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Chapter

1

INTRODUCTION

- Science and Technology are perceived the world over as major tools for rapid social and economic development. The more industrialized countries of the world applied science and technology to develop their economics. China, South Korea, India, Malaysia and Singapore, and a few other countries, followed their footsteps and have also successfully applied science and technology to transform their economies.
- India's commitment to the use of science and technology as a key instrument in national development has been clearly articulated time and again in various policy documents right from the early years of independence. Indeed, progress made by our country since the attainment of the stated goals in policy and plan documents has been substantial.
- In the pre-economic reform era, the question of scientific and technological development in India had a central role in the general debate on the country's development strategy, whether in policy-oriented discussions, in academic considerations or in discussions in the public and political arena.
- This eagerness to perform creatively in science came to be backed with an institutional setup and strong state support after the country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern Science and Technology infrastructure in the country. The Government firmly believed that S&T would be the twin tools that would help bring about social equality and economic development to enable India join the mainstream of world community. This conviction was reflected in the **Scientific Policy Resolution (SPR)** of 1958.
- Today, India is acknowledged as the third largest storehouse in the world for technically qualified workers. The pioneering Indian spirit has manifested itself in many fields and many frontiers have been won over. In the past 5 decades 200 universities affiliating around 3000 colleges have been established to serve as an incubation ground for producing lakhs of technical qualified professionals.

India's Policy in the Field of the Science & Technology

- **Science, Technology and Innovation (STI)** have emerged as the major drivers of national development globally. As India aspires for faster, sustainable and inclusive growth, the Indian STI system, with the advantages of a large demographic dividend and the huge talent pool, will need to play a defining role in achieving these national goals. The national STI enterprise must become central to national development.

- The policies should be driven on the principles of relevance, realism, cost effectiveness, synergy and partnership for becoming a developed economy in the shortest possible time to achieve national development strategy that would harness the nation's total science and technology capacity to achieve national objectives.

- **Objectives of the science technology and innovation policies:**
  - The national science, technology and innovation policy is to ensure that science and technology pervades all sector of the economy.
  - In order to achieve these objectives, sectoral policies, programmes and strategies would be implemented on the basis of the overall National Science, Technology and Innovation Policy.
  - Sectoral policies in Agriculture, Health, Education, Environment, Energy, Trade, Industry, Natural Resources, Human Settlements and Communications shall be driven by sector-specific science and technology programmes and activities.

The Science & Technology Policy Resolution in 1958

- It aims to promote, foster, cultivate and sustain science and scientific research in all aspect to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge. The drafting of this resolution is attributed mainly to Homi Jehangir Bhaba and Jawaharlal Nehru.
- Besides the government also sought the advice of scientists, technologists, and educationists through various conferences. The first national conference was organized in 1958, the second in 1963 and the third in 1970. The aim of these conferences was to bring together on a common platform, all concerned with promotion of S&T efforts, cutting across hierarchy and to enable the Government to direct and interact with S&T personnel, to discuss problems connected with policy matters, structures, programs and issues.
- The third conference has regretted that the implementation of the policy has been highly ineffective, brings the unanimous views that a policy for S&T and for industrial development should be not only mutually compatible but also positively reinforcing. The planning for S&T should be integrated with the overall socio-economic development of the country if Science and Technology has to make an impact on the economy of the nation.
- After the SPR, this was the major Government document, which listed out in concrete terms the objectives of science policy. The entire national thrust was divided into 27 sectors. This document was presented in two volumes. The first volume contained a statement of policy issues and the second dealt with concrete programs. It was a formidable task indeed. The S&T was no doubt integrated with socio-economic programmes but the links were more physical than organic.

Science & Technology Policy of the 1983

- The basic aim is the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources.
- Attain technological competence and self-reliance to reduce vulnerability, particularly in strategic and critical areas, making the maximum use of indigenous resources.
- Provide the maximum gainful and satisfying employment to all strata of society, with emphasis on the employment of women and weaker sections of the society.

- Use traditional skills and capabilities making them commercially competitive.
- Ensure the correct mix between mass production technologies and production by the masses.
- Identify obsolescence of technology in use and arrange for modernization of both equipment and technology.
- Develop technologies which are internally competitive, particularly those with export potential
- Improve production speedily through greater efficiency and fuller utilization of existing capabilities and enhance the quality and reliability of performance and output.
- Reduce demand on energy, particularly energy from non-renewable resources.
- Ensure harmony with the environment, preserve the ecology balance and improve the quality of the habitat
- Recycle waste material and make full utilization of by-products.

Science & Technology Policy 2013

The Policy interalia aspires 'positioning India among the top five global scientific powers'. The policy goal is the establishment of a strong and viable **Science, Research and Innovation system for High Technology led path for India (SRISHTI).**

The Key Features of the STI Policy 2013 are:

- **Budget:** Increasing the Research and Development (R&D) spending to 2% in next five years' time through PPP; creating conductive environment for encouraging private sector investment in R&D.
- **Manpower:** Promotion of spread of scientific temper amongst all sections of society; attracting talented and bright minds towards careers in science, research and innovation; increasing the number of R&D personnel by 66% in next five years; creating environment for women to enter in R&D field; and setting up inter university centers, bringing together different disciplines of humanities and science together.
- **Business:** Identifying 10 sectors of high potential and putting more resources into them for STI; increasing by two folds the global share of high tech products; increasing R&D intensity in service sector, small and medium scale enterprises; sharing the risk on R&D investments with private sector; providing new financing mechanisms for entrepreneurs; creating a public procurement policy that favors indigenous innovations; achieving synergy between R&D policy for agriculture vs. STI policy.
- **Climate Change**: Active role in implementation of National Action plan for Climate Change (NAPCC); and providing incentives for green manufacturing.
- **PPP:** Setting up of a National science, Technology and innovation foundation to facilitate investments in S&T projects under PPP mode and large scale R&D facilities under PPP mode; establishing technology business incubators and science-led entrepreneurships; and treating private sector R&D institutions at par with public sector institutions for giving public funds.
- **IPR:** Modification of Intellectual Property Rights (IPR) for social goods and IPR generated under PPP; setting up of a regulatory and legal framework for sharing IPRs between Investors and inventors.
- **Participation:** Encouraging participation of all STI stakeholders including: a) women and differently-abled and disadvantaged sections of society; b) NGOs who would play pivotal role for delivery science-tech-innovation outputs especially related with rural / grassroots level;

Critical Analysis of Policy

- Unfortunately, the Policy adopts a 'one-size, fit-all' approach towards STI. Though the basic policy tools may remain the same across the board, customized policy tools may be required for each sector.

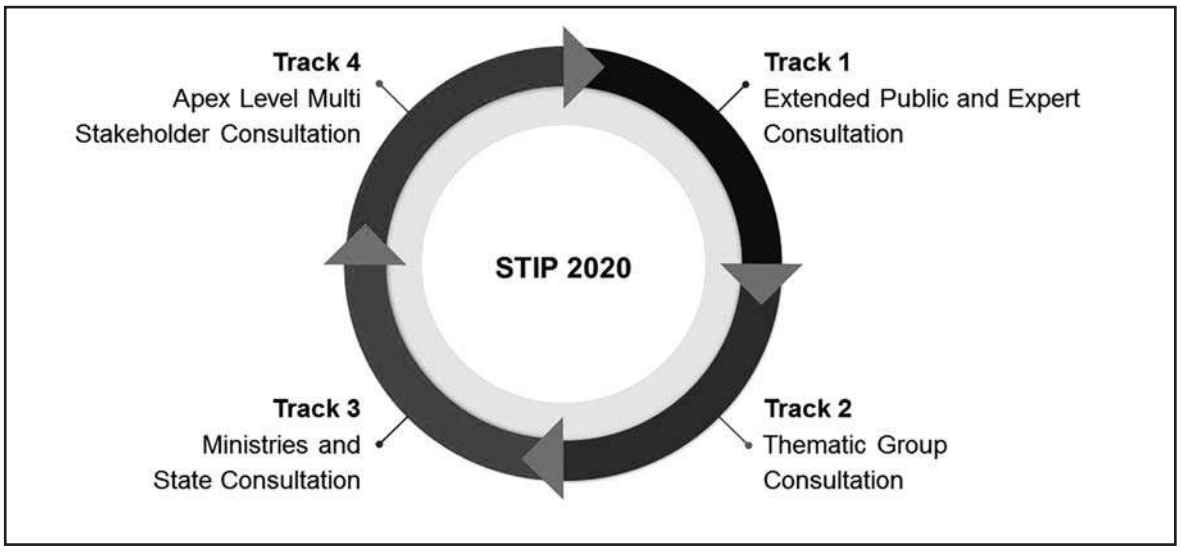
For instance, the policy framework The Policy has also totally overlooked Traditional Knowledge ("**TK**") especially when the potential is untapped. There is ample scope for leveraging our TK for achieving the larger objectives of the Policy. The Policy fails to integrate the aforesaid aspect into its framework. It is to be noted that the Policy seeks to "vertically integrate all dimensions of STI into the socio-economic processes" and promote" inclusive innovation". The Policy, further, states that the focus is on "both people for science and science for people". Perceived in this context, its muted approach towards leveraging TK is perturbing. Further the good and bad of Indian policy initiatives for scientific research and innovation', several forthcoming initiatives of the government are stalled either at Parliament or in Ministry of S&T.

- There exists regulatory deficit in Indian science which is a debilitating factor for any forthcoming wholesome and sustainable progress in STI. The Policy should have called for a quick review and implementation of the same as these delays dent the objectives stated to be achieved.
- Further rather than focusing on enhancing the R&D facilities in universities (which should have received the primary focus), it intends to multiply inter-university centres "to enable a wide cross section of university researchers to access advanced research facilities and equipment which are otherwise not available in university environments."

Science, Technology and Innovation Policy 2020

- It is a milestone moment for Indian science, technology and innovation ecosystem as the formulation of 5th national Science, Technology and Innovation Policy 2020 (#STIP2020) is in full swing.
- As India and the world reorient in the wake of the COVID-19 crisis, a landmark policy initiative has been flagged by the Government of India. STIP 2020 is being formulated at a crucial juncture when India and the world are tackling the COVID-19 pandemic.
- As the crisis has set the 'new normal', the policy aims to reorient STI in terms of priorities, sectoral focus and strategies. It is one of the most significant events amidst many important changes in the past decade that have necessitated formulation of a new outlook and strategy for Science, Technology, and Innovation (STI).
- This policy is the culmination of new perspectives and reforms that addresses India's science, technology and innovation. The core vision of STIP 2020 is the decentralization of policy designing by making it a bottom-up and inclusive process. It aims to realign priorities, sectoral focus and methods of research and technology development with the goals of larger socio-economic progress.

Policy Process



- A participative model with four interconnected tracks has been envisioned to formulate the STIP 2020. The consultation processes on different tracks have already started and are running in parallel.
- Track – I Extended public and expert consultation, aims to capture the aspirations of a larger set of stakeholders and create a repository of public voices that will act as a guiding force for the drafting process. There are six unique activities under this track, designed carefully keeping the limitations (access, reach, digital services, language barriers and last-mile connectivity) of different stakeholder groups in mind. Through live virtual conversations with thought leaders, thematic public panel discussions, focused survey instruments, digital and print media campaigns along with community radio broadcasts and a competition called 'the ideathon' to ignite minds to engage creatively with STIP 2020. Track I, through the Science Policy Forum, engages with a larger pool of public and experts, and gathers inputs during and after the policy drafting process. Click here and unlock opportunities to participate in the drafting process of STIP 2020
- Track II – 21 Thematic Groups, comprises experts-driven thematic consultations to feed evidence-informed recommendations into the policy drafting process. Twenty-one (21) focused thematic groups have been constituted for this purpose.

Science & Technology as a Source of Human Resource Development

- The government supports different programmes aimed at identifying new talent and providing them with financial assistance in the form of fellowships for pursuing research in front-line areas of science and technology. Some schemes are described as below:
- **Ramanujan Fellowships:** The fellowship is meant for brilliant scientists and engineers from all over the world to take up scientific research positions in India, especially those scientists who want to return to India from abroad. The fellowships are scientist-specific and very selective. The Ramanujan Fellows could work in any of the scientific institutions and universities in the country and they would be eligible for receiving regular research grants through the extramural funding schemes of various S&T agencies of the Government of India.
- **J C Bose National Fellowships:** The fellowship is meant to recognize active scientists and engineers for their outstanding performance and contributions. The Department of Science & Technology will administer this scheme. The fellowships are scientist-specific and very selective. All areas of science (in the broadest terms) will be covered by this fellowship.
- **Kishore Vaigyanik Protsahan Yojana (KVPY):** The Kishore Vaigyanik Protsahan Yojana is a programme initiated by the Government of India to encourage students of the Sciences, Engineering and Medicine to take up careers in research in these fields. The programme aims to identify and select students who demonstrate talent and aptitude, and encourage and assist them in pursuing research careers in their chosen fields.
- **Swarnajayanti Fellowships Scheme:** Under this scheme a selected number of young scientists, with proven track record, are provided special assistance and support to enable them to pursue basic research in frontier areas of science and technology. The fellowships are scientist specific and not institution specific, very selective and have close academic monitoring.
- **Women Scientists Scheme:** The "Women Scientists Scheme (WSS)" provide opportunities to women scientists and technologists between the age group of 30-50 years who desire to return to mainstream science and work as bench-level scientists. Under this scheme, women scientists are being encouraged to pursue research in frontier areas of science and engineering, on problems of societal relevance and to take up S&T-based internship followed by self-employment.

- **INSPIRE programme:** Innovation in Science Pursuit for Inspired Research (INSPIRE) is an innovative programme to communicate to the youth of the country the excitements of creative pursuit of science, attract talent to the study of science at an early age and thus build the required critical human resource pool for strengthening and expanding the Science & Technology system and R&D base. INSPIRE Scheme has included three components.
- **KIRAN (Knowledge Involvement in Research Advancement through Nurturing):** KIRAN is addressing various issues related with women scientists (e.g. unemployment, relocation etc.) and aimed to provide opportunities in research (WOS-A), technology development/demonstration (WOS-B), and self-employment (WOS-C) etc. KIRAN is also actively involved in taking proactive measures, under the name CURIE (Consolidation of University Research for Innovation and Excellence in Women Universities) to develop state-of-the-art infrastructure in women universities in order to attract, train and retain promising girls students in S&T domain.
- **Ramalingaswami Re-entry Fellowship:** It was conceived with the idea of encouraging Indian scientists working outside the country (Indian Nationals), and who would like to come back home and pursue their research interests in life sciences and biotechnology and other related areas. During the last six years 247 overseas scientists were selected and 173 have already returned and joined various research institutes/ universities 27 scientists are likely to join in next six months. 50 scientists are selected every year. This has enriched the scientific pool of the country.

Skill Development in North Eastern Region (NER):

- **Twinning Programme**: The goal of this programme is to strengthen R&D activity in the North East India through joint collaborations. Financial assistance is provided to competitive R&D projects from scientists in the North Eastern States in collaboration with scientists from national institutions from other parts of the country. The programme has supported nearly 400 R&D projects, leading to more than 200 papers published in peer reviewed journals, and more than 450 young scientists of NER trained in advanced biotechnology. Every year approximately 70-80 projects under this flagship programme are being supported to NER.
- **Setting up of "DBT-NER Centre for Advanced Animal Diagnostics and Services on Animal Health and Diseases (ADSAHD)"** involving stake holders from all NER States including national laboratories from Bhopal, Bangalore and Hissar.
- **Establishment of Unit of Excellence in Biotechnology (U-Excel):** with a view to recognize promising mid-career scientists in NER, this has been initiated to enable them to pursue their innovative research in frontier areas of biotechnology. So far, 12 units of excellence have been established during the year.

New Initiatives Aligned with the National Agenda

Nano Science and Technology

- National Mission of Nano Science and Technology - an umbrella programme was launched in 2007 to promote R&D in this emerging area of research in a comprehensive fashion.
- **The main objectives of the Nano Mission are:**
  - Basic research promotion,
  - Research infrastructure development,
  - Nano application and technology development,

- Human resource development,
- International collaboration and orchestrating national dialogues.

- India has secured third position amongst nations of the world in terms of scientific publications in this emerging area.

Climate Change

- National Mission for Sustaining the Himalayan Ecosystem (NMSHE) and National Mission for Strategic Knowledge on Climate Change (NMSKCC) launched under National Action Plan for Climate Change (NAPCC) are under implementation by the Department.
- Himalayas Climate Change Portal has been launched to make the knowledge on Himalayas readily available for the end users and community.

Other initiatives

- National Supercomputing Mission was approved in March 2015. This is a visionary programme to enable India to leapfrog to the league of world class computing power nations. The Mission is under implementation jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) at an estimated cost of 4,500 crore over a period of seven years
- DST has launched a new programme viz. Science and Technology of Yoga and Meditation (**SATYAM**) in 2015-16 to rejuvenate research in yoga and meditation.
- National Initiative for Developing and Harnessing Innovations (**NIDHI**) has been evolved as an umbrella scheme for a seamless innovation ecosystem booster.
- ***The specific components of NIDHI are:***
  - Promotion and Acceleration of Young and Aspiring innovators & Startups (**PRAYAS**) - Support from Idea to Prototype;
  - Entrepreneur in Residence (**EIR**) - Support system to reduce risk;
  - Startup-NIDHI through Innovation and Entrepreneurship Development Centres (IEDCs) in academic institutions for encouraging students to promote start-ups; and
  - Start-up Centre in collaboration with MHRD— inculcating a spirit of entrepreneurship in National Institutions of Higher Learning.
- **MANAK** (Million Minds Augmenting National Aspirations and Knowledge): To widen the base of the innovation pyramid by cultural intervention, ideas relevant to the national needs are to be invited from 10 lakh school students in any language.
- With the objective to contribute towards **Swachh Bharat**, a new programme viz. **Technology Development for Waste Management** has been initiated to come up with technological solutions for the problems faced by the country in waste management.

India & World Collaboration in Science Projects

In the last six decades a rash of scientists had left India for better opportunities and, over the years,gained vital exposure to the best global research labs. After years of experimenting and collaborating with some of the top scientists in the world, they have now chosen to return to their homeland.

- Recently, India's participation in frontier mega-projects provides an excellent opportunity for the country's scientific community to showcase its prowess on the global stage. At the same time, next-generation experiments on Indian soil also offer challenging career options in science and technology. This step can be significant in encouraging India's top talents, who are working in foreign organizations and laboratories, to return and work in India.

Mega Science Projects are discussed below:

- Global Mega Science Projects often involve cross-border cooperation between teams of competent researchers. While the scientific goals of these projects are significant, their worldly benefits are equally important. By collaborating, participating and delivering components for these giant projects, India will place itself as a major player in fundamental science. In addition, these projects have the potential to create new avenues for science-industry collaborations and to popularize science in the country.

List of Six Major Science Projects

- LIGO – Gravitational Wave Analysis
- LHC – The God Particle
- Thirty Metre Telescope – World's Most Advanced Telescope
- ITER – Fusion Energy
- FAIR – Facility for Antiproton and Ion Research
- SKA – World's Largest Radio Telescope

LIGO – Gravitational Wave Analysis

- LIGO or Laser Interferometer Gravitational-Wave Observatory is a large-scale physics experiment that detects cosmic gravitational waves and develops them as an astronomical tool.
- There are two LIGO observatories in USA (at Livingston and Richland) that are operated by Caltech and Massachusetts Institute of Technology (MIT). The Indian team in the global LIGO collaboration, which is involved in analysing the data collected by LIGO observatories, has 60 members.

