Group, and various helicopter units (Defence Agency of Japan 2005: 123, 138). Furthermore, the Maritime Self-Defence Force (JMSDF) has adopted flat-deck and helicopter-equipped destroyers (DDH), thereby permitting sustained operations with various types of helicopters far from Japan. Air power is thus taking on an increasingly important role in the strategic framework of Japanese military power.

With respect to outer space, Japan has launched and started operating intelligence-gathering satellites. Although not directly related to the second previous, previous and current NDPGs, this development is important in considering the position of Japanese air power (and then aerospace power) in the future. In this regard the potential of air power in intelligence-gathering activities is expected to become a key element in securing the safety of Japan in the future. If so, Japan may also choose to place greater importance on the range of Japanese air power and military intelligence-gathering activities after recognising technological limitations.

On the other hand, Japan still has virtually no air power capability to attack enemy territory. This is a direct result of constraining the nation's use of its military power (defence capability) to self-defence, as well as improving the SDF and its air power under such conditions. The Japanese Constitution prevents Japan from possessing air power capabilities to assume the offensive, including cruise missiles. Opinions remain divided on whether or not this factor is

responsible for Japanese air power's being less self-sufficient. Still, aside from the monetary cost, the political cost for Japan to possess such capacities appears too high, despite the recent successive North Korean nuclear and missile tests.

The imperative is to secure the safety and prosperity of Japan in the new strategic environment. To be sure, as represented by the idea of pre-emptive attack, the preventive principle is becoming a trend in the twenty-first century. To keep pace with the 'risk society', the preventive principle has undeniable persuasive power. At the same time, however, it does not seem urgent that Japan possess, say, the ability to attack an enemy's territory, when considering today's strategic environment in the Asia-Pacific region, much less a necessity for Japan to become a counterpart to the United States by possessing its own self-sufficient air power.

As indicated in the section on 'Three Approaches' to security in *Defence of Japan 2005*, safety rested not on 'Japan's own efforts', but on a multi-tiered grand strategy of 'cooperative efforts with the United States, Japan's alliance partner' and 'cooperative efforts with the international community' (Defence Agency of Japan 2005: 117). For this reason the Japan–US alliance will become even more important in the future, and it makes sense for Japan to be subjectively and proactively involved in the peace and stability of the international community.

At present, the very nations unwilling to engage in positive efforts to promote the peace and stability of the international community are destined to find themselves as marginal players. This is the twenty-first century's zeitgeist, represented by the term 'globalisation'. The security of Japan as a status-quo power can never be assured without aligning its national interests as closely as possible with those of the international community. At present, as a new aspect of war is emerging, it is dangerous to adhere stubbornly to traditional methods. A new form of war calls for new forms of military power, such as highly networked joint war with air power at its core. As a matter of course, Japan's own strategic culture must support such joint military potential.

As a typical 'middle-power nation', Japan cannot and need not fully protect its interests by itself. The real issues are the purpose for which Japan possesses military power and the missions in which its military power should specialise to achieve national objectives with limited resources.

The discussion in this chapter shows that air power should play a major role in Japan's defence. For the air power that Japan possesses, investment should concentrate on essentials for responding to new threats and diverse situations, and for improving the international security environment. In addition, Japan requires minimum fighter aircraft for anti-overflight measures (also known as air sovereignty missions) and air defence. Japan has no choice other than to leave the remaining incomplete parts of Japan's air power, as well as of its military power in general, to political decisions.

In fact, the first practical diplomatic strategy adopted by Japan has been alliance with nations that share its interests. In this sense, the Japan–US alliance will remain as important as ever in the future, for it positions the 'Japan–US alliance within the world' (Defence Agency of Japan 2005: 120). Political as well as military leaders must identify the unique role that Japan, and specifically air power missions, should play within this framework. The operation of air power to provide logistical support to US forces is also an important role.