LHC – The God Particle

- There is an intrinsic Indian connection to the discovery of Higgs Boson at CERN – Satyendra Nath Bose, the Indian scientist after whom the sub-atomic particle is named. Over the years, CERN, the world's largest particle physics laboratory, has seen Indian scientists make quite a mark with their work.
- Indian scientists have helped build the **Large Hadron Collider (LHC),** the largest single machine and the most powerful particle collider in the world. They are also collaborating on two significant CERN experiments, CMS and ALICE. CMS is one of the two experiments that discovered the Higgs Boson (also called God Particle) and ALICE studies matter under extreme conditions of density and temperature that may have existed at the birth of the universe.
- India is also poised to become an associate member of CERN by the end of 2016, which would entitle it to attend even the restricted sessions of the organization. And this is all thanks to our brilliant scientists.

Thirty Metre Telescope – World's Most Advanced Telescope

- The **Thirty Meter Telescope (TMT)** will be the world's most advanced and capable ground-based telescope. At the heart of the telescope will be a mirror made up of 492 individual segments. Precisely aligned, these segments will work together as a single reflective surface with a diameter of 30 metres.
- The TMT- India project will propel India into a special league of deep space research. The main Indian institutes working on this unique project are **Aryabhatta Research Institute for Observational Sciences (ARIES),** the Indian Institute of Astrophysics (IIA), and the **Inter-University Center for Astronomy and Astrophysics (IUCAA)**.

ITER – Fusion Energy

- ITER (International Thermonuclear Experimental Reactor) is an experimental nuclear fusion reactor that is being built at Cadarache in the south of France. It's the core of a nuclear fusion research megaproject that will also be the world's largest plasma physics experiment.
- The ITER project aims to make the long-awaited transition from experimental plasma physics to full-scale electricity-producing fusion power stations

FAIR – Facility for Antiproton and Ion Research

- The Facility for Antiproton and Ion Research (FAIR) is an international accelerator facility that will be used to study the building blocks of the universe. Situated in Darmstadt in Germany, FAIR will use intense beams of antiprotons and ions for research in the fields of nuclear, particle, plasma and anti-matter physics.
- In India, the project is being co-ordinated by the **Indo-FAIR Coordination Centre (IFCC)** at Bose Institute, Kolkata and being jointly implemented by the Department of Science and Technology and the Department of Atomic Energy. Several Indian industries are also involved in building advanced equipment for the FAIR accelerator.

SKA – World's Largest Radio Telescope

- The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope that is currently scheduled for completion in 2024. With an unprecedented large collecting area of over a square kilometre, the SKA will be 50 times more sensitive and 10,000 times faster than any imaging radio telescope array previously built.

Benefits of indulging in collaboration

- Academic and research collaboration is a very valuable tool that not only accelerates the progress but also enhances the quality of the work and extends the repertoire of the partners. Academic collaboration is beneficial to the faculty in learning new teaching tools, and to the students in increasing the breadth of their knowledge and learning different approaches to solving a problem.

These opportunities include:

- Enhancing scientific capabilities,
- Enhancing the stability of science goals and funding
- Supporting foreign policy
- Addressing global science and technology issues.

PROJECT	PURPOSE	COST	IMPACT OF INDIA
Thirty Meter Telescope, to be built in Hawaii	**To be the world's** most advanced ground-based telescope	**More than $1billion,** shared by five countries. India's share to be more than Rs.1000 cr	**At least Rs.700 cr of orders** for Indian companies, with enhancement of engineering capabilities in optics and alloys.
Square Kilometre Array radio telescope, to be built in South Africa and Australia	**50 times more** sensitive and 10000 times faster than any other radio telescope	**€ 650 m** for Phase I, India to spend Rs. 145 cr	**Lead the telescope manager,** developing state-of-the-art control systems

India-based Neutrino Observatory	**To detect and study** neutrinos, mysterious particles that could provide insights into fundamental physics	**Rs.1,500 cr** Entirely borne by India	**Building giant magnets** and control systems, apart from research on detectors.
Laser Interferometry Gravitational Wave Observatory (Ligo) India	**To study gravitational** waves that could provide a new window to the cosmos	**Rs.1,200 cr**	**Precision optical engineering,** development of high vacuum.

Way Forward

- Government of India is working for the development of India as a technological hub. Many projects for the better utilization of science and technology in day to day activities have already been initiated or are going to be initiated. As development in field of science is an ongoing process thus a constant effort is required for its progression.
- India having 50% population under age of 25 years, thus proper initiatives should be taken to attract best talent of the country in field of science. Government has already started fellowship programmes and scholarships to motivate young talent towards the field of science but an inclusive plan to cover children of all caste, race and economic status is must for the development of the nation as a technological hub.

****

Chapter

2

SPACE

From the perspective of an Earthling, outer space is a zone that occurs about 100 kilometers (60 miles) above the planet, where there is no appreciable air to breathe or to scatter light. In that area, blue gives way to black because oxygen molecules are not in enough abundance to make the sky blue. Further, space is a vacuum, meaning that sound cannot carry because molecules are not close enough together to transmit sound between them. That's not to say that space is empty, however. Gas, dust and other bits of matter float around "emptier" areas of the universe, while more crowded regions can host planets, stars and galaxies.

No one knows exactly how big space is. The difficulty arises because of what we can see in our detectors. We measure long distances in space in "light-years," representing the distance it takes for light to travel in a year (roughly 5.8 trillion miles, or 9.3 trillion kilometers).

Space science encompasses all of the scientific disciplines that involve space exploration and study natural phenomena and physical bodies occurring in outer space, such as space medicine and astrobiology.

Satellite communication

Satellite communication is the use of artificial satellites to provide communication links between various points on Earth. A satellite is basically a **self-contained communications system** with the ability to receive signals from Earth and to retransmit those signals back with the use of a transponder—an integrated receiver and transmitter of radio signals.

Type of Orbits

- **Polar Orbits:** A polar orbit is one in which a satellite passes above or nearly above both poles of the body being orbited (usually a planet such as the Earth) on each revolution.
  - These orbits have an inclination near 90 degrees. This allows the satellite to see virtually every part of the Earth as the Earth rotates underneath it. The important features of the satellites revolving in polar orbits are as follows:
    - A satellite in a polar orbit will pass over the equator at a different longitude on each of its orbits.

- It takes approximately 90 minutes for the satellite to complete one orbit.
- These satellites have many uses like measuring ozone concentrations in the stratosphere or measuring temperatures in the atmosphere; earth mapping and observation; reconnaissance; study of weather etc.

- **Sun Synchronous Orbits:** A satellite whose time period is such that it makes exactly an integral number of revolutions (usually 13, 14 or 15) around earth in 24 hours. After passing over a certain place on Earth, next day it will again pass over the same place at the same time of day.
  - While Earth spins one rotation, relative to sun in 24 hours, the satellite makes an accurately integral number of revolutions. Thus, satellite will be able to look at that place and photograph it on consecutive days in identical illumination, Sun being in the same position relative to that place. Such an orbit is called a sun-synchronous orbit & the satellite moving in this orbit is called a sun-synchronous satellite. The important features of the satellites moving in the sun synchronous orbits are as follows:
    - These orbits allow a satellite to pass over a section of the Earth at the same time of day. Since there are 365 days in a year and 360° in a circle, it means that the satellite has to shift its orbit by approximately 1° per day.
    - These satellites orbit at an altitude between 700 to 800 km.
    - These satellites are very important for military and remote sensing purposes.
- **Geosynchronous Orbits/ Geostationary Orbit:** The satellites in these orbits circle the Earth at the same rate as the Earth spins. The orbit of such satellite is in the plane of equator, i.e. its inclination is 0o, at a height of about 36,000 km above the equator and keeps this distance constant.
  - Thus, it is a circular orbit. Hence, relative to any location on earth, the position of the satellite is stationary. This orbit is called geo-stationary orbit. A satellite revolving in this orbit is called a geo-stationary satellite. The important features of the satellites moving in the geostationary orbits are as follows:
    - Geosynchronous orbits allow the satellite to observe almost a full hemisphere of the Earth. These satellites are used to study large scale phenomenon such as hurricanes, or cyclones.
    - These orbits are also used for communication satellites. The disadvantage of this type of orbit is that since these satellites are very far away, they have poor resolution. The other disadvantage is that these satellites have trouble monitoring activities near the poles.
- **Low Earth Orbit (LEO):** The Low Earth Orbit extends from 200 km. to 1200 km. It means that it is relatively low in altitude, although well above anything that a conventional aircraft can reach. However LEO is still very close to the Earth, especially when compared to other forms of satellite orbit including geostationary orbit. The important features of the Low Earth Orbit are as follows:
  - Orbit times are much less than for many other forms of orbit.
  - Less energy is expended placing the satellites in LEO than higher orbits.
  - The lower orbit means the satellite and user are closer together and therefore path losses a less than for other orbits such as GEO.
  - LEO satellites have shorter life spans than others.
  - Some speed reduction may be experienced as a result of friction from the low, but measurable levels of gasses, especially at lower altitudes.
  - Radiation levels are lower than experienced at higher altitudes.
    - A variety of different types of satellite use the LEO orbit levels. These include different types and applications including communications satellites, earth monitoring satellites etc.
    - The International Space Station is in an LEO that varies between 320 km. (199 miles) and 400 km. (249 miles) above the Earth's surface.

- **Space Debris in LEO:** Apart from the general congestion experienced in Low Earth Orbit, the situation is made much worse by the general level of space debris that exists. There is a real and growing risk of collision and major damage - any collisions themselves are likely to create further space debris.

- **Medium Earth Orbits (MEO):** They are in between LEO and geostationary orbits & operate about 8,000-20,000 km. above the earth. They are placed in an elliptical orbit.
  - The orbit is basically used for communication satellites.
  - Examples include GPS and Global Communication and Orblink.

Launch Vehicles

ASLV:

- Augmented Satellite Launch Vehicle (ASLV) was developed to act as a low cost intermediate vehicle to demonstrate and validate critical technologies.
- With a lift off weight of 40 tonnes, the 23.8 m tall ASLV was configured as a 5 stage, all-solid propellant vehicle, with a mission of orbiting 150 kg class satellites into 400 km circular orbits.
- The strap-on stage consisted of 2 identical 1m diameter solid propellant motors, Under the ASLV programme 4 developmental flights were conducted.
- ASLV provided valuable inputs for further development.

PSLV:

- The Polar Satellite Launch Vehicle, usually known as PSLV is the 1st operational launch vehicle of ISRO.
- PSLV is capable of launching 1600 kg satellites in 620 km. sun-synchronous polar orbit and 1050 kg. satellite in Geo-synchronous Transfer Orbit (GTO).
- In the standard configuration, it measures 44.4 m. tall, with a lift off weight of 295 tonnes.
- PSLV has 4 stages using solid and liquid propulsion systems alternately. The 1st stage is one of the largest solid propellant boosters in the world and carries 139 tonnes of propellant.
- A cluster of 6 strap-ons attached to the 1st stage motor, 4 of which are ignited on the ground and 2 are air-lit.
- The reliability rate of PSLV has been superb. With its variant configurations, PSLV has proved its multi-payload, multi-mission capability in a single launch and its Geosynchronous launch capability.

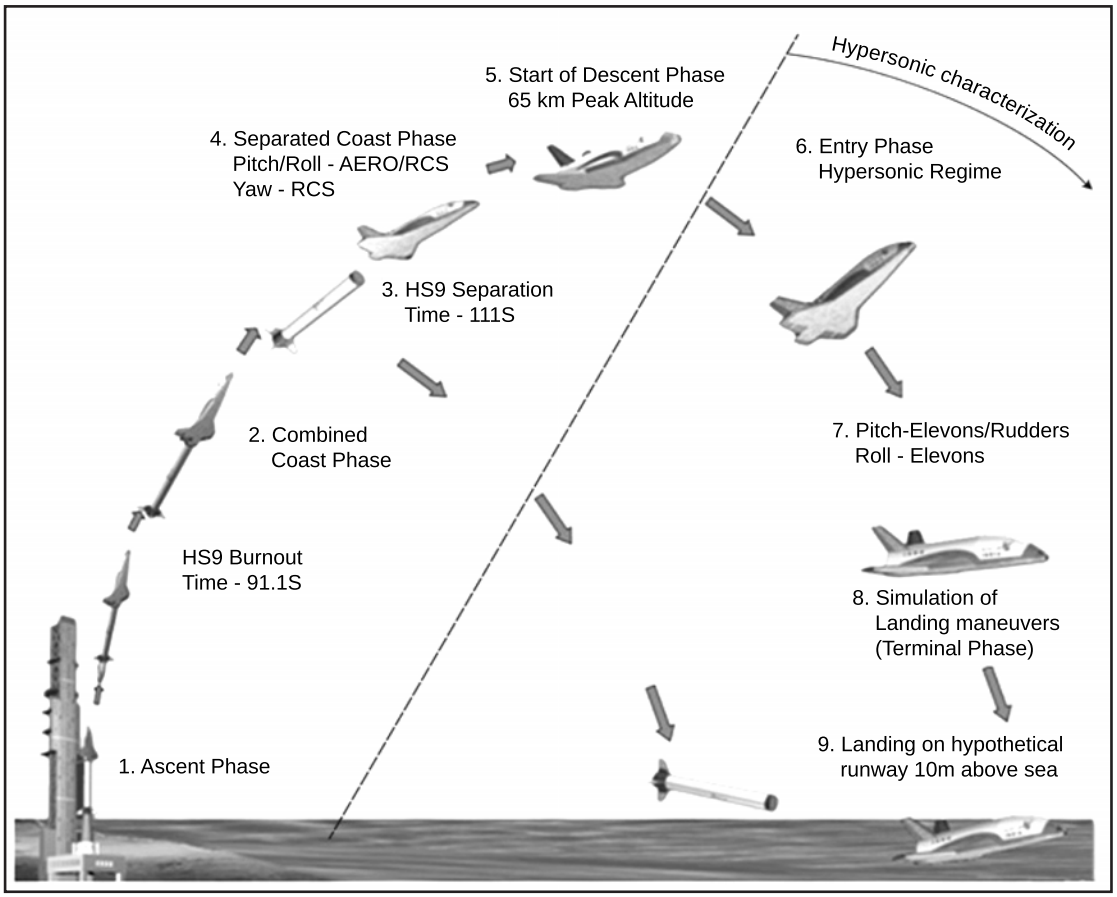
GSLV Mk I & II:

- Geosynchronous Satellite Launch Vehicle (GSLV)-Mark I&II , is capable of placing INSAT-II class of satellites (2000 - 2,500 kg) into Geosynchronous Transfer Orbit (GTO). GSLV is a 3 stage vehicle GSLV is 49 m tall, with 4141 lift off weight.
- It has a maximum diameter of 3.4 m at the payload fairing. 1st stage comprises S125 solid booster with four liquid (L40) strap-ons. 2nd stage (GS2) is liquid engine and the 3rd stage (GS3) is a cryo stage. The vehicle develops a lift off thrust of 6573 km.

GSLV Mk III:

- The GSLV-III or Geosynchronous Satellite Launch Vehicle Mark III is a launch vehicle currently under development by the Indian Space Research Organization.

- GSLV Mk III is conceived and designed to make ISRO fully self reliant in launching heavier communication satellites of INSAT-4 class, which weigh 4500 to 5000 kg.
- It would also enhance the capability of the country to be a competitive player in the multimillion dollar commercial launch market.
- The vehicle envisages multi-mission launch capability for GTO, LEO, Polar and intermediate circular orbits.



Reusable Launch Vehicle:

- A reusable launch system (or reusable launch vehicle, RLV) is a launch system which is capable of launching a launch vehicle into space more than once. This contrasts with expendable launch systems, where each launch vehicle is launched once and then discarded.
- **Reusable Launch Vehicle-Technology Demonstration (RLV-TD)** Programme of ISRO is planned as a series of technology demonstration missions that have been considered as a first step towards realising a **Two Stage To Orbit (TSTO)** fully reusable vehicle.
- A Winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies using air breathing propulsion. These technologies will be developed in phases through a series of experimental flights.
- **Hypersonic experiment (HEX)** flight, the first in the series of experimental flights, will be followed by the **Landing experiment** (LEX), **Return flight experiment (REX) and Scramjet Propulsion experiment (SPEX).**
- RLV-TD HEX1 is planned to demonstrate the hypersonic aerothermo dynamic characterisation of winged re-entry body, autonomous mission management to land at a specified location and characterisation of hot structures.

- Application of these technologies would bring down the launch cost by a factor of 10.
- The first experimental mission of ISRO's Scramjet Engine towards the realisation of an Air Breathing Propulsion System was successfully conducted from Satish Dhawan Space Centre SHAR, Sriharikota.
- The Scramjet engine designed by ISRO uses Hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser. This test was the maiden short duration experimental test of ISRO's Scramjet engine with a hypersonic flight at Mach 6. ISRO's **Advanced Technology Vehicle (ATV),** which is an advanced sounding rocket, was the solid rocket booster used for the test of Scramjet engines at supersonic conditions. ATV carrying Scramjet engines weighed 3277 kg at lift-off.

Cryogenic Rockets

- Cryogenic fuelled liquid rockets use **liquid hydrogen (Liquid H2) as fuel and liquid oxygen (Liquid O2)** as oxidizeras. These liquid gases are stored on board at **below minus 253 & 183 degree** centigrade temperature respectively.
- The cryogenic fuels are stored on board a rocket, in separate tanks. These liquid fuels are pumped out from storage tanks and injected into the combustion chamber in the gaseous form.
- The gaseous mixture in combustion chamber is ignited by a pyrotechnic igniter. This process generates high pressure combustion gases which are expelled out through the nozzle connected to the chamber, giving the required thrust to move the rocket body up.
- Now the first technological challenge in using cryogenic propulsion system is to produce and harness liquid hydrogen and oxygen in tanker type storage, transport these liquids to the launch site, interim storage at launch site and fill these propellants into the rocket at the time of launch count down.
- The most difficult task is to handle hydrogen since it burns with even the slightest trigger of inadvertent ignition. The flame is invisible hence a great safety hazard. The gravity of the hazard can be visualized in the fact that a man will be burning even if no flame is seen.

Gravitational Waves

- Gravitational waves are ripples in the space time curvature traveling outward from the source produced by violent events such as collision of 2 black holes or by supernova explosion. They are produced by accelerating masses just the same as accelerating charged particles produce radio waves (electrons in antennas).
- GW are akin to Electromagnetic Waves (EM) waves, but emitted by gravitating bodies in motion such as black holes, spiraling towards each other in binary orbits.

Properties

- Can penetrate regions of space that EM have no reach
- Gravitational waves are hypothesize to arise from cosmic inflation (expansion of universe after big bang)

How do the waves manifest themselves on the earth?

- Gravitational waves travel at the speed of light and distort space-time on their path. The effect would be such that the length between 2 objects on earth would vary with time whenever a wave is passing through them. But these variations are so small, it is impossible to directly measure them even with the most accurate measuring techniques.

LIGO And The Indigo

- LIGO- laser interferometer gravitational wave observatory -is large scale collaboration between scientists of MIT, Caltech and other institutions.
- Founded in 1992 aimed at detecting the gravitational waves that were once predicted by Einstein and also validate this general theory of relativity.
- For the first time, scientists at LIGO have observed ripples in the fabric of space time called gravitational waves, arriving at the earth from a cataclysmic event in the distant universe.

What is the significance of the discovery?

- GW Astronomy: this discovery opens a new avenue for space exploration. Primary tool for exploring the universe is observation through telescopes that rely only on light waves reaching earth from outer space. But objects like black-hole and dark matter do not emit light and there is no easy way to detect them.
- However, they can interact via gravity, and gravitational waves might be the only agent which carries their information to earth. Though the current technology is not adequate to make large-scale detections using gravitational waves, this might be a first step to unveiling a brand new technique of observing the unobserved part of universe.
- Lastly, the discovery almost confirms Einstein's General Relativity beyond doubt. This will help in developing further research in several theoretical fields such as Quantum Gravity and unification of the fundamental forces.
- Clue about origin of universe: light could not pass through the opaque plasma medium of early universe. However GW could easily propagete. Hence carry the clue to origin of the universe

India's gravitational wave observatory initiative (IndIGO)

- The Indian cabinet has approved the construction of the country's own laser interferometer gravitational-wave observatory for cosmology research. It has given permission to establish a state-of-the-art gravitational wave observatory in the country in collaboration with the Laser Interferometer Gravitational-wave Observatory (LIGO) in the US.
- The project will build an Advanced LIGO Observatory in India, a move that will significantly improve the ability of scientists to pinpoint the sources of gravitational waves and analyze the signals.
- Project will set up advanced experimental facilities, with appropriate theoretical and computational support, for a multi-institutional Indian national project in gravitational-wave astronomy.
- Since 2009, the IndIGO Consortium has been involved in constructing the Indian road-map for Gravitational Wave Astronomy and a phased strategy towards Indian participation in realizing the crucial gravitational-wave observatory in the Asia-Pacific region.

Reusable Launch Vehicle

- A reusable launch system (or reusable launch vehicle, RLV) is a launch system which is capable of launching a launch vehicle into space more than once. This contrasts with expendable launch systems, where each launch vehicle is launched once and then discarded.
- RLV-TD consists of a fuselage (body), a nose cap, double delta wings and twin vertical tails. It also features symmetrically placed active control surfaces called Elevons and Rudder. This technology demonstrator was boosted to Mach 5 by a conventional solid booster (HS9) designed for low burn rate.
- The selection of materials like special alloys, composites and insulation materials for developing an RLV-TD and the crafting of its parts is very complex and demands highly skilled manpower. Many high technology machinery and test equipment were utilised for building this vehicle.

- A Winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies using air breathing propulsion. These technologies will be developed in phases through a series of experimental flights.

Objectives of RLV–TD:

- Hypersonic aero thermodynamic characterisation of wing body
- Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes
- Integrated flight management
- Thermal Protection System Evaluation

General working principle of RLV

- **First stage–subsonic and supersonic stage:** The RLV with its payload takes off from the runway and climbs to about 100,000 feet or 30 km using conventional jet-engines, or using a combination of conventional jet-engine and ramjet engine, or using another plane to carrier pull the plane to a lower height and using a booster rocket. Ramjet operates by this principle. It uses very less moving parts compared to a conventional jet-engine with thousands of moving parts.
- **Second stage-Hypersonic stage:** When the space plane is at an altitude of about 100,000 ft and at a velocity of about mach 4, the scramjets are fired. Scramjets are basically ramjets. They introduce fuel and mix it with oxygen obtained from the air which compressed for combustion. The air is compressed by the shape of the inlet and forward speed of the vehicle.
- **Third stage-Space stage:** When the rocket engine fires by mixing oxygen from the onboard storage tanks into the scramjet engine, thereby replacing the supersonic air flow. The rocket engine is capable of accelerating the RLV to speeds of about Mach 25, which is the escape velocity. It takes the RLV into orbit. The rocket engine takes the RLV to the payload release site and the required operations are done.
- **Fourth stage–Re entry stage:** Once the RLV finishes its mission in space, It performs de-orbit operations to slow itself down, thereby dropping to a lower orbit and ev entually entering the upper layers of the atmosphere. It is here that the structure of the plane undergoes heavy thermal stress. If the heat shields do not protect the plane, it would simply burn off to the ground. Once it reaches dense air, it can use its aerodynamics to glide down to the landing strip. It can also use any remaining fuel to fire the ramjet or conventional jet (depends on the design) and change its course. Once on the landing strip it engages it slows down using a series of parachutes and engages the brake.

Significance of RLV test on Indian Space Program

- ISRO's RLV Technology Demonstration Programme (RLV-TD) is a plane-like reusable vehicle launched by an expendable single state solid booster.
- The mission will end with a splashdown in the Indian Ocean. The rocket launcher will help it to reach Mach 6, and an altitude of 100 km. After reaching the required height it will undergo the re-entry phase, glide down and finally splash down in the Bay of Bengal.
- The vehicle will spend nearly 5 minutes in its coast phase at the maximum altitude before doing re-entry. The RLV-TD Program is not just a technology demonstration for India, but a way to prove how much it has progressed in the field of space exploration. The test is a part of a larger plan to build a fully functional two stage to orbit **(TSTO)** vehicle.
- A successful RLV program would reduce the cost of space missions, making India more competitive in the launcher market. For now, the test program will expand the technological capabilities of India, enabling it to be a forerunner in space exploration in near future.
- The success of the Mars Orbiter Mission at the first attempt has boosted the hopes of ISRO to send humans to Mars. A highly developed version of RLV for launching humans to space could demonstrate the technological ability and progress achieved by Indians in the field of space exploration.

- The series of experiments that need to be carried out will help in expansion of space technology and capability of ISRO and India culminating in a fully developed version of RLV used as Two Stages to Orbit (TSTO) vehicle.

Satellite Communication in India

- India's experience in rocketry began in ancient times when fireworks were first used in the country, a technology invented in neighbouring China, and which had an extensive two-way exchange of ideas and goods with India, connected by the Silk Road. Military use of rockets by Tipu Sultan during the Mysore War against the British inspired William Congreve to invent the Congreve rocket, predecessor of modern artillery rockets, in 1804.
- After India gained independence from British occupation in 1947, Indian scientists and politicians recognized the potential of rocket technology in both defence applications, and for research and development. Recognizing that a country as demographically large as India would require its own independent space capabilities, and recognising the early potential of satellites in the fields of remote sensing and communication, these visionaries set about establishing a space research organisation.
- Dr. Vikram Sarabhai was the founding father of the Indian space program, and is considered a scientific visionary by many, as well as a national hero. After the launch of Sputnik in 1957 he recognized the potential that satellites provided. India's first prime minister, Jawaharlal Nehru, who saw scientific development as an essential part of India's future, placed space research under the jurisdiction of the Department of Atomic Energy in 1961. The DAE director Homi Bhabha, who was father of India's atomic programme, then established the Indian National Committee for Sapce Research (INCOSPAR) with Dr. Sarabhai as Chairman in 1962. India decided to go to space when Indian National Committee for Space Research (INCOSPAR) was set up by the Government of India in 1962. With the visionary Dr Vikram Sarabhai at its helm, INCOSPAR set up the Thumba Equatorial Rocket Launching Station (TERLS) in Thiruvananthapuram for upper atmospheric research. Indian Space Research Organisation, formed in 1969, superseded the erstwhile INCOSPAR.

INSAT Satellite Applications

- Satellite Communication (Satcom) technology offers the unique capability of simultaneously reaching out to very large numbers spread over large distances even in the most remote corners of the country.
- INSAT system is a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan in 1983.
  - **EDUSAT Programme:** EDUSAT, launched by Geosynchronous Satellite Launch Vehicle (GSLV-F01) in September 2004, is India's first thematic satellite dedicated exclusively for educational services. The satellite is specially configured to relay through audio-visual medium, employing multi-media multi-centric system, to create interactive classrooms. EDUSAT is already providing a wide range of educational delivery modes like one-way TV broadcast, interactive TV, video conferencing, computer conferencing, web-based instructions, etc. Networks have already been setup in 24 states covering almost entire country including all islands (Andman & Nicobar, Lakshdweep), North-Eastern states and Jammu & Kashmir. Implementation in remaining states is under progress.

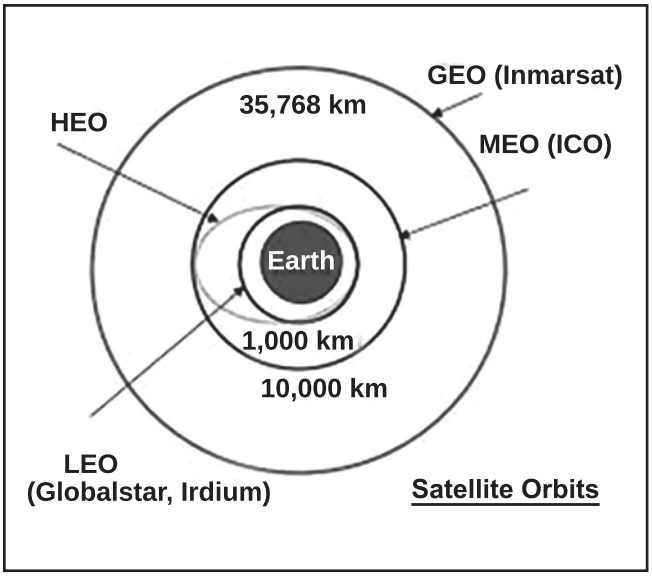
EDUSAT

- One of the innovative networks on EDUSAT is the network for "Blind schools". Blind People's Association, Ahmedabad is a leading organisation promoting education, training, employment and rehabilitation for blind persons. Considering the specific needs of the blind people, an altogether different kind of broadcast network configuration delivering live audio and data which is read by blind person through its printed impression (Braille) was set up. Another special network in Ext C-band connecting 50 engineering institutes across the country has been established to impart teaching by distinguished professors/faculty from top 21 universities in USA who would visit India to conduct eight-week courses in various subjects in engineering. This network is now shared by IIT-Bombay network with additional 30 end users.
- **Educational TV Services:** INSAT is being used to provide Educational TV (ETV) service for primary school children

- **Telemedicine Programme:** ISRO's telemedicine pilot project was started in the year 2001 with the aim of introducing the telemedicine facility to the grass root level population as a part of proof of concept technology demonstration. The telemedicine facility connects the remote District Hospitals/ Health Centres with Super Specialty Hospitals in cities, through the INSAT Satellites for providing expert consultation to the needy and underserved population.
- **Television:** INSAT has been a major catalyst for the expansion of television coverage in India. Satellite television now covers 100% area and 100% population. The terrestrial coverage is over 65 percent of the Indian land mass and over 90 percent of the population. At present 40 Doordarshan TV channels including news uplinks are operating through C-band transponders of INSAT-3A, INSAT-4B, INSAT-3C and INSAT-2E (Additionally IS-10 & IS-906 INTELSAT leased). All of the Satellite TV channels are digitalized.
- **Satellite Aided Search and Rescue:** India is a member of the international COSPAS-SARSAT programme for providing distress alert and position location service through LEOSAR (Low Earth Orbit Search And Rescue) satellite system. Under this programme, India has established two **Local User Terminals (LUTs),** one at Lucknow and the other at Bangalore. The **Indian Mission Control Centre (INMCC),** is located at ISTRAC, Bangalore.
- Indian LUTs provide coverage to a large part of Indian Ocean region rendering distress alert services to Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka and Tanzania. The operations of INMCC/LUT are funded by the participating agencies, namely, Coast Guard, **Airports Authority of India (AAI)** and Director General of Shipping and Services.
- **Disaster Management:** The **Disaster Management Support (DMS)** Programme of ISRO, provides timely support and services from aero-space systems, both imaging and communications, towards efficient management of disasters in the country. The DMS programme addresses disasters such as flood, cyclone, drought, forest fire, landslide and Earthquake. To support the total cycle of disaster/ emergency management for the country, in near real time, the database creation is addressed through **National Database for Emergency Management (NDEM),** a GIS based repository of data. Towards providing emergency communication for disaster management activities, and at the behest of **Ministry of Home Affairs (MHA),** ISRO has set up a satellite based Virtual Private Network (VPN) linking the National Control Room at MHA with DMS-DSC at NRSC, important national agencies, key Government Offices in Delhi and the Control Rooms of 22 multi-hazard-prone States. Further ISRO has developed and deployed INSAT Type-D terminals (portable satellite phones), INSAT based **Distress Alert Transmitter (DAT)** for fishermen, **Cyclone Warning Dissemination System (CWCS)** and DTH based **Digital Disaster Warning System (DDWS)** in disaster prone areas.

New ocean observation satellite of China

- The Haiyang-2D (HY-2D) satellite, a new ocean observation satellite of China was launched from the Jiuquan Satellite Launch Centre in northwest China.
- The HY-2D is developed by the China Academy of Space Technology, and the carrier rocket by the Shanghai Academy of Spaceflight Technology.
- Function: China successfully sent the ocean-monitoring satellite into orbit as part of its effort to build an all-weather and round-the-clock dynamic ocean environment monitoring system which would provide early warning on marine disasters.



- The satellite was launched by a Long March-4B rocket.
- It is put in low earth orbit.
- The HY-2D will form a constellation with the HY-2B and HY-2C satellites to build an all-weather and round-the-clock dynamic ocean environment monitoring system of high frequency and medium and large scale.
- The constellation will support the country's early warning and prediction of marine disasters, sustainable development and utilisation of ocean resources, effective response to global climate change as well as ocean research.

Long March-4B rocket

- The Long March 4B also known as the Chang Zheng 4B, CZ-4B and LM-4B is a Chinese expendable orbital Launch vehicle.
- It is a 3-stage rocket, used mostly to place satellites into low Earth orbit and sun-synchronous orbits.
- It was first launched on 10 May 1999, with the FY-1C weather satellite, which would later be used in the 2007 Chinese anti-satellite missile test.

Copernicus Sentinel-1 mission

- Sentinel-1 is the first of the Copernicus Programme satellite constellation conducted by the European Space Agency.
- This mission is composed of a constellation of two satellites, Sentinel- 1A and Sentinel-1B, which share the same orbital plane.
- They carry a C-band synthetic-aperture radar instrument which provides a collection of data in all-weather, day or night.
- Its activities include sea and land monitoring, emergency response due to environmental disasters, and economic applications.

Remote Sensing Applications

- Remote sensing has enabled mapping, studying, monitoring and management of various resources like agriculture, forestry, geology, water, ocean etc. It has further enabled monitoring of environment and thereby helping in conservation.
- India has its own satellites like **Indian Remote Sensing Satellite (IRS)** series - Resourcesat, Cartosat, Oceansat etc which provide required data for carrying out various projects. Some of the important projects carried out in the country include Groundwater Prospects Mapping under Drinking Water Mission, Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL), Forest Cover/Type Mapping, Grassland Mapping, Biodiversity Characterisation, Snow & Glacier Studies, Land Use/Cover mapping, Coastal Studies, Coral and Mangroves Studies, Wasteland Mapping, etc.
  - **Groundwater Prospects and Recharge Zone Mapping:** The occurrence and movement of groundwater is mainly controlled by many factors such as rock types, landforms, geological structures, soil, land use, rainfall etc. Remote sensing based groundwater prospect zone map serves as a base for further exploration using hydro geological and geophysical methods to locate well sites. Studies have shown that if remote sensing data are used at first level to delineate prospective zones and further followed up by hydro geological and geophysical surveys, higher success could be achieved besides savings in terms of cost, time and work.
  - **Wetlands:** The primary objective of this project is to map the wetlands of India (natural, manmade, coastal and inland) at 1:50,000 scale and create a database with a query shell. This project has been taken up at the specific request of **Ministry of Environment and Forests (MoEF).** Digital analysis of two date (pre and post monsoon) satellite data is used for the purpose. This is the first time that country will have country specific classification system, updated database and map of wetlands at 1:50,000 scale which will help in conservation/preservation plan, water resources plan, methane emission study etc.
  - **National Urban Information System (NUIS):** National Urban Information System (NUIS) is approved as National Mission Programme of Ministry of Urban Development (MUD, GOI). NUIS comprises **of broadly two major components - (a) Urban Spatial Information System (USIS)** to meet the Spatial (maps / images) data / information requirements of urban planning and management functions, (b) National Urban Data Bank & Indicators (NUDB&I) to develop town-level urban database to support development of indices through a network of **Local Urban Observatories (LUOs)** under the **National Urban Observatory (NUO)** Programme. Under USIS of NUIS a comprehensive 3-tier GIS database for each town/city to support the urban planning and management is envisaged:
    - Generate 1:10,000 scale GIS-compatible spatial information from IRS images and integrate attribute information to enhance Master Plan / Development Plan of urban settlements
    - Generate 1:2,000 scale GIS-compatible spatial information from aerial photographs and integrate attribute information to enhance Municipal Plan / Zonal Plan and detailed Town Planning schemes.
    - Establish a 1:1000 scale utilities GIS using Ground Penetrating Radar data on a pilot basis to include water-supply, sewerage, power and communication for Utilities Planning and Management.

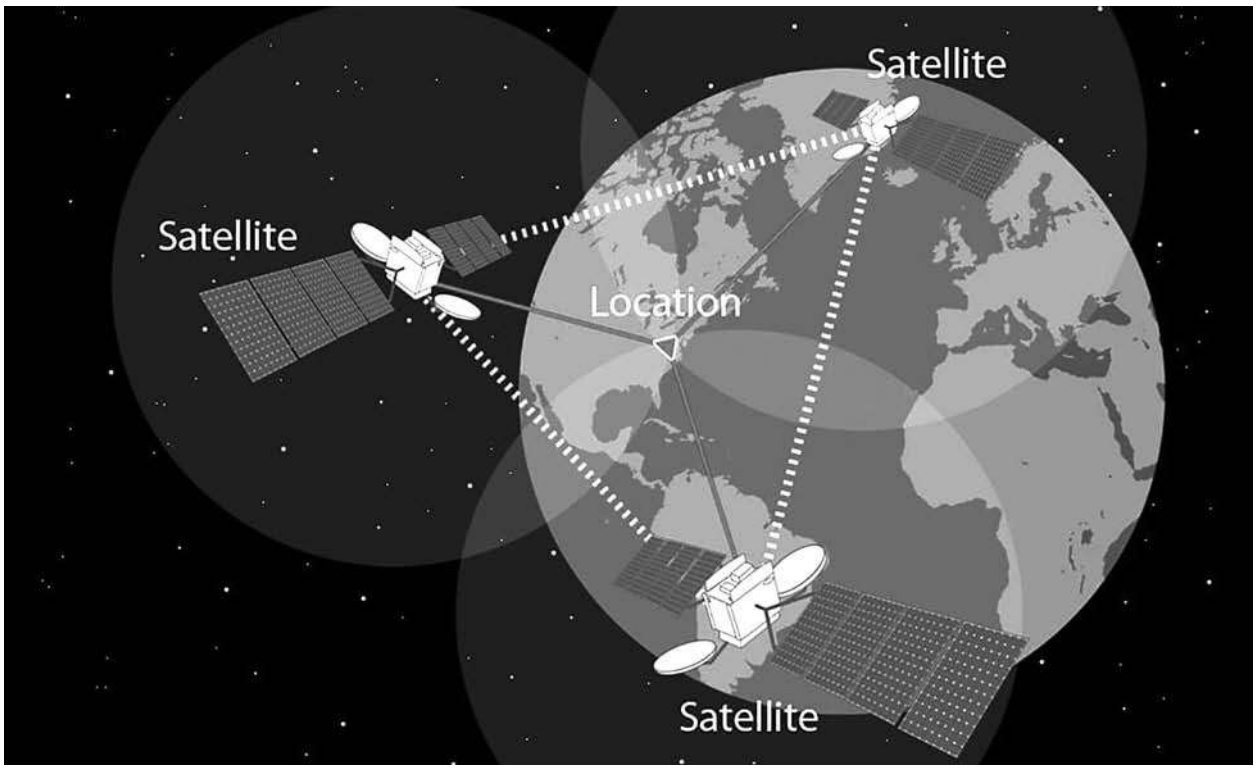
Navigation Application

Global Positioning System

- The **Global Positioning System (GPS)** is a space-based **Global Navigation Satellite System (GNSS)** that provides reliable location and time information in all weather and at all times. It was established in

1973. The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, **Navigation, and Timing (PNT)** services. This system consists of three segments: the space segment, the control segment, and the user segment. The U.S. Air Force develops, maintains, and operates the space and control segments.