Because Japan depends heavily on other countries for many resources and bases its development and prosperity on free trade, sustained peace and cooperation within international society are extremely important for the nation. Japan's cooperative assistance in the international community is as important as the alliance policy and here, too, air power presents new possibilities: the operation of air power within the framework of 'international peace cooperation activities'. Concerning Japan's current air power, for example, the AWACS (E-767 early

warning and control aircraft) and P-3C/P-1 (fixed-wing maritime patrol plane), as well as transport aircraft and a variety of helicopters, all offer the possibility of use as a 'public good' for the international community to build a stable international security environment.

In recent years, Japan has aggressively participated in the 'Proliferation Security Initiative' to stop the diffusion of material related to weapons of mass destruction, but so far mainly through activities on the sea. At the same time, however, Japanese authorities are reviewing the possibility of air support for this mission. In practice, such military power-based 'policing' will become increasingly likely in the future.

Certainly, Japan must examine the advantages of air power as the core of its defence capability or deterrent. This would represent a change from the response-oriented defence capability set forth in the 2005 NDPG as well (Defence Agency of Japan 2005: 136). But this does not necessarily suggest that Japan should possess attack and strategic (long-range) bombing capabilities or should improve self-sufficient air power. In brief, even if long-range cruise missiles, aircraft carriers, and nuclear weapon are not options, other methods exist for taking full advantage of air power as a deterrent, and then as a defence capability, based on existing equipment.

Finally, when considering the future of air power, the topic of integration inevitably arises. Today, Japan is also establishing a joint operations system and, apart from the question of whether or not traditional services will disappear, joint operations are indispensable for the effective use of military power as a means for implementing grand strategy (Defence Agency of Japan 2005: 154–159). To execute its missions swiftly and effectively by rapidly responding to new threats and diverse contingencies in the new security environment, the SDF needs to enhance the joint operational posture. While increasing the effectiveness of the newly established Joint Staff, Japan is now also strengthening the infrastructure for joint operations in such areas as education and training, intelligence, and communications.

At the same time, necessity has compelled Japan to establish network-centric military power. In fact, the capacity of air power when married with information will make air power increasingly important. In such cases, however, simply urging that military power be integrated and network centric makes no sense, and concurrent development of an integrated culture and restructuring of military organisations will become the key challenges.

Japan must also review its industrial infrastructure and government policies and public perceptions for future orientation, casting back to the original meaning of 'air power' and 'military power'. Since military power, particularly air power, is evidence of a nation's overall ability, Japan must set a national policy concerning collaboration among industry, the academic world, and the military (the Defence Ministry/SDF).

Conclusion

In conclusion, the central issue for Japan is to define its national objectives clearly. It makes no sense to discuss the future of Japan's military power and air power without considering such questions as the direction in which Japan is heading and what roles Japan is willing to play in the international arena. Thus, Japan needs to define its grand strategy and make known when, for what and how the nation will use military power and air power in particular – that is, to establish the 'Japanese Way in Warfare' (Ishizu 2000). The 'Japanese Way in Warfare' goes beyond any purely military approach to Japan's foreign and defence policy and should be based upon the nation's geopolitical conditions and history. Furthermore, it must also be informed by Japan's cultural values and the attitude of the Japanese population towards war and peace. In other words, the 'Japanese Way in Warfare' must be based upon Japan's own *Weltanschauung*.

The Japanese government established the National Security Council in 2013 within the Japanese Cabinet. The Council has identified Japan's national interests and national security objectives to a certain degree. This is clearly good news for Japan's SDF, because, as demonstrated in the Vietnam War and the Kosovo conflict, if the grand strategy that military power is to support has significant flaws, the value of the military power itself becomes irrelevant and only makes the ensuing defeat or failure more costly.

Notes

1 The views expressed in this chapter are the author's own and do not reflect the views of the National Institute for Defence Studies, the Defence Ministry, or the Government of Japan.

2 The 'Basic Policy on National Defence' was replaced by the National Security Strategy (NSS) of 2013, which represents Japan's first-ever basic policy on national security with a focus on diplomatic affairs and defence policy. The NSS defines approaches that Japan should follow based on a long-term view of its national interests. The 'National Defence Programme Guidelines for FY 2014 and beyond' were established based on the NSS.