- **Space Segment:** The space segment consists of a nominal constellation of 24 operating satellites that transmit one-way signals that give the current GPS satellite position and time.
- **Control Segment:** The control segment consists of worldwide monitor and control stations that maintain the satellites in their proper orbits through occasional command manoeuvre, and adjust the satellite clocks. It tracks the GPS satellites, uploads updated navigational data, and maintains health and status of the satellite constellation.
- **User Segment:** The user segment consists of the GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time.



Other satellite based navigation systems are:

- **GLONASS:** The Global Navigation Satellite System (GLONASS) is based on a constellation of active satellites which continuously transmit coded signals in two frequency bands, which can be received by users anywhere on the Earth's surface to identify their position and velocity in real time based on ranging measurements.
- **GALILEO:** Galileo is a Global Navigation Satellite System (GNSS) currently being built by the **European Union (EU)** and **European Space Agency (ESA).** Its aim is to provide a high-accuracy positioning system upon which European nations can rely independent of the Russian GLONASS and US GPS systems which can be disabled for commercial users in times of war or conflict.
- **BEIDOU NAVIGATION SYSTEMB:** The BeiDou Navigation System (COMPASS) Navigation Satellite System is a project by China to develop an independent satellite navigation system. It may refer to either one or both generations of the Chinese navigation system. The first BEIDOU system, officially called BEIDOU Satellite Navigation Experimental System, or known as BeiDou-1, consists of 3

satellites and has limited coverage and applications. The second generation of the system known as Compass or BEIDOU-2 will be a global satellite navigation system consisting of 35 satellites, is still under construction.

- **India launches its own satellite-based navigation system GAGAN:** GPS Aided Geo Augmented Navigation ''GAGAN'' is an augmentation system to enhance the accuracy and integrity of GPS signals to meet precision approach requirements in Civil Aviation and is being implemented jointly by **Airports Authority of India (AAI)** and ISRO. The goal is to provide navigation system for all phases of flight over the Indian airspace and in the adjoining areas. GAGAN will increase safety by using a three-dimensional approach which will provide course guidance to the runways to help to reduce the risk of controlled flight into terrain i.e., an accident whereby an airworthy aircraft, under pilot control, inadvertently flies into terrain, an obstacle, or water.
- **IRNSS: India's Navigation system:** The NAVIC (Navigation in Indian Constellation) system consist of a constellation of 3 satellites in **Geostationary Orbit (GEO),** 4 satellites in **Geo Synchronous Orbit (GSO)** at approximately 36,000 kilometers (22,000 mi) altitude above earth surface, and two satellites on the ground as stand-by, in addition to ground stations.
- IRNSS provide two types of services, namely, **Standard Positioning Service (SPS)** which is provided to all the users and **Restricted Service (RS)**, which is an encrypted service provided only to the authorized users.
- The IRNSS System is expected to provide a position accuracy of better than 20 metres in the primary service area.

Components of IRNSS

- IRNSS comprises of a space segment and a ground segment.
- The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit.
- IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring and time keeping**.**

Significance

- There are lot of areas in which IRNSS is significant for common civilians. But the primary objective of the object is to help India become independent of US controlled GPS systems.
- The current ballistic missile systems are all dependent on positioning systems to accurately hit their target.
- There have been two instances where USA has manipulated or denied this information which has made India go forward with its own independent positioning system.
  - During the Iraq war, the Americans sent wrong GPS signals to the Iraqi jets and missiles, therefore Iraqis could not attack Americans forces in a precise manner.
  - During the Kargil war of 1999, USA denied India the required GPS information which would have helped them to tackle the enemy in a better way
- Having our own GPS System will ensure that something like this doesn't happen in the future. Plus, if India has to project itself as a superpower so it needs to have such a system in place.
- It will make India self-dependent on its own network system and also extending services up to 1500 km from the mainland, covering SAARC countries as well.
- It will Open up a conduit for SAARC countries to come together.

Importance of Navigation System

ISRO conceived IRNSS in 2010 when India released to install its own navigation and communication satellites replacing country's dependence on foreign navigational systems such as the US-GPS and the Russian-GLONASS. The system is aimed to provide better communication services which will be divided into two categories viz. 'Standard Positioning Services' available to all users and 'Restricted Services' provided to authorized users such as armed forces. Completion of project with 7 satellites installed in geosynchronous (4) and geostationary (3) orbits which will add India among nations having their own navigation system such as the US - GPS, China ongoing BEIDOU.

Applications

- Better mapping of the terrestrial boundary of the country, helping in marking precisely coordinates of landmarks like forests, roads, etc.
- Disseminating timely disaster alert to vulnerable areas.
- Goods such as ammonium nitrate (MHA recently made regulatory measures) could be geotagged reducing its wrong use.
- Terrestrial, Aerial and Marine Navigation.
- Visual and voice navigation for drivers.
- Precise timing helping in better scientific calculations during experimentations and other activity
- Urban planning in case of smart cities.
- Vehicle tracking and fleet management.

Significance

- There are a lot of areas in which IRNSS is significant for common civilians. But the primary objective of the object is to help India become independent of US-controlled GPS systems.
- The current ballistic missile systems are all dependent on positioning systems to accurately hit their target.
- There have been two instances where the USA has manipulated or denied this information which has made India go forward with its own independent positioning system.
- During the Iraq war, the Americans sent wrong GPS signals to the Iraqi jets and missiles, therefore Iraqis could not attack Americans forces in a precise manner.
- During the Kargil war of 1999, USA denied India the required GPS information which would have helped them to tackle the enemy in a better way.
- Having our own GPS System will ensure that something like this doesn't happen in the future. Plus, if India has to project itself as a superpower so it needs to have such a system in place.
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IRNSS: India's Navigation system

- The **NAVIC (Navigation in Indian Constellation)** system consist of a constellation of 3 satellites in Geostationary orbit (GEO), 4 satellites in Geo Synchronous Orbit (GSO) at approximately 36,000 kilometers (22,000 mi) altitude above earth surface, and two satellites on the ground as stand-by, in addition to ground stations.
- IRNSS provides two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorized users.

- The IRNSS System is expected to provide a position accuracy of better than 20 meters in the primary service area.

Components of IRNSS

- IRNSS comprises a space segment and a ground segment.
- The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit.
- IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring and timekeeping.

GAGAN– Geo Augmented Navigation System

- GPS Aided Geo Augmented Navigation ''GAGAN'' is an augmentation system to enhance the accuracy and integrity of GPS signals to meet precision approach requirements in **Civil Aviation** and is being implemented jointly by Airport Authority of India (AAI) and ISRO. It will augment GPS signals over the Indian landmass, the Bay of Bengal, South East Asia, the Middle East, and the Arabian Sea widening its reach up to Africa. At present, radio navigation aids are used for precision landing and approach at Indian airports.
- **Objectives:** The objective of GAGAN to establish, deploy and certify satellite-based augmentation system for safety-of-life civil aviation applications in India has been successfully completed. The system is interoperable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS, etc. The goal is to provide a navigation system for all phases of flight over the Indian airspace and in the adjoining areas.
- **Benefits:** Improved efficiency, Increased fuel savings, Direct routes, Reduced workload of flight crew and air traffic controllers, Improved safety, Ease of search and rescue operation.

GEMINI (GAGAN Enabled Mariner's Instrument for Navigation and Information)

- The new system called GEMINI (GAGAN Enabled Mariner's Instrument for Navigation and Information) has developed on this limitation by utilising GAGAN (GPS Aided Geo Augmented Navigation) satellite systems of the AAI to transmit PFZ and disaster warnings to the fishermen.
- The data coverage of GEMINI covers the entire India Ocean full-time, which will help in information transmission to the fishermen far away from coastal areas.
- GEMINI is a portable device which receives data from the GAGAN satellites and sends it to the user's cellphone. The GEMINI app on the cellphone decodes the signals from GEMINI device and alerts the user on imminent threats like cyclones, high waves, strong winds along with PFZ and search and rescue mission.

Role of Space in Development

- India has been among the world leaders in developing end-to-end capability in both satellite remote sensing and communication. Indian Space Research Organization (ISRO) has made remarkable progress in building state of the art space infrastructure such as the **Indian National Satellite (INSAT)** for communication and the **Indian Remote Sensing (IRS)** satellites for earth observation. ISRO has piloted several socially relevant space application projects like the **Satellite Instructional Television Experiment (SITE),** the **Training and Development Communication Channel (TDCC),** the **Jhabua Development Communications Project (JDCP)** using INSAT; and finding prospective groundwater zones to provide drinking water in villages, providing land and water resources development plans at

watershed level using IRS. Space based services, emanating from **Satellite Communication (SatCom)** and Earth Observation (EO) hold much value in transforming the village society. While SatCom provides the conduit for effective delivery of information and services across vast regions; the EO provides community-centric spatial information in terms of geo-referenced land record, natural resources, sites for exploiting groundwater for potable and recharge, incidence of wastelands having reclamation potential, watershed attributes, environment, infrastructure related information, alternative cropping pattern, etc. Synthesising the spatial information with other collateral and weather information, EO also facilitates locale-specific advisory services at community level.

Space Technology Applications for Rural Development are discussed below:

- **Village Resource Centre (VRC):** ISRO has embarked upon VRC programme to disseminate the portfolio of services emanating from the space systems as well as other Information Technology (IT) tools, directly down-the-line to the rural communities. VRCs essentially have: digital connectivity (for video conferencing and information transfer) with knowledge centers and specialty healthcare providers enabled via INSAT; spatial information on natural resources generated using IRS data; a host of information pertaining to management of natural resources and socio-economic relevance; and facilities for primary healthcare services and distance education.
- With the involvement of stakeholders, VRCs will catalyse rural entrepreneurship; and facilitate e-Governance and other services of social relevance. ISRO is implementing VRC programme in partnership with reputed NGOs, Trusts and other agencies including the Governmental ones.
- **Satellite Communication:** ISRO had undertaken several projects that focused on development of humanity through sophisticated satellite-based communication. Right from the inception of utilizing space programmes for development, the experiments like **Satellite Instructional Television Experiment (SITE), Kheda Communications Project (KCP), Jhabua Development Communications Project (JDCP), Training and Development Communication Channel (TDCC)** have been carried out.
- **Example:**
  - **ISRO's Gram SAT** satellite connects rural development ministry with 1100 panchayats. The exercise was aimed at getting feedback on the various rural development schemes under operation in the state and to gain an insight into the problems at the field level, on which the ministry needed to focus further planning efforts.
  - The effort was equally aimed at enhancing the awareness of the beneficiaries on their entitlement and various processes involved for availing the benefit of the schemes.
  - Gram SAT pilot projects are being run in some select states of the country and are being utilised very to reach out development messages directly to the villagers by ensuring community listening, viewing and linking up large body of villagers.
- **Tele-Education:** The tele-education programme launched by ISRO, serviced by the exclusive satellite **'EDUSAT',** is primarily intended for school, college and higher levels of education to support both curricula based as well as vocational education. With 5 Ku-band transponders providing spot beams, and one Ku-band transponder providing national beam, and 6 extended C-band transponders with national coverage beams, EDUSAT is specifically configured for audio-visual medium, employing digital interactive classroom and multimedia multi-centric system. Many important institutions such as the IGNOU, UGC, IITs, and many State Education Departments and Universities are making use of the EDUSAT network.
- **Tele-Medicine:** Telemedicine is a confluence of Communication Technology, Information Technology, biomedical Engineering and Medical Science. The Telemedicine system consists of customised hardware and software at both the Patient and Specialist doctor ends with some of the Diagnostic Equipments like ECG, X-ray and pathology Microscope/Camera provided at the patient end. They are connected through a **Very Small Aperture Terminal (VSAT)** system and controlled

by the Network Hub Station of ISRO. Through a Telemedicine system consisting of simple computer with communication systems, the medical images and other information pertaining to the patients can be sent to the specialist doctors, either in advance or on a real time basis through the satellite link in the form of Digital Data Packets. These packets are received at the specialist centre.

- **Disaster Management Support:** India is one of the most disaster prone countries in the world with increasing vulnerability to cyclones, floods, landslides, droughts and earthquakes. The **Disaster Management Support (DMS)** Programme of ISRO, provides timely support and services from aero-space systems, both imaging and communications, towards efficient management of disasters in the country. The DMS programme addresses disasters such as flood, cyclone, drought, forest fire, landslide and Earthquake. These include creation of digital data base for facilitating hazard zonation, damage assessment, etc., monitoring of major natural disasters using satellite and aerial data; development of appropriate techniques and tools for decision support, establishing satellite based reliable communication network, deployment of emergency communication equipments and R&D towards early warning of disasters.
- To support the total cycle of disaster/ emergency management for the country, in near real time, the database creation is addressed through **National Database for Emergency Management (NDEM),** a GIS based repository of data. NDEM is envisaged to have core data, hazard-specific data, and dynamic data in spatial as well as a spatial form.
- **Remote sensing applications:** India has its own Indian Remote Sensing Satellite (IRS) series – Resourcesat, Cartosat, Oceansat etc which provide required data for carrying out various projects. Some of the important projects carried out in the country include Groundwater Prospects Mapping under Drinking Water Mission, Forecasting Agricultural output using Space, Agro-meteorology and Land based observations **(FASAL),** Forest Cover/Type Mapping, Grassland Mapping, Biodiversity Characterization, Snow & Glacier Studies, Land Use/Cover mapping, Coastal Studies, Coral and Mangroves Studies, Wasteland Mapping etc.

Some future programmes:

- **Space Based Information System for Decentralized Planning (SIS-DP):** Realizing the potential and capability of remote sensing and GIS for providing cost and time-effective resource database, the Planning Commission, Ministry of Panchayati Raj and Ministry of Rural Development has proposed to prepare District Resource Atlases using remote sensing and GIS techniques to strengthen various aspects of decentralized district level planning through a co-ordinated approach.
- The ICT enabled geospatial platform can be formed using space based EO systems and engaging local bodies for planning and carrying out area developmental activities in a decentralized, speedy and transparent manner. The major objectives are:
  - Spatial depiction of land & water resource along with their attribute information for preparation of District Resource Geospatial Atlas keeping Village Cadastral data as base on seamless manner for entire country States which are already covered may be brought to uniform standard with respect to content and accuracies.
  - Development of software tools and utilities (including web based GIS applications and standalone) for providing multipurpose user driven applications for speedy, accurate and transparent decision making for district planning.
  - Capacity building in state departments along with training of manpower and capability for spatial data analysis, which will maintain, update & manage database for decentralized planning.
- Village cadastral maps will be collected, scanned, vectorised and geo-referenced to be overlaid onto ortho-rectified imagery. Attribute data from user departments will be converted into spatial layer and various customized information system will be developed for use in planning activity. One node for each state will be created for providing centralized facility for archiving, organizing, updating and dissemination of information at grassroots level.

- The objective of the Space based Information System for Decentralized Planning mission is to establish and enable the information system comprising of spatial natural resources and non-spatial data towards supporting the districts for the decentralized planning. This GIS database will be customized to meet the requirements of stake holder departments/concerned in providing the digital resource atlases and any other requirements of the States based on their problems/ priority/ developmental programme at Village/ Block/ Taluka/ District level. The Mission is intended to be executed and supported by State Remote Sensing Application Centres / Institutes / IT Departments and Industries and ownership of the database and resource information will be with respective individual stakeholder departments.

ISRO as Soft Power

- The term 'soft power' is defined as 'the ability to get what you want through attraction instead of coercion or payment.' A country's soft power rests on three resources:
  - Its culture,
  - Its political values, and
  - Its foreign policies.

Promote Soft Power through Space Commerce

- India is steadily and quietly expanding its influence over a large part of the developing world by making available its expertise and services for building and launching satellites. India's spreading influence through space technology is quite evident in many third world countries.
- From the last few years, India is using its space industry to extend its Soft-Power. It is establishing linkages in the space arena with countries in Africa and South America, including Nigeria, Venezuela, and Brazil. India is already working with a few international partners like NASA, but such partnerships are more from the point of view of technology collaboration.

India is particularly well suited to make very effective use of space as an instrument of soft power for a number of reasons:

- As the ISRO Commission on Smart Power notes, India is the only global nation, and the expansion of the human sphere of influence into space is indisputably a global undertaking.
- The successes and challenges of space exploration, from the 'chandrayan to magalyan', these missions, are dramatic examples of key India characteristics such as hope, enthusiasm, and optimism.
- Unlike other countries, Indian civilian space activities have always been explicitly kept apart from the national security space activities of the defense and intelligence communities.
- Exploration and the civil applications of space are obvious, high-profile, high-leverage mechanisms for exercising soft power.
- The broad array of civil space applications provides a multitude of options for highly tailored cooperation. From exploration to remote sensing and climate change to digital economy integration, the sphere of engagement can be tailored to address security concerns or to provide significant information-gathering opportunities concerning the capabilities and intentions of other space-faring nations.
- India is strategically positioning itself as a focal point for all space-related activities, from providing financial assistance to manufacturing, and launching facilities for states in Asia, Africa and South America. This approach has multiple benefits – an increase in India's global footprint, flow of benefits to the Chinese space industry, experimentation with new technologies, and wins friends.

Commercial branch of ISRO – ANTRIX Corporation

- The Bangalore based commercial arm of the Indian space programme, has made modest forays in the global space market for launch services, sale of satellite resources data and spacecraft hardware and components in addition to mission support service. It was set up in 1992 as a Government of India owned company.
- Vision of ANTRIX is to emerge as a globally significant space company fully utilizing the strengths of Indian Space Research Organisation (ISRO) and other entities in the field of space.
- **The current business activities of Antrix include:**
  - Provisioning of communication satellite transponders to various users,
  - Providing launch services for customer satellites,
  - Marketing of data from Indian and foreign remote sensing satellites,
  - Building and marketing of satellites as well as satellite sub-systems,
  - Establishing ground infrastructure for space applications, and
  - Mission support services for satellites.
- In particular Antrix is looking at nations like Algeria, Brazil and Kazakhstan to boost its commercial prospects. Meanwhile India is offered to make available Indian satellite resources data to South East Asian countries for managing natural disasters and also offered Indian help in launching small satellites built by them.
- Antrix continues to forge ahead with the sale of Indian Remote Sensing Satellite (IRS) imageries over a wide part of the world through distributors and satellite imagery marketing outfits. Satellite data sale currently account for around 10 per cent Antrix's turn over. While in Europe and North America there is fairly good demand for IRS data, the sale of IRS data products has been growing in Asian countries including Nepal, Turkey and Japan.
- Of the 39 satellites launched so far by Antrix, 17 have been Indian and the rest belong to overseas customers. Antrix now has the contract for launching Algeria's Alsat-2 satellite, Italy's IMSAT spacecraft as piggy back payloads. Also in the line for launch is X-sat micro satellite of Singapore's Nanyang Technological University (NTU). PSLV has already launched satellites from countries including South Korea, Indonesia, Turkey, Belgium and Germany.
- The three stages, 629-tonne GSLV-MK, will enable Antrix to bid for orbiting heavier class commercial communications satellites. But then there are many serious entry barriers that Antrix will have to overcome before it emerges as a leading player in the multibillion dollar global markets for launching satellites.

What is the Antrix Devas Case?

- In 2005, Devas Corporation and Antrix Corporation had struck a deal which had provided for the launch of two satellites allowing Devas. These satellites were to establish a hybrid satellite and terrestrial communications network to supply wireless audio-visual, broadband and mobile internet service across India.
- But later, Antrix Corporation terminated the contract citing changes in Indian policy and that the allocation of S-band Spectrum to companies unconnected with India's space programme was now regarded as a risk to national security.
- Devas moved to PCA (Permanent Court of Arbitration), citing Antrix had breached the deal named the reasons for termination of deal as "contrived excuses". It had also asked damages amounting to 1.6 billion dollars from Indian Government under the **UNCITRAL** (United Nations Commission on International Trade Law) Arbitration Rules.
- Later, the **Permanent Court of Arbitration (PCA)** tribunal in The Hague, Netherlands has ruled against Antrix Corporation in the case with Devas Corporation over sharing of spectrum on satellites.

ISRO'S Role In Socio-Economic Development

- Over the last four decades, the Indian Space program has made remarkable progress towards building the space infrastructure as the community resource to accelerate various developmental processes and harness the benefits of space applications for socio-economic development.
- ISRO plays an important role in rural and urban development. The concept of development connotes the overall development of the nation with a view to improving the quality of life of people. In this sense, it encompasses the development of agriculture and allied activities, village and cottage industries, socio-economic infrastructure, community services and facilities, and above all the human resources.

ISRO Programmes / Missions drawn up for Socio-Economic Development

- The Programmes/ missions drawn up and proposed by ISRO for the socio-economic development of the country include
- Earth Observation Programme for natural resources inventory and management (like agriculture, land and water resources, fisheries), near real-time disaster management support, weather forecasting, smart governance;
- Satellite Communication Programmes for telecommunication, television broadcasting, Direct-to-Home services, search and rescue, tele-education, telemedicine and
- Satellite Navigation Programme for location-based services.

ISRO can help in socio-economic development which is pro-people

- Developing Scientific Temperament: ISRO provides great opportunities in scientific research and technological development. Thus; creating awareness about the value of science amongst Indian people which in future will attract youth in research and scientific activities.
- Economic development through Resource generation: ANTRIX the commercial entity of ISRO generates huge profit through utilizing the success of our launch vehicle. That income is utilized by ISRO to further do research and reducing the burden on the government for its research activities so, the government can utilize its fiscal efficiency for socio-development.
- Making India Digitally Empowered: Digital India is the new mantra of the socio and economic development of India. For the success of the E-governance and the Skill development and the tele-education like activities, it is necessary that the remotest of place in India must be connected through the Internet and the Mobile and broadband communication. It can only happen when there are sufficient SPECTRUM and Bandwidth available for these kinds of activities.
- Resource Mapping and resource management, Mineral exploration, managing the river conservation plans through the IRS satellite will help in preparing plans for these activities. Urban planning, forest management, Thermal imaging in the border areas will also help the government in the future to manage the planning and defense activities so that peaceful and democratic development of India will take place.

To enable these, ISRO has embarked on the following Programmes:

- Launch Vehicle development programme comprising of Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV) and next-generation GSLV Mk-III launch vehicle missions.
- Earth Observation programme consisting of state-of-the-art remote sensing satellites viz. Resourcesat, Cartosat, Oceansat, Radar Imaging Satellite, Geo-Imaging Satellite and weather/ climate satellites viz. INSAT-3DR missions.
- Satellite Communication programme comprising of INSAT/GSAT communication satellites

- Satellite Navigation programme consisting of constellation of 7 Indian Regional Navigation Satellite System (IRNSS) along with associated ground segment intended to provide accurate positional information and timing services.
- Space science and planetary exploration programme.
- It is required that government make prudent use of these programmes and services by combining ISRO's technology advancement with its public policies. For example:
- Mapping of national highways through satellite imaging will help NHAI to lay highways in a better way.
- Smart City project: precise planning with the help of remote sensing satellites, which can help in the success of the Smart city project.
- Mineral exploration: to utilize NMET (National Mineral Exploration Fund) in a sound manner for exploration activities of alternative sources of energy. It can also help in mapping of mineral resources.
- Weather forecasting: Project like RISAT which is solely working to generate accurate weather forecast, can help farmers and coastal people in case of cyclones, etc.
- Communication: to provide services like health, education to remote areas it is required that these people could be connected with the wider world and for this communication satellite can reinforce this work.
- Navigation: services of IRNSS such as route mapping, shortest distance, etc. has helped in reducing time consumed and also helping in avoiding accidents.
- Defense: From the security point of view, GSAT-7 is providing proper surveillance to the armed forces.
  - The village resource center,
  - Tele-Education & Tele-Medicine
  - Disaster Management Support
  - Remote sensing applications
  - Urban Planning, Engineering, and Construction
  - Crime Mapping

ISRO plans for nuclear energy use in space

- The UR Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) invited proposals for the three phase development of a 100 Watt Radioisotope Thermoelectric Generator (RTG).
- It is ISRO's lead centre for design, development, fabrication, and testing of all Indian-made satellites.
- The centre envisions using RTG for power generation and thermal management of ISRO's deep space missions.
- RTGs were first used in space during the Cold War in 1961 for the US's Transit-4A Mission. Since then, the erstwhile Soviet Union had launched over two dozen nuclear-powered space objects.
- However, budget constraints, complicated designs, progress in alternative sources of energy, and the possibility of escalation of the Cold War led to the curtailment of nuclear propulsion projects.
- Now, the importance of the space frontier and the desire to make new scientific discoveries increase, nuclear power sources have come into the spotlight once more.
- RTGs provide power by using thermocouples to convert thermal energy generated by the natural decay of radioactive isotopes into electrical energy.

- They are highly reliable and maintenance-free as the absence of moving parts in thermocouples reduces the chances of failure and wear out.
- Nuclear-propelled rockets are more fuel efficient and lighter than chemical rockets. Hence, they would travel further, are faster, and would shorten the trip time

Private Sector Participation in Space

- Privatization of space refers to the control of the space exploration industry by the private companies. It started in the 1990s. Space exploration was earlier and still largely is a monopoly of the state and the state controlled agencies like NASA, ESA, JAXA, ROSCOSMOS, etc. But more and more small private companies catering to space exploration are budding. For instance, SpaceX became the first private firm to dock a spacecraft (Dragon) at the International Space Station (ISS) in 2012.
- Today the global space industry is worth $400 billion and is set to touch $1 trillion by 2040. India's participation in it is only 2%. In order to improve toward this end, Indian National Space Promotion and Authorisation Centre (IN-SPACe) has been set up to address the needs of the private sector in India's space programme. It will independently make decisions to regulate space activities in the private sector. Similarly, New Space India Limited (NSIL) , the commercial arm of ISRO, enables Indian industries to take up high tech speed related activities.
- Likewise, ANTRIX Corporation Ltd. the marketing arm of ISRO manages ISRO's commercial deals for satellites and launch vehicles with foreign customers. Other private players in India to venture into the field of space exploration are Skyroot Aerospace- test fired Raman, Pixxel and Bellatrix Aerospace to name a few.

Global Protocols on outer space

The treaties commonly referred to as the "five United Nations treaties on outer space" govern the outer space:

- **The Outer Space Treaty-**Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. It entered into force on 10 October 1967. India signed the treaty in 1967 and ratified it in 1982.
- **The Rescue Agreement-**Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space. It entered into force on 3 December 1968 and is ratified by India.
- **The Liability Convention-**Convention on International Liability for Damage Caused by Space Objects. This treaty entered into force on 1 September 1972.
- **The Registration Convention-**Convention on Registration of Objects Launched into Outer Space. Adopted by the General Assembly in its resolution 3235 (XXIX), opened for signature on 14 January 1975, entered into force on 15 September 1976
- **The Moon Agreement-**Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. Adopted by the General Assembly in its resolution 34/68, opened for signature on 18 December 1979, entered into force on 11 July 1984.
- **Indian private players:** India, because of the efforts of ISRO has come a long way to make a mark of its own among the topmost nations when it comes to space exploration. But for private players to reach the level of international companies like SpaceX, Planet Labs, Blue Origin a lot of private funding and participation is required.

Unintended consequences of Global space race

- **Space Debris**-unfettered space race by humans has resulted in an increased space debris revolving in the orbits. This is not just dangerous for the satellites but also manned space stations and missions, life of which can be jeopardized in case of collisions.
- **Exchange of terrestrial micro-organisms**-the outer space is essentially vacuum, the to and fro exchange of life from earth to space, specially moon and mars can transfer micro-organism from earth, which can cause adverse and unknown effects
- **Undue load on resources**-space programs requires enormous amount of resources; expensive fuel, technology, rare earth minerals, semiconductors among others. Commercialization of the space race is likely to deplete these resources at a far greater pace.
- **Power struggle**-dominance for space is likely to trigger a cold war like situations among various nations. Ex China is already planning to mine Helium from Moon surface making entire world nervous.

Mars Orbiter Mission

Mission objectives:

- One of the main objectives of the first Indian mission to Mars is to develop the technologies required for design, planning, management and operations of an interplanetary mission. From **technological viewpoint**, ISRO is looking at the mission that would help in design and realization of a Mars orbiter with a capability to survive and perform Earth bound manoeuvres, cruise phase of 300 days, Mars orbit insertion / capture, and on-orbit phase around Mars. It will also explore possibilities of deep space communication, navigation, mission planning and management and incorporate autonomous features to handle contingency situations. The **scientific objective** which ISRO intends to achieve is the exploration of Mars surface features, morphology, mineralogy and Martian atmosphere.

Significance of Mars Orbiter Mission

- India has sent its mars mission first time "to study a celestial body outside Earth's sphere of influence. **The significance are:**
  - If the satellite makes it into the Red Planet's orbit, India's space agency will become the fourth in the world after those of the US, Russia and Europe to undertake a successful Mars mission.
  - A successful Mars mission would be a boost for India's space diplomacy as it has, in the past two decades, begun sharing experiences with other countries. The Mars Mission could lead to significant international collaborations.
  - Many countries in Asia, Africa and Latin America are seeing good economic growth. But they lack skilled manpower, technology and budget to setup their own launch vehicles and premier space agencies. But they too need satellites for communication and military. So, they outsource the satellite launch/survey work to established players. Presently ISRO's commercial Arm ANTRIX makes annual profit of Rs. 100 crore rupees from such 'outsourced' contracts. As ISRO establishes reputation will get more contracts from third world.
  - India Rs.450 crore mission to Mars is intended to survey its geology and atmosphere. This is important as it will help improve understanding why only the Earth is habitable and others are not.
  - The spacecraft shares some scientific objectives with America's **Mars Atmosphere and Volatile Evolution mission (MAVEN).** Sensors on both spacecraft will examine processes that have drastically thinned the Martian atmosphere, which was one thick enough to allow substantial bodies of liquid water to exist on the Red Planet's surface.

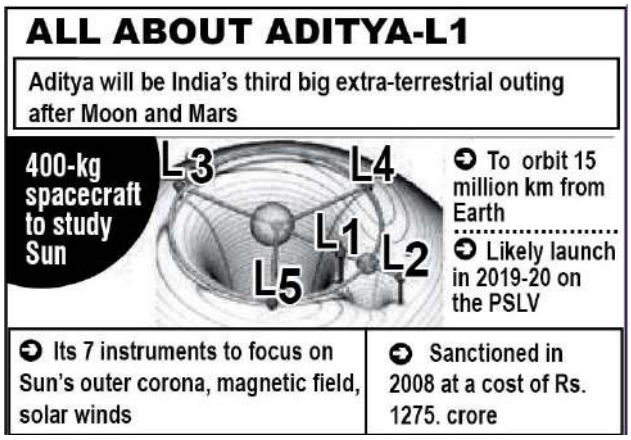
- It was made entirely indigenously. Indian-educated scientists designed and fabricated it in barely 15 months. It had been made at low cost, with the total bill coming in at under $73 million, or about a fifth of what the few other countries that have sought to explore Mars have spent. Hence will start a new era of low cost space missions.

Solar Mission– ADITYA

- ADITYA-1 is the first Indian space based Solar Coronagraph intended to study the outermost region of the sun called 'Corona'.

About Corona:

- The Temperature of the solar corona goes beyond million degrees. From the ground, the Corona could be seen only during total solar eclipses mainly due to the bright solar disc and the scattering of the sunlight by the Earth's atmosphere. One has to go beyond the atmosphere to be able to mask the bright solar disc and study the Corona.



Objectives of the Mission:

- The major scientific objectives of Aditya-1 are to achieve a fundamental understanding of the physical processes that,
  - Heat the solar corona,
  - Accelerate the Solar Wind,
  - Produce Coronal Mass Ejections (CMEs).
- Aditya-L1, the Indian Sun mission which may turn out to be a unique formation of not one but 2 spacecraft looking at the Sun from 2 stable orbital points is ready to observe the Sun.
- The project will increase our understanding about the Sun.
- Activities related to the Aditya-L1 mission have started. The 2 [spacecraft to Sun] together will become unique. Having another one at L5 will give a significant advantage in measurements.

The Challenges

- The 1ST concern is to build a few ultra-sensitive instruments to accurately measure minute details about the Sun.
- Another concern is about the cost of the project as the mission will be a unique formation of two spacecraft looking at the fiery star.

About Lagrangian' point

- There are five other locations around a planet's orbit where the gravitational forces and the orbital motion of the spacecraft, Sun and planet interact to create a stable location from which to make observations. These points are known as Lagrangian or 'L' points.

Chandrayaan-2 Mission

- Chandrayaan-2 is the second lunar exploration mission developed by the Indian Space Research Organisation (ISRO), after Chandrayaan-1. It consists of a lunar orbiter, and also included the Vikram lander, and the Pragyan lunar rover, all of which were developed in India.
- The main scientific objective is to map and study the variations in lunar surface composition, as well as the location and abundance of lunar water.
- The spacecraft was launched on its mission to the Moon from the second launch pad at the Satish Dhawan Space Centre in Andhra Pradesh on 22 July 2019 at 09:13:12 UTC by a GSLV Mark III-M1.
- The craft reached the Moon's orbit on 20 August 2019 and began orbital positioning manoeuvres for the landing of the Vikram lander.
- The lander and the rover were scheduled to land on the near side of the Moon, in the south polar region at a latitude of about 70° south on 6 September 201W9 and conduct scientific experiments for one lunar day, which approximates to two Earth weeks.
- However, the lander crashed when it deviated from its intended trajectory while attempting to land on 6 September 2019. According to a failure analysis report submitted to ISRO, the crash was caused by a software glitch. ISRO will re-attempt a landing in 2023 with Chandrayaan-3.

Chandrayaan-3

- Chandrayaan-3is a planned third lunar exploration mission by the Indian Space Research Organisation (ISRO).
- Following Chandrayaan-2, where a last-minute glitch in the soft landing guidance software led to the failure of the lander's soft landing attempt after a successful orbital insertion, another lunar mission for demonstrating soft landing was proposed.
- Chandrayaan-3 will be a mission repeat of Chandrayaan-2 but will only include a lander and rover similar to that of Chandrayaan-2.
- It will not have an orbiter, but its propulsion module will behave like a communications relay satellite. The spacecraft is planned to be launched in the first quarter of 2023.
- The rocket for the launch of the spacecraft was declared ready and awaits the module
- In the second phase of the Chandrayaan programme to demonstrate soft landing on the Moon, ISRO launched Chandrayaan-2 onboard a GSLV Mk III launch vehicle consisting of an orbiter, a lander and a rover. The lander was scheduled to touchdown on the lunar surface in September 2019 to deploy the Pragyan rover.

Gaganyaan

In 1984, India's first astronaut Wing Commander (retd.) Rakesh Sharma orbited Earth as part of a Soviet mission.

The Prime Minister of India in his Independence Day address announced that an **Indian astronaut would go into space by 2022** when India celebrates her 75th year of Independence.

Details

- **Launch Vehicle:** Isro's Geosynchronous Satellite Launch Vehicle GSLV Mk III, the three-stage heavy-lift launch vehicle, will be used to launch Gaganyaan as it has the necessary payload capability. GSLV

Mk III is designed to carry 4 ton class of satellites into Geosynchronous Transfer Orbit (GTO) or about 10 tons to Low Earth Orbit (LEO). The powerful cryogenic stage of GSLV Mk III enables it to place heavy payloads into LEO's of 600 km altitude.

- **Strap-Ons:** The launcher uses two S200 solid rocket boosters to provide the huge amount of thrust required for liftoff.
- **Orbit:** The spacecraft will be placed in a Low earth orbit of 300-400 km.
- **Cost:** Rs. The 17,500-crore mission will be a turning point in India's space journey.
- **Technologies Involved:** Isro has developed some critical technologies like re-entry mission capability, crew escape system, crew module configuration, thermal protection system, deceleration and flotation system, sub-systems of life support system required for Mission Gaganyaan. It is going to be a Reusable Vehicle.
- **International Assistance:** ISRO will receive assistance from the French space agency CNES, in terms of expertise in various fields including space medicine, astronaut health monitoring, radiation protection, and life support.

Progress

- **Contingency Plan:** In pursuance of this, in July 2018, ISRO conducted an experiment for the emergency escape of astronauts called the Pad Abort Test which demonstrated the safe recovery of the crew module in case of an emergency at the launch pad.
- The 'pad abort' test or Crew Escape System is an emergency escape measure that helps pull the crew away from the launch vehicle when a mission has to be aborted.

Challenges

- Astronaut related Safeguards: Sending a satellite is quite different from sending a human being because, in zero gravity environments, various physical and psychological changes appear in the humans. So rigorous training, safeguards, and testing are required.
- Cost Implications: India is a country where a significant population is still under the web of poverty, malnutrition, and unemployment. In such a scenario, Gaganyaan will add a huge financial burden to the Indian Economy.
- Launch Vehicle: The launch vehicle for this mission has gone only twice into space. In order to rely on the launch vehicle for sending a human into space, it should be tested for at least 10-15 times.

Significance of the Mission

- India will join the elite club of 4 nations i.e US, Russia, China and now India who have sent a manned mission in space.
- The technologies, being developed and used in this mission could be used to solve several other problems prevailing in the country. For example, a heat resistant gel has been developed to create a cool environment in the spacecraft. This technology also finds application in the hot steam pipes which reduces the chances of Pipe explosion accidents.
- It will further enhance the credentials of Antrix Corporation Limited, the commercial arm of the Indian Space Research Organisation, in the world.

Way Forward

Gaganyaan will prove to the world that India can become a major power in many areas. However, there are several technological challenges in the pipeline for ISRO to overcome in order to make this ambitious mission, a successful one. The deadline for the mission is achievable but there should not be any compromise in taking care of all the necessary technical safeguards.

Indian National Space Promotion and Authorization Centre (IN–SPACe)

- The Government of India has launched a new initiative by the name Indian National Space Promotion and Authorization Centre (IN-SPACe) to provide a level playing field for private companies to use Indian space infrastructure, which will be extended into the Indian Space Research Organisation (ISRO).
- The new Indian National Space Promotion and Authorisation Centre (IN-SPACe), which is expected to be functional within six months, will-
- assess the needs and demands of private players, including educational and research institutions
- explore ways to accommodate these requirements in consultation with ISRO
- IN-SPACe is supposed to be a facilitator, and also a regulator. It will act as an interface between ISRO and private parties, and assess how best to utilise India's space resources and increase space-based activities.
- Existing ISRO infrastructure, both ground- and space-based, scientific and technical resources, and even data are planned to be made accessible to interested parties to enable them to carry out their space-related activities.
- National Space, Promotion & Authorisation Centre (IN-SPACe) will help private players through encouraging policies, through a regulatory environment that is friendly as well as guiding private players in space activities.
- Indian Space Research Organisation (ISRO) will remain the basic body that decides what missions are to be undertaken but this new body will help fill the gaps.