3 This defence White Paper cites the following three roles as the primary roles of defence forces: 'effective response to new threats and diverse situations', 'subjective and proactive activities to improve the international security environment', and 'preparation to meet full-scale invasion'. In 2010 and 2013, the Japanese Cabinet adopted a resolution about the 'National Defence Programme Outline for FY 2011 and beyond' and 'National Defence Programme Outline for FY 2014 and beyond' respectively, but the bottom line of the previous and current Guidelines is basically the same as the second previous one.

4 The 'Mid-Term Defence Programme (FY2011–2015)' was adopted in 2010 and the 'Mid-Term Defence Programme (FY2014–2018)' was adopted in 2013 respectively.

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CONCLUSION

The Shape of Things to Come

John Andreas Olsen

The *Routledge Handbook of Air Power* shows that over the past three decades air power has come to play an increasingly important role in national security, international relations and warfare. Air power – the ability of a nation to assert its will by projecting military power in, through and from the air domain – has demonstrated that its relative impact in shaping war outcomes has been far greater than that of the other force elements. The transformation in operational tempo, concepts and technology since the Vietnam War has made air power a dominant force element across the board, even though it may not be the most decisive force in every case. Military commanders who have witnessed recent warfare first-hand realise that successful operations are virtually impossible without the extensive employment of air power. Diplomats who have been engaged in resolution of violent conflicts recognise that the threat and actual use of air power offer considerable advantages in negotiations. However, although air power is now strategically essential, it is not a panacea and it is not risk free. The authors of this volume make the case that modern warfare – even with solid intelligence, high technology and precise weapons – still contains fog, friction, uncertainties and unpleasant surprises. The new-found influence of air power does not do away with the fact that warfare is a human activity.

The book validates that whether air power is subordinate to land power, or vice versa, depends upon the war's overall military-strategic context. Rather than contrast land power and air power it is better to consider them as inherently complementary dimensions of variable relative significance within a single military, strategic and political effort. What should be clear is that air power, applied to its fullest potential in the given context, can greatly ease the tasks of all other force elements in a joint fight. It may not always be the principal player, but it invariably enables all else in force employment either as an agent of kinetic effect or as a multi-component enabler of ground, naval and interagency forces. Air power, under the right circumstances, can be independently decisive or pivotal in determining outcomes of regional conflicts.

Importantly, the authors strongly bring out the importance of connecting air power and policy. The single most important lesson is that even the most robust and technically capable air weapon can never be more effective than the strategy and policy it is intended to support. The effectiveness of air power is highly context specific and its achievements must be measured against political objectives, not merely in terms of tactical-technological performance. This means that observers will have different interpretations of how successful a particular

application of air power was in the given circumstances. Unlike tactical-technological results, no common terms of reference exist for measuring air power's strategic impact. When evaluating strategic and functional effects, rather than attrition and destruction, traditional metrics no longer apply. This book offers nuances and informed perspectives on air power's contribution to national objectives rather than a conclusion as to its decisiveness. The goal from the outset of this project was to promote a greater depth of air power knowledge, not to produce a specific, recommendation for action.

This volume also shows that the scholarly literature on air power is maturing. It is only in recent decades that the study of air power has become academically respectable. The period between 1991 and the present were years of unprecedented plenty for historians. A series of books and articles now present intellectually honest research. These publications have not only 'succeeded in placing air power in its proper historical context, but in pushing the subject beyond the fighting front to embrace a whole range of different historical issues and approaches' (Overy 2002: x). That, too, is a sign that air power has come of age. Several military journals focus specifically on the air power profession and several Western countries have invested in establishing air power centres of various sorts.