Green Propulsion For India's Human Space Mission 'Gaganyaan'

What is Green Propulsion?

- **Green alternative:** It is a **green alternative for the conventional chemical propulsion** systems for future spacecraft.
- This is called a "green" fuel because when **combusted it transforms into nontoxic gasses.**
- **Efficient:** The green propulsion system seeks to improve **overall propellant efficiency.**
  - It delivers **a higher specific thrust** delivered to per given quantity of fuel.
  - It strives to **optimize the performance** of the hardware, systems, and power solutions.
  - This is easier and safer for storage and handling.
- **Less toxic:** It will reduce the handling concerns which are associated with the toxic fuel hydrazine.
- **Lower cost:** It requires a potentially shorter launch processing period and results in lowering costs.
- **Example: Hydroxylammonium nitrate (NH3OHNO3)** fuel/oxidizer blend which is also known as AF-M315E is one example of green propellant.

NASA's OSIRIS-REx

- OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer) is a NASA asteroid-study and sample-return mission.The mission's primary goal is to obtain a sample of at least 60 g (2.1 oz) from 101955 Bennu, a carbonaceous near-Earth asteroid, and return the sample to Earth for a detailed analysis. The material returned is expected to enable scientists to learn more about the formation and evolution of the Solar System, its initial stages of planet formation, and the source of organic compounds that led to the formation of life on Earth.
- OSIRIS-REx was launched on 8 September 2016, flew past Earth on 22 September 2017, and rendezvoused with Bennu on 3 December 2018. It spent the next several months analyzing the surface to find a suitable site from which to extract a sample.
- On 20 October 2020, OSIRIS-REx touched down on Bennu and successfully collected a sample. Though some of the sample escaped when the flap that should have closed the sampler head was jammed open by larger rocks, NASA is confident that they were able to retain between 400 g and over 1 kg of sample material, well in excess of the 60 g (2.1 oz) minimum target mass.
- OSIRIS-REx is expected to return with its sample to Earth on 24 September 2023 and subsequently start its new mission to study 99942 Apophis as OSIRIS-APEX ('APophis EXplorer'), arriving at that asteroid in 2029.

What is asteroid?

- Asteroids are rocky objects which orbit the Sun.
- They much smaller than planets and are also called minor planets.
- There are around 994,383 known asteroids.

Asteroid Bennu

- Bennu is a tall asteroid and located about 200 million miles away from the Earth.
- Bennu is said to have been born in the Main Asteroid belt between Mars and Jupiter and because of gravitational tugs from other celestial objects.
- Bennu is named after an Egyptian deity.
- The asteroid was discovered by NASA-funded Lincoln Near-Earth Asteroid Research team in 1999.
- Bennu is classified as a Near Earth Object (NEO).
- NEOs are comets and asteroids nudged by the gravitational attraction of nearby planets into orbits which allow them to enter the Earth's neighbourhood.
- Bennu is a B-type asteroid which implies that it contains significant amounts of carbon and various other minerals.
- Because of the high carbon content, the asteroid reflects about 4% of the light that hits it, which is very low in comparison to Venus, which reflects about 65 per cent of the light and Earth that reflects about 30 per cent.
- There is a slight possibility that Bennu, might strike the Earth in the next century between the years 2175 and 2199.

Reason behind its study

- This is studied for information about the formation and history of planets and the sun because asteroids were formed at the same time as other objects in the solar system.

- Bennu is considered to be an ancient asteroid which has not gone much composition-altering change through billions of years.
- It means that below its surface lie chemicals and rocks from the birth of the solar system.
- It might give the clues about the origins of the solar system, the sun, the Earth and the other planets.

How the spacecraft collected the sample in October 2020?

- **Rock stirring:** The spacecraft contacted the surface of the asteroid and fired a burst of nitrogen gas that stirred the rocks and soil.
  - After the surface was disturbed, the spacecraft's robotic arm captured some samples.

What will scientists do with the samples?

- **Samples:** The spacecraft will return in September 2023 and will bring back the largest sample collected by a NASA mission since the Apollo astronauts.
  - The samples will be used to study the formation of the solar system and of habitable planets such as Earth.

SpaceX's Starship

Serial number 15 (SN15) Prototype

- **Privately developed:** It is designed by Elon Musk's company SpaceX, which is the first private company to do so.
- **Reusable:** The spacecraft is considered as a game-changer for space travel, as it is a fully reusable transportation system for crew and cargo to the Earth's orbit, Moon and Mars.
  - It is full-scale, stainless steel, bullet-shaped rocketship.
- **Starship's Prototype:** Serial number 15 (SN15) is a prototype of the futuristic Starship rocket.
  - Starship is a spacecraft and super-heavy booster rocket.
  - tarship has been under development since 2012
  - It is a reusable transportation system for crew and cargo to the Earth's orbit, Moon and Mars.
  - It has an ability to carry over 100 metric tonnes to the Earth's orbit.

Advantages over other rockets

- **Replacement:** Starship system is expected to replace SpaceX's partially reusable Falcon rockets, which is partially reusable and currently in operation.
- **Reduced cost:** Starship can deliver satellites at lower marginal costs than Falcon vehicles.
  - It can ferry both cargo and crew to the International Space Station (ISS).
  - As it is reusable, it would reduce the cost of travelling to space by a hundredfold.
- **Large cargo:** Starship is also expected to carry large amounts of cargo to the Moon.
- **Interplanetary:** The spacecraft is being designed for carrying the crew and cargo for interplanetary missions as well.

- **Resistant:** The Starship spacecraft will enter Mars's atmosphere at a speed of 7.5 km per second.
  - It will be designed to withstand multiple entries.
- **First to mars:** While no human being has set its foot on Mars yet.
  - SpaceX is planning the first cargo mission to the red planet by 2022 and by 2024.

How it is supportive to NASA's Artemis mission?

- **Successful bidder:** SpaceX has been choosen to build a lander for NASA's Artemis programme, which plans to send humans to the Moon.
  - SpaceX won it in a bidding war against traditional space giants, Amazon and Dynetics.
  - The present flight success supports it current Artemis bid.

Artemis Program

- The Artemis Program is a NASA's international human spaceflight program.
- It will be the first crewed lunar mission after the Apollo program in 1972.
- NASA aims to demonstrate new technologies, capabilities and business approaches which will ultimately be needed for the future exploration of Mars.

Space Station

- A space station, also known as an orbital station or an orbital space station, is a spacecraft capable of supporting a human crew in orbit for an extended period of time, and is therefore a type of space habitat.
- It lacks major propulsion or landing systems.
- Stations must have docking ports to allow other spacecraft to dock to transfer crew and supplies.
- As of 2021, one fully operational and permanently inhabited space station is in low Earth orbit: the International Space Station (ISS).
- China, India, Russia, and the U.S., as well as Bigelow Aerospace and Axiom Space, are all planning other stations for the coming decades.

Lunar Space Station

- The Lunar Gateway, or simply Gateway, is a planned small space station in lunar orbit intended to serve as a solar-powered communication hub, science laboratory, short-term habitation module, and holding area for rovers and other robots.
- Gateway development includes four of the International Space Station partner agencies: NASA, ESA, JAXA, and CSA.
- Its construction is planned to take place in the 2020s.

China's 'Artificial Sun'

About the new record

- China's **Experimental Advanced Superconducting Tokamak (EAST)** mimics the energy generation process of the sun.

- It set a new record after it ran at 216 million degrees Fahrenheit (120 million degrees Celsius) for 101 seconds, according to state media. For another 20 seconds, the "artificial sun" also achieved a peak temperature of 288 million degrees Fahrenheit (160 million degrees Celsius), which is over ten times hotter than the sun.
- **Significance:** It is a significant step in the country's quest to unlock clean and limitless energy, with minimal waste products.

China's 'artificial sun' EAST

- The Experimental Advanced Superconducting Tokamak (EAST) reactor is an advanced nuclear fusion experimental research device located at the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in Hefei, China.
- The purpose of the artificial sun is to replicate the process of nuclear fusion, which is the same reaction that powers the sun.
- The EAST is one of three major domestic tokamaks that are presently being operated across the country.
- It first became operational in 2006.
- EAST has set several records for the duration of confinement of exceedingly hot plasma.
- The EAST project is part of the International Thermonuclear Experimental Reactor (ITER) facility, which will become the world's largest nuclear fusion reactor when it becomes operational in 2035.
- The project includes the contributions of several countries, including India, South Korea, Japan, Russia and the United States.

How the 'artificial sun' EAST works?

- The EAST Tokamak device is designed to replicate the nuclear fusion process carried out by the sun and stars.
  - Nuclear fusion is a process through which high levels of energy are produced without generating large quantities of waste.
  - For nuclear fusion to occur, tremendous heat and pressure are applied on hydrogen atoms so that they fuse together.
  - The nuclei of deuterium and tritium — both found in hydrogen — are made to fuse together to create a helium nucleus, a neutron along with a whole lot of energy.
- Fuel is heated to temperatures of over 150 million degrees C so that it forms a hot plasma "soup" of subatomic particles. With the help of a strong magnetic field, the plasma is kept away from the walls of the reactor to ensure it does not cool down and lose its potential to generate large amounts of energy.
- The plasma is confined for long durations for fusion to take place.

Next move

- The next goal for the scientists behind the experimental reactor is to maintain the high temperature for a long period of time.
- Previously, the EAST had reached a record temperature of 100 million degrees Celsius in 2018.
- "It's more like a future technology that's critical for China's green development push," he said.

Neutrino Observatory

- India-based Neutrino Observatory **(INO)** is an underground laboratory with a rock cover of approximate 1200 metre for non-accelerator based high energy and nuclear physics research in India.
- The project also includes Inter-Institutional Centre for High Energy Physics **(IICHEP)** and Iron Calorimeter Detector **(ICAL)**.

About INO

- The INO laboratory will host experiments such as the neutrino-less double beta decay and the search for dark matter.
- The project will be jointly supported by the Department of Atomic Energy and the Department of Science and Technology.
- The infrastructural support will be given by the State Government of Tamil Nadu since the project is located in Tamil Nadu.
- The construction of 50000 tonne magnetised ICAL is to study the properties of the neutrino especially the mass hierarchy among different types of neutrino.

The Goals of INO Are:

- To Study neutrinos which are fundamental particles belonging to the lepton family. Neutrinos come in 3 flavours, one associated with electrons and the others with their heavier cousins the muon and the Tau.
- Development of detector technology and its varied applications.

Why INO?

- Neutrino detectors around the world seem to see evidence that these weakly interacting, little-understood particles are not really massless, as was thought so far. Not only do they have non-zero masses, different species (or flavors) of neutrinos seem to mix and oscillate into one another as they traverse through the cosmos. If this is true, this is not only one of the 1st pieces of evidence for physics beyond the so-called Standard Model of Particle Physics but would also have great impact on diverse fields such as nuclear and particle physics, astrophysics and cosmology. It is thus imperative to study the details of the interactions of these particles. The best option of course is to have a lab in order to do so. In order to maximize the sensitivity to the interactions of these weakly interacting particles, such a neutrino lab is necessarily placed underground.

International Effort

- By this India will join the elite club of selected countries (USA, Russia, France, Italy, China, Japan).
- China has started underground neutrino detectors –JUNO

NGT has suspended green nod

- The Southern Bench of the National Green Tribunal has suspended the Environmental Clearance (EC) granted to the India-based Neutrino Observatory (INO).

About Nuetrinos

What are neutrinos?

- Neutrinos are the elementary particles, which have no charge and have very little mass (10–37).
- Electrically neutral, weakly interactive fundamental particles.

Applications

- **Nuclear Proliferation Detection:**
  - They could be used to remotely detect nuclear proliferation, as radiations are routinely generated by radioactive activities (especially plutonium 239 a by product of nuclear reactor)
- **Data Communication:**
  - They could be used for faster data communication, because they travel large distances without getting attenuated .
- **Mineralogy:**
  - As they change their direction and spin, depending upon the medium they pass, they could be utilized to map resources inside earth.
- **Disaster Prediction:**
  - Geoneutrinos produced by radioactive decay of (Th, U) can give valuable information about earthquakes.
- **Information Bearers of Universe:**
  - Neutrinos could also be helpful in unearthing the mystery of dark matters, because they are few of the particles that pass through dark matter.

Space Activities Bill, 2017

Introduction

- Space activities in India, which started in early 1960s, are hitherto pursued by Department of Space (DOS), as nodal agency for space activities in India. As per 'Government of India (Allocation of Business) Rules 1961(as amended from time to time) DOS has been responsible for the space activities in India, for more than five decades, with the major objective of bringing the benefits of space technology and its applications to societal needs and national development.
- Pursuance of Space activities were focused on three major areas namely:
  - Space Infrastructure which includes realization of spacecraft for various applications and associated ground infrastructure,
  - Space Transportation systems, which include through realization of various types/class of launch vehicles and associated ground infrastructure including launch facilities, and
  - Space applications for various national requirements through establishment of necessary ground infrastructure and coordination mechanisms.

Need for national space legislation

- Over a period, with the logical evolution of space activities in India from conceptual, experimental, operational, commercial and further expansion phases, the demands for space systems, applications and services for national needs and beyond have been rapidly growing. This scenario also encourages the participation of Indian industry and service providers at much higher levels in all round space activities under the technical guidance and authorization of the Government through Department of Space.
- Further, a few start-up companies too in India are showing interest in engaging in space systems activities. Commercial opportunities in space activities and services, nationally and internationally demand higher order of participations by private sector agencies. This situation demands for a

necessary legal environment for orderly performance and growth of space sector. Constitution of India too provides for implementation of international treaty obligations, vide Articles 51 and 253.

- Thus there is a need for national space legislation for supporting the overall growth of the space activities in India. This would encourage enhanced participation of non-governmental/private sector agencies in space activities in India, in compliance with international treaty obligations, which is becoming very relevant today.

Salient features of the Bill

- The provisions of this Act shall apply to every citizen of India and to all sectors engaged in any space activity in India or outside India
- A non-transferable licence shall be provided by the Central Government to any person carrying out commercial space activity
- The Central Government will formulate the appropriate mechanism for licencing, eligibility criteria, and fees for licence.
- The government will maintain a register of all space objects (any object launched or intended to be launched around the earth) and develop more space activity plans for the country
- It will provide professional and technical support for commercial space activity and regulate the procedures for conduct and operation of space activity
- It will ensure safety requirements and supervise the conduct of every space activity of India and investigate any incident or accident in connection with the operation of a space activity.
- It will share details about the pricing of products created by space activity and technology with any person or any agency in a prescribed manner.
- If any person undertakes any commercial space activity without authorisation they shall be punished with imprisonment up to 3 years or fined more than Rs.1 crore or both.

Analysis of the bill

- The Bill has not specified any department or body within the Government of India to take ownership of regulating space activities. Since ISRO is managed by the DoS, an independent body should be created or nominated to administer space activities. This is to ensure no conflict of interest arises between state and non-governmental/private actors. A good example, and longstanding demand, is to split up the licensing and administrative duties of the Telecom Regulatory Authority of India.
- Activities like satellite-based communications need inter-ministerial as well as inter-departmental inputs today. Therefore, a nodal agency comprising officials from the relevant ministries and departments, all of whom are stakeholders in the activity, will help move things along by being able to offer single-window clearances for licensing, promote better conditions for FDI and provide regulatory transparency.
- So having an independent nodal agency will catalyse the formation of a space-based digital economy in the country. Today, new players in the space ecosystem such as Luxembourg have gone on to provide sovereign national funds as well as legal frameworks to private companies to capture potential business opportunities in space mining. While this may be debatable from an international obligations POV (referring to the Outer Space and Moon Treaties), they have created national legal frameworks to enable businesses to own material extracted in space.

Private sector in India's space programme

- Government, **under Aatma Nirbhar Bharat Abhiyaan (Self-Reliant India Mission),** announced role for **private sector in India's space programme,** including in satellites, launches and space-based services.

- **Following announcements were made under Aatma Nirbhar Bharat Abhiyaan (Self-Reliant India Mission)**
- **Level playing field provided to private companies** in satellites, launches and space-based services.
- **Predictable policy** and **regulatory environment** to private players.
- **Private sector** will be allowed **to use ISRO facilities** and other relevant assets **to improve their capacities**.
- Recently, ISRO **opened up its facilities for private players**, which includes helping a consortium of companies to build **polar satellite launch vehicle.**
- Future projects for **planetary exploration, outer space travel** etc. shall also be **open for private sector.**
- There will be **liberal geo-spatial data policy** for providing remote-sensing data to tech-entrepreneurs.

Benefits of private sector in space activities:

- Increasing Demand for satellites with need to launch 18-20 satellites every year. With existing ISRO manpower, it is difficult and private sector can play role here meeting global requirements too.
- Getting latest innovations and trends: Collaboration with private players is vital for capacity building, getting cutting-edge technology, latest innovations etc.
- Freeing up resources: A large chunk of ISRO's manpower is involved in manufacturing and launch vehicles, so active involvement of the private sector would allow ISRO to devote more time to core research, deep-space missions etc.
- Reducing dependence on taxpayer's money: Privatizing activities in space sector will allow economic contribution from private sector and will reduce dependence on funds from government.

Space Debris

What are Space Debris?

- Space debris is defined as all non-functional, human-made objects, including fragments and elements thereof, in Earth orbit or re-entering into Earth's atmosphere. Human-made space debris dominates over the natural meteoroid environment, except around millimeter sizes.
- There are more than 20,000 pieces of debris larger than a softball orbiting the Earth.
- They travel at speeds up to 17,500 mph, fast enough for a relatively small piece of orbital debris to damage a satellite or a spacecraft.
- There are 500,000 pieces of debris the size of a marble or larger. There are many millions of pieces of debris that are so small they can't be tracked.

What is Kessler Syndrome?

- The Kessler Syndrome is a theory proposed by NASA scientist Donald J. Kessler in 1978, used to describe a self-sustaining cascading collision of space debris in LEO. It's the idea that two colliding objects in space generate more debris that then collides with other objects, creating even more shrapnel and litter until the entirety of LEO is an impassable array of super swift stuff. At that point, any entering satellite would face unprecedented risks of headfirst bombardment.

What are the effects due to the presence of Space Debris?

- **Astronauts are at risk -** Space debris puts astronauts at risk during their spacewalks. NASA defines a spacewalk as "any time an astronaut gets out of a vehicle while in space."

- **The threat to Space Missions:** The greatest risk to space missions comes from non-trackable debris. Even tiny paint flecks can damage a spacecraft when traveling at these velocities. In fact, a number of space shuttle windows have been replaced because of damage caused by material that was analyzed and shown to be paint flecks.
- **The threat to Humans on Earth:** Large space-debris objects (e.g. spacecraft, rocket bodies or fragments thereof) that re-enter into the atmosphere in an uncontrolled way can reach the ground and create a risk to the population on the ground.
- **Impact on Earth's Weather:** The main threat to our weather from space junk is indirect: the density of the junk may become so great that it could hinder our ability to use weather satellites, and hence to monitor weather changes caused by our own ground-based pollution.

What is the current status of Space Junk?

- The number of Space Junk objects has **increased sharply** in recent decades thanks to both the 2009 satellite collision and China's 2007 destruction of the Fengyun-1C weather satellite during an anti-satellite missile test.
- On March 27, 2019, **India** announced it also successfully completed an **anti-satellite missile** test, creating a new cloud of at least 400 pieces of debris, which increased the risk of impacts to the International Space Station (ISS) by an estimated 44 percent over a 10-day period.

What are the ways by which we can remove space debris?

- **Snagging and Moving Space Junk -** The e.DeOrbit mission – first proposed publicly in early 2014 – would seek out satellite debris in a polar orbit at an altitude between 800 and 1,000 kilometers (500 to 620 miles). The European Space Agency is considering several kinds of "capture mechanisms" to pick up the debris, such as nets, harpoons, robotic arms, and tentacles.
- **Using the Power of Electricity -** The Japanese Aerospace Exploration Agency proposes to use an electrodynamics tether whose current would slow down the speed of satellites or space debris
- **Solar Sail -** A British proposal called CubeSail would use the drag of a solar sail to push orbiting space debris down to lower orbits.
- **Huffing and Puffing -** This method (called Space Debris Elimination, or SpaDE) would push satellites into a lower orbit by using air bursts within the atmosphere.
- **Knock Junk Down with a Net -** A network of nanosatellites, connected with a piece of electrically conducting tape that could be as long as 2 miles (3 kilometers), could knock satellites down as it passes through Earth's magnetic field and produces voltage.

What are the initiatives taken up across the globe for cleaning the Space junk?

- **Remove Debris -** Rather than engaging in active debris removal (ADR) of real space debris, the RemoveDEBRIS mission plan is to test the efficacy of several ADR technologies on mock targets in low Earth orbit.
- **OSCaR -** Researchers are developing a cleanup CubeSat called OSCaR (Obsolete Spacecraft Capture and Removal), which would hunt down and de-orbit debris on the cheap using onboard nets and tethers. And OSCaR would do so relatively autonomously, with little guidance from controllers on the ground.
- JAXA, Japan's space agency, is testing an electronic space whip that stretches six football fields long, known as the **electrodynamic tether (EDT).** The electrified line, nearly 2,300 feet long, is capped with a 44-pound weight. When deployed, it's intended to knock debris out of orbit, sending it to burn up in Earth's atmosphere.
- **The Space Fence project -** Lockheed Martin is working to complete a digital radar system that could wrap around the Earth like a fence

- Other proposals include **giant magnets, harpoons, and nets** to safely whittle down the growing debris cloud.

Way Forward

- In order to understand and address the threat of space, debris requires both scientific perspectives as well as a legal approach. The future of space operations needs an active debris removal scientific mechanism thereby ensuring protection and conservation of the environment. A holistic and a comprehensive policy framework comprising of procedures and guidelines for mitigating the impact of space debris needs to be formulated for implementation of the scientific plan by the international community.

Outer Space Treaty

Introduction

- Space exploration is governed by a complex series of international treaties and agreements which have been in place for years.
- Outer Space Treaty was signed in 1967, was agreed through the UN, and today it remains as the 'constitution' of outer space. It has been signed and made official, or has been ratified, by 105 countries across the world.

Provisions

- The Outer Space Treaty, like all international law, is technically binding to those countries who sign up to it. But the obvious lack of "space police" means that it cannot be practically enforced. So a country, individual or company could simply ignore it if they so wished. Implications for not complying could include sanctions, but mainly a lack of legitimacy and respect which is of importance in the international arena.
- Under the terms of the treaty, the parties are prohibited from placing nuclear arms or other weapons of mass destruction in orbit, on the Moon, or on other bodies in space. Nations cannot claim sovereignty over the Moon or other celestial bodies. Nations are responsible for their activities in space, are liable for any damage caused by objects launched into space from their territory, and are bound to assist astronauts in distress.
- Their space installations and vehicles shall be open, on a reciprocal basis, to representatives of other countries, and all parties agree to conduct outer-space activities openly and in accordance with international law.

Challenges so far

- Although there are many points to consider in the treaty, one of the most important is that outer space is to be used for "peaceful purposes" – weapons of mass destruction cannot be used in space. Another is that celestial territory (such as the moon or Mars), is not subject to "national appropriation" – in other words, no country can lay claim to them.
- These points have been subject to challenges since the treaty came into play – the first example of such a challenge was the **Bogota Declaration in 1976**. A group of eight countries tried to claim ownership of a segment of an orbit that was in the space situated above their land – since if their borders projected into the heavens, any "stationary" satellite there would always be within their borders.

- They claimed that this space did not fall under the definition of 'outer space' by the Outer Space Treaty and was, therefore, a 'natural resource'. This declaration was not seen as an attempt to undermine the treaty, but rather to say that orbits that go around the Earth's equator, or in the direction of the Earth's rotation, must be owned by the countries beneath. However, this was eventually dismissed by the international community.
- In 2007 China was thought to have violated the treaty when it shot down one of its own weather satellites with a "ground-based medium-range ballistic missile". This was seen as "aggressive" by Japan, but since the missiles did not come under the definition of "weapons of mass destruction", it was found that it did not violate the treaty. There was, however, international outcry because of the debris cloud it caused within the orbit.
- Outer Space Treaty does have some specific failings in the modern era – mainly since it is focused on countries only. Many private companies, such as Lunarland, have exploited this and have offered to sell plots of land on celestial bodies such as the moon. Agents doing this justify their activity because the treaty says that territory is not subject to national appropriation – and therefore, this technically means that private companies or individuals could, however, make claims to celestial territory, since they are not countries.
- Issues such as the privatization of space exploration, the dangers of excessive satellite debris, the utilization of satellite technology for unethical breaches of privacy, the emergence of Quantum Physics, Quantum Mechanics and Quantum Computing; all pose tremendous challenges to our understanding of Space today. While the OST does deal with some of these issues, there is a need to rework the treaty and contemporize it to deal more directly with issues of the current era. The possibilities of space exploration are boundless but there remains a need to cultivate and establish a stable and well-defined framework that can help with conflict de-escalation and crisis resolution.

20 Years of International Space Station

Context

- The International Space Station has turned 20 years old on November 20, 2018.

What is the International Space Station?

- The International Space Station is a large spacecraft. It orbits around Earth. It is a home where astronauts live.
- The space station is also a science lab. Many countries worked together to build it. They also work together to use it.
- The space station is made of many pieces. The pieces were put together in space by astronauts. The space station's orbit is approximately 250 miles above Earth. NASA uses the station to learn about living and working in space. These lessons will help NASA explore space.
- The ISS programme is a joint project between five participating space agencies: NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada).
- The ownership and use of the space station are established by intergovernmental treaties and agreements.

What is the purpose of ISS?

- **Home in Space:** The space station is a home in orbit. People have lived in space every day since the year 2000. The space station's labs are where crew members do research. This research could not be done on Earth.

- **Scientific Research:** The ISS serves as a microgravity and space environment research laboratory in which crew members conduct experiments in biology, human biology, physics, astronomy, meteorology, and other fields.
- **Future Missions:** It provides transportation, maintenance, and act as a staging base for possible future missions to the Moon, Mars, and asteroids
- **Educational Purposes:** The ISS crew provides opportunities for students on Earth by running student-developed experiments, making educational demonstrations, allowing for student participation in classroom versions of ISS experiments, and directly engaging students using radio, video link, and email.
- In the 2010 United States National Space Policy, the ISS was given additional roles of serving commercial, diplomatic and educational purposes.

What are the achievements of the International Space Station?

- **Commercializing low-Earth orbit -** For the first time, the market is expressing what research can and should be done aboard the microgravity laboratory without direct government funding.
- **Supporting water purification efforts worldwide -** Using technology developed for the space station, at-risk areas can gain access to advanced water filtration and purification systems, making a life-saving difference in these communities.
- **Growing high-quality protein crystals -** There are more than 100,000 proteins in the human body and as many as 10 billion in nature. Each protein holds important information related to our health and to the global environment. The perfect environment in which to study these structures is space. Microgravity allows for optimal growth of the unique and complicated crystal structures of proteins leading to the development of medical treatments
- **Improving eye surgery with space hardware -** The Eye Tracking Device experiment gave researchers insight into how humans' frames of reference, balance and the overall control of eye movement are affected by weightlessness.
- **Making inoperable tumors operable with a robotic arm -** The delicate touch that successfully removed an egg-shaped tumor from Paige Nickason's brain got a helping hand from a world-renowned arm—a robotic arm, that is. The technology that went into developing neuroArm, the world's first robot capable of performing surgery inside magnetic resonance machines
- **Preventing bone loss through diet and exercise -** In the early days of the space station, astronauts were losing about one-and-a-half percent of their total bone mass density per month. Researchers discovered an opportunity to identify the mechanisms that control bones at a cellular level. These scientists discovered that high-intensity resistive exercise, dietary supplementation for vitamin D and specific caloric intake can remedy the loss of bone mass in space.
- **Updates:** Now, ISRO has announced that it would be launching a space station by 2030. It left many surprised, but with first manned mission Gaganyaan set to take-off by 2022, a space station seems like only a logical extension to the program.

James Webb Space Telescope

- The telescope has been in the works for years. NASA led its development with the European Space Agency (ESA) and the Canadian Space Agency. It was launched aboard a rocket on December 25, 2021, and is currently at a point in space known as the Sun-Earth L2 Lagrange point, approximately 1.5 million km beyond Earth's orbit around the Sun.
- Lagrange Point 2 is one of the five points in the orbital plane of the Earth-Sun system. Named after Italian-French mathematician Josephy-Louis Lagrange, the points are in any revolving two-body

system like Earth and Sun, marking where the gravitational forces of the two large bodies cancel each other out. Objects placed at these positions are relatively stable and require minimal external energy or fuel to keep themselves there, and so many instruments are positioned here.

- L2 is a position directly behind Earth in the line joining the Sun and the Earth. It would be shielded from the Sun by the Earth as it goes around the Sun, in sync with the Earth.

What can be seen in the image?

- According to NASA the image shows galaxies that were once invisible to mankind. The image shows shining objects packed together in hues of blue and orange. Swirling, faraway galaxies — similar to how the Milky Way looks — are also visible.
- Taken by Webb's Near-Infrared Camera (NIRCam), the image was made by combining various images at different wavelengths. The image shows the galaxy cluster called SMACS 0723, as it appeared 4.6 billion years ago.
- The combined mass of the galaxy cluster acts as a gravitational lens, magnifying much more distant galaxies behind it. This will help researchers in learning more about the galaxies' masses, ages, histories, and compositions, as Webb seeks out the earliest galaxies in the universe.

Mission of the James Webb Space Telescope

- NASA says the James Webb Space Telescope will be "a giant leap forward in our quest to understand the Universe and our origins", as it will examine every phase of cosmic history: from the Big Bang to the formation of galaxies, stars, and planets to the evolution of our own Solar System.
- The science goals for the Webb can be grouped into four themes. The first is to look back around 13.5 billion years to see the first stars and galaxies forming out of the darkness of the early universe. Second, to compare the faintest, earliest galaxies to today's grand spirals and understand how galaxies assemble over billions of years. Third, to see where stars and planetary systems are being born. And fourth, to observe the atmospheres of extrasolar planets (beyond our solar system), and perhaps find the building blocks of life elsewhere in the universe. The telescope will also study objects within our own Solar System.
- The JWST will be able to see right through and into massive clouds of dust that are opaque to earlier generation visible-light observatories like the Hubble Telescope. Another difference is that the Webb is equipped with cameras and other instruments sensitive to infrared or "heat" radiation, and the Hubble is not. The expansion of the universe causes the light that would normally be in wavelengths that are visible to be shifted to longer infrared wavelengths, normally invisible to human eyes, The New York Times said in a report.

NASA Parker Solar Probe Mission

About the mission

- NASA's historic Parker Solar Probe mission will revolutionize our understanding of the sun, where changing conditions can propagate out into the solar system, affecting Earth and other worlds.
- The primary science goals for the Parker Solar Probe mission are to trace how energy and heat move through the solar corona and to explore what accelerates the solar wind as well as solar energetic particles.
- Parker Solar Probe will travel through the sun's atmosphere, closer to the surface than any spacecraft before it, facing brutal heat and radiation conditions — and ultimately providing humanity with the closest-ever observations of a star.

- In order to unlock the mysteries of the sun's atmosphere, Parker Solar Probe will use Venus' gravity during seven flybys over nearly seven years to gradually bring its orbit closer to the sun. The spacecraft will fly through the sun's atmosphere as close as 3.9 million miles to our star's surface, well within the orbit of Mercury and more than seven times closer than any spacecraft has come before.

Parker Solar Probe has three detailed science objectives:

- Trace the flow of energy that heats and accelerates the solar corona and solar wind.
- Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind.
- Explore mechanisms that accelerate and transport energetic particles.

Significance of the mission

- The Sun is the only star we can study up close. By studying this star we live with, we learn more about stars throughout the universe.
- The Sun is a source of light and heat for life on Earth. The more we know about it, the more we can understand how life on Earth developed.
- The Sun also affects Earth in less familiar ways. It is the source of the solar wind; a flow of ionized gases from the Sun that streams past Earth at speeds of more than 500 km per second (a million miles per hour).
- Disturbances in the solar wind shake Earth's magnetic field and pump energy into the radiation belts, part of a set of changes in near-Earth space known as space weather.
- Space weather can change the orbits of satellites, shorten their lifetimes, or interfere with onboard electronics. The more we learn about what causes space weather – and how to predict it – the more we can protect the satellites we depend on.
- The solar wind also fills up much of the solar system, dominating the space environment far past Earth. As we send spacecraft and astronauts further and further from home, we must understand this space environment just as early seafarers needed to understand the ocean.

Space tourism

Context:

- Blue Origin has successfully launched Jeff Bezos and three other civilians into space on the first crewed flight of the New Shepard spacecraft.

Why in News?

- New Shephard is named after astronaut Alan Shephard who was the first American to go to space and offers flights to space over 100 km above the Earth and accommodation for payloads.
- Essentially, it is a rocket system that has been designed to take astronauts and research payloads past the Karman line, which is the internationally recognized boundary of space. The idea is to provide easier and more cost-effective access to space meant for purposes like academic research, corporate technology development, and entrepreneurial ventures among others.
- Apart from its academic and research-oriented goal, New Shephard will also allow space tourists to experience microgravity by taking them 100 km above the Earth.

Benefits:

- The materials used, and the design elements, could be incorporated in safety equipment in cars and bullet trains.
- Another set of positive consequences may be the clean-up of space debris. It seeks to give people the ability to go to space for recreational, leisure or business purposes.

Issues:

- **Climate change:** Soot or black carbon that results from rocket emissions accumulated in the stratosphere (approximately 5 to 31 miles above the Earth) cannot be washed away by rain or winds, as it is in the lower atmosphere. As a result, black carbon may linger in the stratosphere for years, causing exponentially more climate change.
- **Health:** It can cause health concerns as passengers could also face motion sickness and disorientation, which can affect vision, cognition, balance and motor control.

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Chapter

3

IT, TELECOM & ELECTRONICS

Information technology, also called "IT' in short form is a common term that includes all forms of technology used to create, store, exchange, and use information in various forms. In contemporary technical environment, information technology has vital role to perform numerous human activities and business operations. Basically, Information technology is the study and use of systems for storing, retrieving, and sending information. This comprises of software, hardware, and applications. Information technology assists in arena of Business, education, and even healthcare.

IT Industry in India

- The Indian IT industry evolved under very adverse conditions. In earlier time, there were no local markets and government policy toward private enterprise was antagonistic. The Indian IT Industry started by Bombay-based conglomerates that entered the business by supplying programmers to global IT firms located in foreign. In the decade of 1970's, the Indian economy was state-controlled and remained hostile to the software industry.
- With great success of the IT industry, India is progressing in many sectors. In India, Metropolitan Cities such as Bangalore, Mumbai, Delhi, Chennai and Hyderabad have established numerous IT companies HSBC, Dell, Microsoft, GE, Hewlett Packard, and several Indian multinational firms like Infosys Technologies, Wipro. As these cities offer good infrastructure, with large floor space and great telecom facilities, India's IT sector comprises of two parts.
- The IT industry has also created significant demand in the Indian education sector, especially for engineering and computer science. The Indian IT and ITeS industry is divided into **four major segments –** IT services, Business Process Management (BPM), software products and engineering services, and hardware.
- There is a huge scope of IT Industry in India. IT provides employment, generates foreign exchange, beneficial to other countries, results in more off shoring, increases employees job commitment, financial assistance and Government Support.
- The remarkable growth of the Indian IT Software and Services, IT Enabled Services (ITES) and Business Process Outsourcing (BPO) sector have great effect on the Indian economy. It has direct positive impact on national income and the sector has grown to become the biggest employment generator, and has produced the growing of several subsidiary industries such as transportation, real estate and catering, and has created young consumers.

Computers

Supercomputer and its Applications

- A type of computer which is used to focus on the applications that requires large mathematical and difficult calculations at frontline of processing capacity is known as Super computer. Supercomputers are key to new reforms in all societal sectors of the economy from manufacturing, defence, power, agriculture, communications, engineering sciences, banking, seismic sciences, weather and climate prediction, biotechnology, drug discovery, early warning for natural calamities, key data analysis, life sciences, data mining among others.

The applications of supercomputers have been discussed below:

- **Recreating the Big Bang:** The "Big Bang" or the initial expansion of all energy and matter in the universe, happened more than 13 billion years ago in trillion-degree Celsius temperatures, but supercomputer simulations make it possible to observe what went on during the universe's origin. Researchers can run models that require upward of a thousand trillion calculations per second, allowing for the most realistic models of these cosmic mysteries till date.
- **Understanding earthquakes:** By modeling the three-dimensional structure of the Earth, researchers can predict how earthquake waves will travel both locally and globally. The resulting techniques can be used to map the subsurface for oil exploration or carbon sequestration, and can help researchers understand the processes occurring deep in the Earth's mantle and core
- **Modeling swine flu:** Potential pandemics like the H1N1 swine flu require a fast response on two fronts: First, researchers have to figure out how the virus is spreading. Second, they have to find drugs to stop it. Supercomputers can help with both.
- **Testing nuclear weapons:** Computer simulations to ensure that the country's cache of nuclear weapons is functional and safe. The real aim is to create better simulations of nuclear explosions and to do away with real-world nuke testing for good.
- **Predicting climate change:** The challenge of predicting global climate is immense. There are hundreds of variables, from the reflectivity of the earth's surface. Dealing with these variables requires supercomputing capabilities. The resulting simulations both map out the past and look into the future. Models of the ancient past can be matched with fossil data to check for reliability, making future predictions stronger. New variables, such as the effect of cloud cover on climate, can be explored.
- **More scientific advances:** Supercomputing is needed for processing sophisticated computational models able to simulate the cellular structure and functionalities of the brain. This should enable us to better understand how our brain works and how we can cope with diseases such as those linked to ageing.
- **More reliable decision-making:** The world faces an increasing number of challenges at the local level as well as at the planetary scale. The convergence of HPC, Big Data and Cloud technologies will allow new applications and services in an increasingly complex scenario where decision-making processes have to be fast and precise to avoid catastrophes. Supercomputers are in the front line for developing essential public policies, from homeland security to climate action.

Different supercomputers are:

- **Tianhe-2 or TH-2 ("Milky Way 2")**
  - It is a 33.86-petaflops supercomputer located in National Supercomputer Center in Guangzhou China.It is the world's fastest supercomputer according to the TOP500 lists for June 2013,

November 2013, June 2014 and November 2014.Tianhe-2 runs on Kylin Linux, a version of the operating system developed by NUDT. Resource management is based on Simple Linux Utility for Resource Management (SLURM).