Western military doctrines have sought to improve the vocabulary, concepts and language of air power. This constitutes an unremitting challenge: air power can never reach its true potential as long as it is bound to an old view of war, described in land warfare terminology. Future researchers must overcome this limitation by looking beyond the entrenched battlefield-oriented model that has continued to dominate military doctrine, theory, strategy and warfare long after air power offered new options, but they do not have to start from scratch (see, for example, Mason 1994; Meilinger 1997, 2017; Peach 1998; Cox and Gray 2002; Gray 2012; Lambeth 2000, 2013; Mueller 2015; Olsen 2015, 2017; Black 2016). Modern air power can offer political decision-makers more and better options – provided the underlying strategy coherently links the application of air power directly to the end-state objectives rather than limiting it to 'the battle'. Not only do the authors of this volume refer to solid academic work, they also contribute to further research by offering an update on the available literature and by identifying areas that merit more attention as warfare continues to develop.

Ultimately, this book demonstrates that to understand air power one must look beyond the physical component of equipment and capabilities to include the conceptual and moral components. Ideas matter: fifth-generation technology must be matched by fifth-generation organisational adaptation and fifth-generation strategic thinking. Equally important is the ethical and judicial foundation for operations, especially when dealing with the implications of the fourth industrial revolution, the 'robotisation' in the form of remotely piloted vehicles and autonomous systems. The future of air power lies in mastering the conceptual and moral high ground in addition to its underlying algorithms. The future of air power also depends on finding and keeping the right people; to recruit and retain the best and the brightest must be a continuous cycle based on both well-established values and new incentives.

The future of air power requires an ability to look beyond 'presentism': apparent impossibilities for one generation can be the 'everyday normal' for the next. In the process the analyst must distinguish between the truly significant and the transitory in contemporary wars: to determine whether an event or innovation is short lived or indicative of a long-term trend that should be harnessed. The future of air power must combine lateral thinking and science; military leaders must encourage new, forward-leaning concepts. As Lieutenant General David A. Deptula states in the foreword to this book: 'If we can learn anything from air power's relatively short history, it should be that air power's potential is limited only by our vision and our willingness to advance.' The true mastery of air power lies in commitment to professional insight, techno-

logical innovation, conceptual imagination and strategic acumen and in the ability and readiness to communicate air power's qualities to the wider public and to the politicians elected to make strategic decisions. Air power did not come this far only to come this far.

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AFTERWORD

'The sky's the limit' is perhaps an unsatisfactory idiom when considering the study of air and space power, but it does suitably express the magnitude of John Andreas Olsen's ambition – and success – in composing this magnificently comprehensive and well-orchestrated collection of air power essays. Coinciding as it does with the centenary of the Royal Air Force, the publication of this volume offers an excellent vantage point from which to reflect on military air power's evolution over little more than a hundred years, and its rapid ascent from being a tactical ancillary at the beginning of the First World War, through the realisation of its potential as a strategically decisive instrument of power at the end of the Second World War, to our ability today to exploit its core attributes fully and employ air power to span all levels of warfare – often within a single mission.[1]

In addition to analysing air power's evolution and contemporary utility, the chapters in this book also prompt us to peer into an uncertain future. One of the principal challenges to air power professionals is to ensure that air and space power can exploit its full utility – tactically, operationally, strategically and, increasingly, *ethically*. I am particularly pleased, therefore, that mixed with the chapters focused on air power's roles and the challenge of 'jointery' are the equally valuable treatises on 'Air power, international law and ethics' (Chapter 5) and 'Air power and the media' (Chapter 20). Indeed, the battle of the 'narrative', in which ethics are an important component, is one that is equally relevant to the increasingly contested international environment (where strategic competition between states has been firmly reasserted as an issue) and the struggle against Daesh and its misguided disciples. Air commanders should be only too aware of how these issues cut across every aspect of the delivery of air power, but these topics have too often in the past been neglected in air power academic literature. This volume has rectified that omission, and in so doing John Andreas Olsen and the authors of those chapters have rendered current and future commanders an invaluable service.

Logistics is a further area of air power that has historically been neglected in air power (and, indeed, most military) literature, and Air Vice-Marshal Rich Knighton's Chapter 12 cites several regrettable examples of overlooking and, it has to be said, ignoring this vital enabler of air operations. From Sun Tzu to the present day, history is replete with examples highlighting the role of logistics in military victories and how neglecting this vital function contributed to defeats, but in the Royal Air Force we have done much to address Sir Winston Churchill's stinging wartime assertion that:

> The Air Force, except in the air, is the least mobile of all the Services. A squadron can reach its destination in a few hours, but its establishment, depots, fuel, spare parts and workshops take many weeks, and even months, to develop.

Throughout the post-Cold War period in particular, the Royal Air Force has demonstrably repudiated this accusation, deploying swiftly and operating for long periods at the end of extended logistics chains. The ability to deploy air power globally, reliably, and at extremely short notice, largely accounts for air power's attractiveness to military and political decision-makers alike. Owing to their rapid deployability, air forces are likely to remain the first recourse in response to international crises, but flexibility and adaptability of air power in its purest sense must be matched by similar agility in logistics. Joint logistics planning that appropriately prioritises and understands air power must be complemented by partnering with international allies and industry, and must address the potential vulnerabilities associated with an attendant reliance on cyberspace. The F-35 programme, which is vital to many of the air forces cited in this volume, is exploiting the opportunities for global logistics management while addressing the threat of cyber disruption, ensuring that support and sustainment will match the outstanding military capabilities of Lightning II. The unprecedented scale of international partnering in the F-35 programme also demonstrates that a monocular (i.e. Western) view of air power is neither achievable nor desirable.

Contemporary scholars are sometimes criticised for assessing the utility and effectiveness of air power through this narrow Western prism, focused on Western coalitions and, in particular, on those led by the US. In its concluding section, this handbook has more than adequately countered that accusation of collective myopia. The chapters which focus on non-Western nations are valuable not just because they open a window onto the perspectives of states whose strategic aims differ from those countries most often studied, but also because they provide a welcome opportunity to remind us of the dangers of complacency in our established ways of doing things. Indeed, we would be foolish to assume that any one air force, or even one alliance, commands a monopoly of air power knowledge, and the chapters included in Part V of this book provide important insights into other nations' approaches.

We all know that the world is changing rapidly and, as many of the authors point out, the freedom that Western air forces have enjoyed for nearly three decades in leveraging the asymmetric advantages of their air power is diminishing. Air power will not, however, decline in importance. Indeed, the degree to which control of the air is increasingly being contested underlines its vital significance to all current and future joint military operations.

While different air forces face different challenges, ranging from their unique strategic positions and industrial capacities to the selection, training, and retention of their airmen and women, the need to innovate to meet those challenges is universal. As Richard Hallion has observed in Chapter 4, all of aviation's major advancements – from the gas turbine to stealth technology – have depended on the successful cultivation of the spirit of enterprise and exploration which led to humankind taking flight in the first place. Predicting the future is dangerous, but I am certain that the powers of innovation and invention that inspired the revolutionary technologies to which aerospace gave birth will be in equally high demand and just as influential in the future.

The challenges facing air power professionals around the world – technological, financial, legal, and many more besides – demand that those who occupy leadership positions at all levels provide the vision, direction, and investment necessary to ensure that air and space power continues to offer the options decision-makers need. While we do this every day on operations, we must also ensure that this culture is nurtured throughout our organisations. This volume

offers well-honed guidance in this area and, for those with responsibilities for the higher command of air forces, Alan Stephens's Chapter 2 is well worth re-reading on completion of the remainder of the book. The four components he identifies as being of greatest importance to higher command – organisation, intellect (strategy), politics and inspiration (leadership) – are as relevant today as they were in Hugh Trenchard's day a century ago. Indeed, I am certain that, were Lord Trenchard alive today, he would be surprised that despite the revolutionary developments that have served as waypoints on air power's route through history, the principles of high command that are vital to air power's relevance and success have remained constant, as have, perhaps just as surprisingly, air power's core roles.

We are, as General Hap Arnold remarked, 'Only as good as our ideas', and Alan Stephens has correctly identified that the principal challenge facing high-level commanders 'lies within the contest of ideas'; it has ever been thus. It will be through fostering a conceptual environment in which our people's ideas can emerge, grow, and be sustained that future air and space power will continue to exploit its unique attributes to the full throughout the next century.

Air Chief Marshal Sir Stephen Hillier, RAF

Note

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