- **Param Yuva II**
  - Param Yuva 2 is Indian Super computer developed by C-DAC in 2013.It is an improved version of Other Param Series supercomputers. Yuva 2 is developed using hybrid technology, processor, coprocessor and hardware accelerators.
  - Param Yuva II will be used for research in space, bioinformatics, weather forecasting, seismic data analysis, aeronautical engineering, scientific data processing and pharmaceutical development.

Param Kanchenjunga

- PARAM is a series of supercomputers designed and assembled by the Centre for Development of Advanced Computing (C-DAC) in Pune, India. The latest machine in the series is the PARAM Yuva II.
- Param Means 'supreme' in Sanskrit.

Here are five lesser known facts about the fastest supercomputer in Sikkim

- 'PARAM Kanchenjunga' is a collaboration between Center for Development of Advanced Computing (C—DAC) and the Ministry of Communications and IT
- 'PARAM Kanchenjunga' would also be the fastest supercomputer among all the NITs.
- The machine is equipped with latest Intel-based processor and accelerator technologies with a peak computing power of 15 Teraflops.
- Using the 'PARAM Kanchenjunga', two faculty members of National Institute of Technology Sikkim (NIT) are already studying how to increase the efficiency of fuel movement through long oil pipelines such as from Middle East to India

K-Computer

- It's a Japan's fastest supercomputer developed by Japanese MNC Fujitsu and is active since 2011.K computer was based on Sparc chips designed by Sun Microsystems. It's based distributed memory architecture and has achieved performance target of 10 petaflops. K computer is being used in a broad range of research fields including drug discovery, earthquake/tsunami research, weather forecasting, space science, manufacturing and material development.

Pratyush Supercomputer

- Pratyush is a collection of several computers that can deliver a peak power of 6.8 petaflops, facilitating the weather forecasting and climate monitoring in the country.
- India's Pratyush is its first multi-petaflop supercomputer to date that is a part of the efforts made by Ministry of Earth Sciences to grow 'High Performance Computing' (HPC) in the country.
- The sole purpose of installing such a high-capacity supercomputer in India is to accelerate the weather forecasting in the country, primarily before the arrival of Monsoon season in India.
- In addition, Pratyush will monitor the onset of other natural calamities such as floods and Tsunami in the country. As a matter of fact, farmers will get a big relief as the unprecedented rainy season in India often results in a bad annual crop production.

National Supercomputing Mission

- Over the years, supercomputers have benefited mankind in several ways. Thus to improve capabilities beyond current levels National Supercomputing Mission has been launched by the government to connect national academic and R&D institutions with a grid of over 70 high-performance computing facilities at an estimated cost of Rs 4,500 crore.
- These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network (NKN).
- The NKN is another program of the government which connects academic institutions and R&D labs over a high speed network. Academic and R&D institutions as well as key user departments/ ministries would participate by using these facilities and develop applications of national relevance.
- The Mission also includes development of highly professional High Performance Computing (HPC) aware human resource for meeting challenges of development of these applications.
- The mission would be implemented by the Department of Science and Technology and Department of Electronics and Information Technology (Deity) through Center for Development of Advanced Computing (C-DAC) and Indian Institute of Science (IISc), Bangalore.

Edge computing

- The origins of edge computing lie in content delivery networks that were created in the late 1990s to serve web and video content from edge servers that were deployed close to users.
- In the early 2000s, these networks evolved to host applications and application components at the edge servers, resulting in the first commercial edge computing services[4] that hosted applications such as dealer locators, shopping carts, real-time data aggregators, and ad insertion engines.
- Modern edge computing significantly extends this approach through virtualization technology that makes it easier to deploy and run a wider range of applications on the edge servers.
- Edge computing brings analytical computational resources close to the end users and therefore helps to speed up the communication speed. A well designed edge platform would significantly outperform a traditional cloud-based system.
- Due to the proximity of the analytical resources to the end users, sophisticated analytical tools and Artificial Intelligence tools can run on the edge of the system. This placement at the edge helps to increase operational efficiency and contributes many advantages to the system.

Applications of edge computing

- Edge application services reduce the volumes of data that must be moved, the consequent traffic, and the distance that data must travel. That provides lower latency and reduces transmission costs. Computation offloading for real-time applications, such as facial recognition algorithms, showed considerable improvements in response times, as demonstrated in early research.
- Further research showed that using resource-rich machines called cloudlets near mobile users, which offer services typically found in the cloud, provided improvements in execution time when some of the tasks are offloaded to the edge node.
- On the other hand, offloading every task may result in a slowdown due to transfer times between device and nodes, so depending on the workload an optimal configuration can be defined.
- Another use of the architecture is cloud gaming, where some aspects of a game could run in the cloud, while the rendered video is transferred to lightweight clients running on devices such as mobile phones, VR glasses, etc. This type of streaming is also known as pixel streaming.
- Other notable applications include connected cars, autonomous cars, smart cities, Industry 4.0 (smart industry) and home automation systems

Applications of Information Technology

- Computers and other electronic devices are becoming increasingly inexpensive in technically changing world. They continue to be more powerful as information-processing tools as well as easier to use. Humans are constantly becoming dependant on IT-enabled devices to perform even simple tasks like remembering a phone number as well as complicated activities. Information Technology has many applications in all sectors.
  - **Business and Commerce:** Major applications of computers are to keep and manage business and financial records. Most big companies keep the employment records of all their workers in large databases that are managed by computer programs. Similar programs and databases are used in business functions like billing customers; tracking payments received and payments to be made; and tracking supplies needed and items produced, stored, shipped, and sold. With today's sophisticated hardware, software, and communications technologies, it is often difficult to categorize a system as belonging exclusively to one specific application program.
  - **Science and Engineering:** Scientific development is almost entirely dependent on the use of computers and other microprocessor-controlled devices. For example, using supercomputers, meteorologists predict future weather by using a combination of observations of weather conditions from many sources. Computer-aided design (CAD) and computer-aided manufacturing (CAM) programs have led to improved products in many fields, especially where designs tend to be very detailed.
  - **Education:** Development of IT has enabled the people to gain more knowledge and education. With computer literacy, users get more options of jobs. Computer education is an essential course at the primary level in most schools across the world. With more information getting digitized every day, and the internet making it accessible to anyone across the world, students are increasingly relying on electronic sources of information.
  - **Governance:** The notion of e-governance is new applications of IT which has changed the life of global populace around the world. Computerization of Government activities makes it easier to supervise and audit, and makes the administration more responsive to the needs of society. It also bridges the divide between the Government and the people.
  - **Medicine:** IT has immense importance in the field of medicine. For example, in MRI (Magnetic Resonance Imaging) in which a computer combines the pictures to produce detailed three-dimensional images of the body's organs. Additionally, the MRI produces images that show changes in body chemistry and blood flow. Most critical life support equipment are programmed to respond to changes in the patient's status in split-seconds, thereby reducing the response time and risk of human error.
  - **Entertainment:** Information technology also impacted greatly the entertainment industry. It changed the lifestyle of people. The convergence of various technologies has created various options for entertainment like games, streaming music and video, digital television broadcasts, satellite radio, animated movies which can be accessed with the help of mobile phones, notebook computers or on television either with a cable connection or wirelessly using newer-generation WiFi, WCDMA or 4G technologies.

Advantages

- **Increases production and Saves time:** Many businesses use technology to mechanize tasks.
- **Improves communication through communication technology:** It is observed that with information technology devices such as communication technology of phones, video conferencing, electronic mail, databases, it has become easy to perform business operations. Employees can easily move information across departments without having any interruptions.

- **Improves data storage and file management:** Today business use cloud hosting services to store and backup business data. Also, information technology saves on paper work and makes transfer and access of data from remote location.
- **Improves financial management:** Software are created for individuals and firms to manage their financial affairs.
- **Cuts costs of operation and increases on Return on Investment (ROI):** Communication technology and social technology have made business advancement and product launch inexpensive. Numerous small scale business companies explored ways to use social technology to increase on their brand awareness and get more clients at a minimal cost. In business, cost of operation has major role in the development and growth of that business. So when businesses use information technology to curtail costs of operation, then their ROI will increase which will result into business growth.
- **Improves business to consumer relationship:** Businesses have incorporated the social technology to interact with their consumers. This creates a strong business to consumer relationship and it results into business development. Information technology can be used to improve customer service in so many ways.
- **Improves on business competitive advantage:** Today firms have used technology to gain competitive advantage over their competitors. A business will improve on its technology and improve on its services and products to satisfy its customers.
- **Improved innovation:** Technology greatly assists in job creation and innovation in companies. With access to a computer and internet, experts can start business while at home.
- **Improved entertainment:** Technology has transformed the entertainment industry.
- **Improved social discovery:** With the growth of information technology, people can find both old and new friends on many websites such as face book and twitter.
- **Globalization of knowledge:** In current situation, Information technology enables individuals to use the internet to get the latest news from any country around the globe. Services like ''Twitter'' have enabled people to become journalist so they report news on instant by twitting.
- **Improved communication:** It is cheaper and efficient way of communication.

Disadvantages

- **Implementation Expenses:** Information technology is quite expensive and Small scale firms cannot afford this expensive technology so they lose their clients to a business which has improved its technology and provides a better service or product.
- **Job Elimination:** Technology has substituted most positions which humans used to occupy. Accounting is now being done by software, so accountants run out of opportunities.
- **Security Breaches:** Since businesses store their data on remote cloud servers which can be accessed with a user name and password, there is a risk of losing that data to wrong minded knowledge works, hackers or viruses, which can harm the business.
- **Faulty products and duplication:** In many cases, auction websites have products that are not real. So a user can bid on a shoe thinking it is original, upon delivery, they discover that the shoe is fake and it does not resemble the picture on auction.
- **Privacy:** Business websites collect personal data using cookies to know more about clients and suggest products basing on that information. This data is collected without any notice but with selfish intention.
- **Security:** Managing and strengthening security and privacy for the organizations' systems and data is main concern across all industries. Also, Security is a major strategic issue for educational institutions who use information technology. Given the large amount of information that needs to

be protected, the expanding body of rules, regulations, and laws governing information security and privacy, and the current economic recession, which makes it difficult for an institution to get the funding required keeping up with requirements.

- **Internet security issues:** Information technology has security issues. If client ordering online, they have to provide their financial details. This sensitive information is at risk. Experienced hackers can use this loop hole to channel this information and use it for their own needs.

Telecommunication

- The telecom services have been recognized the world-over as an important tool for socio-economic development for a nation.
- It is one of the prime support services needed for rapid growth and modernization of various sectors of the economy.

Mobile Generations and Technology

Name	1st Generation Mobile Network	2nd Generation Mobile Network	3rd Generation Mobile Network	4th Generation Mobile Network
Introduced in year	1980s	1993	2001	2009
Technology	AMPS (Advanced Mobile Phone System), NMT, TACS	IS-95, GSM	IMT2000, WCDMA	LTE, WiMAX
Multiple Address /Access system	FDMA	TDMA, CDMA	CDMA	CDMA
Speed (data rates)	2.4 Kbps to 14.4 kbps	14.4 Kbps	3.1 Mbps	100 Mbps
Special Characteristic	First wireless communication	Digital version of 1G technology	Digital broadband, speed increments	Very high speeds, All IP
Features	Voice only	Multiple users on single channel	Multimedia features, Video Call	High Speed, real time streaming
Bandwidth	Analog	25 MHz	25 MHz	100 MHz

Evolution of Wireless Generations – 1G, 2G, 3G, 4G and 5G

- **0G Wireless technology:** 0G refers to pre-cell phone mobile telephony technology, such as radio telephones that some had in cars before the advent of cell phones. Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are called 0G (zero generation) systems.
- **1G:** Analog Cellular Networks: The main technological development that distinguished the First Generation mobile phones from the previous generation was the use of multiple cell sites, and

the ability to transfer calls from one site to the next as the user travelled between cells during a conversation. The first commercially automated cellular network (the 1G generations) was launched in Japan by NTT in 1979.

- **2G:** Digital Networks: In the 1990s, the 'second generation' (2G) mobile phone systems emerged, primarily using the GSM standard. These 2G phone systems differed from the previous generation in their use of digital transmission instead of analog transmission, and also by the introduction of advanced and fast phone-to-network signaling. The rise in mobile phone usage as a result of 2G was explosive and this era also saw the advent of prepaid mobile phones.
- The second generation introduced a new variant to communication, as SMS text messaging became possible, initially on GSM networks and eventually on all digital networks. Soon SMS became the communication method of preference for the youth. Today in many advanced markets the general public prefers sending text messages to placing voice calls.
- "2.5G" using GPRS (General Packet Radio Service) technology is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G. GPRS could provide data rates from 56 Kbit/s up to 115 Kbit/s. It can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access.
- **3G :** High speed IP data networks: The 2G technology was nowhere near up to the job, so the industry began to work on the next generation of technology known as 3G. The main technological difference that distinguishes 3G technology from 2G technology is the use of packet switching rather than circuit switching for data transmission.
- **4G:** Growth of mobile broadband: It is basically the extension in the 3G technology with more bandwidth and services offers in the 3G. The expectation for the 4G technology is basically the high quality audio/video streaming over end to end Internet Protocol. The first two commercially available technologies billed as 4G were the WiMAX standard and the LTE standard, first offered in Scandinavia by TeliaSonera.
- One of the main ways in which 4G differed technologically from 3G was in its elimination of circuit switching, instead employing an all-IP network. Thus, 4G ushered in a treatment of voice calls just like any other type of streaming audio media, utilizing packet switching overinternet, LAN or WAN networks via VoIP.
- **5G:**
  - 5G is a not-yet-implemented wireless technology that's intended to improve on 4G.
  - 5G promises significantly faster data rates, higher connection density, much lower latency, and energy savings, among other improvements.
  - The anticipated theoretical speed of 5G connections is up to 20 Gbps.
- **5G Use Cases Lab:**
  - 5G Use Cases Lab for the Banking and Financial Sector were inaugurated at the Institute for Development and Research in Banking Technology (IDRBT).
  - The objectives of 5G Lab are- developing and demonstrating 5G use cases for banking and financial services, setting up a 5G R&D experience platform, and provide state-of-the-art experimental test bed solutions for mobile, wireless technologies, IoT and security services for Banking Financial Services and Insurance (BFSI).

Government Initiatives

Digital India Initiative

- The Digital India programme has been launched with an aim of transforming the country into a digitally empowered society and knowledge economy. The Digital India would ensure that Government

services are available to citizens electronically. It would also bring in public accountability through mandated delivery of government's services electronically.

Background

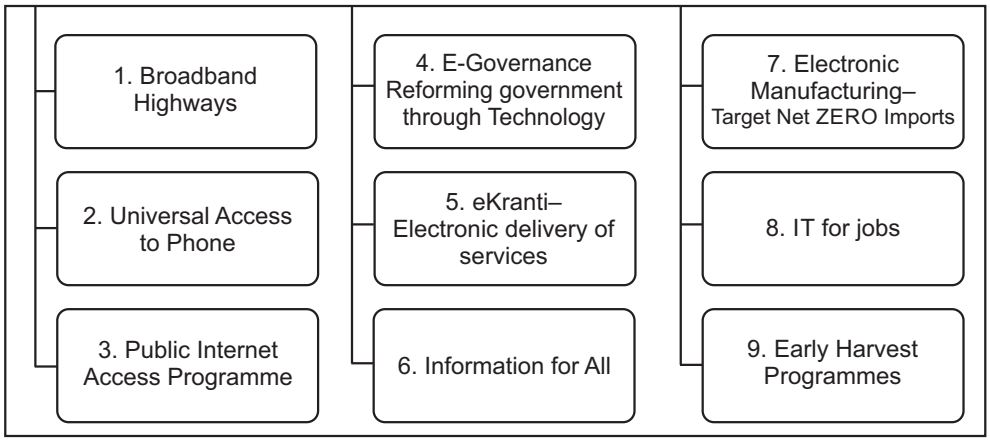
- Even though India is known as a powerhouse of software, the availability of electronic government services to citizens is still comparatively low. The National e-Governance Plan approved in 2006 has made a steady progress through Mission Mode Projects and Core ICT Infrastructure, but greater thrust is required to ensure effective progress in electronics manufacturing and e-Governance in the country.
- The Digital India vision provides the intensified impetus for further momentum and progress for this initiative and this would promote inclusive growth that covers electronic services, products, devices, manufacturing and job opportunities.

Vision

- The vision of Digital India aims to transform the country into a digitally empowered society and knowledge economy. The programme will be implemented in phases till 2018. The Digital India is transformational in nature and would ensure that Government services are available to citizens electronically. It would also bring in public accountability through mandated delivery of government's services electronically, a Unique ID and e-Pramaan based on authentic and standard based interoperable and integrated government applications and data basis.
- The source of funding for most of the e-Governance projects at present is through budgetary provisions of respective Ministries/ Departments in the Central or State governments. Requirements of funds for individual project(s) for Digital India will be worked out by respective Nodal Ministries/ Departments.
- **The vision areas of Digital India:**
  - **Infrastructure as Utility to Every Citizen:**
    - High speed internet as a core utility shall be made available in all Gram Panchayats.
    - Cradle to grave digital identity - unique, lifelong, online and authenticable.
    - Mobile phone and Bank account would enable participation in digital and financial space at individual level.
    - Easy access to a Common Service Centre within their locality.
    - Shareable private space on a public Cloud.
    - Safe and secure Cyber-space in the country.
  - **Governance and Services on Demand:**
    - Seamlessly integrated across departments or jurisdictions to provide easy and a single window access to all persons.
    - Government services available in real time from online and mobile platforms.
    - All citizen entitlements to be available on the Cloud to ensure easy access.
    - Government services digitally transformed for improving Ease of Doing Business.
    - Making financial transactions above a threshold, electronic and cashless.
    - Leveraging GIS for decision support systems and development.
  - **Digital Empowerment of Citizens:**
    - Universal digital literacy.
    - All digital resources universally accessible.
    - All Government documents/ certificates to be available on the Cloud.

- Availability of digital resources / services in Indian languages.
- Collaborative digital platforms for participative governance.
- Portability of all entitlements for individuals through the Cloud.

- **Scope of Digital India**
  - The overall scope of this programme is:
  - To prepare India for a knowledge future.
  - On being transformative that is to realize IT (Indian Talent) + IT (Information Technology) = IT (India Tomorrow)
  - Making technology central to enabling change.
  - On being an Umbrella Programme – covering many departments.
    - The programme weaves together a large number of ideas and thoughts into a single, comprehensive vision, so that each of them is seen as part of a larger goal. Each individual element stands on its own, but is also part of the larger picture.
    - The weaving together makes the Mission transformative in totality.
    - The Digital India Programme will pull together many existing schemes which would be restructured and re-focused and implemented in a synchronized manner. The common branding of the programmes as Digital India, highlights their transformative impact.
  - **Digital India aims to provide the much needed thrust to the nine pillars of growth areas, namely:**



    - Broadband Highways,
    - Universal Access to Mobile Connectivity,
    - Public Internet Access Programme,
    - e-Governance: Reforming Government through Technology,
    - e-Kranti - Electronic Delivery of Services,
    - Information for All,
    - Electronics Manufacturing,
    - IT for Jobs
    - Early Harvest Programmes.

Key Projects of Digital India programme

- **Digital Locker System** aims to minimize the usage of physical documents and enable sharing of e-documents across agencies. The sharing of the e-documents will be done through registered repositories thereby ensuring the authenticity of the documents online.

- **MyGov.in** has been implemented as a platform for citizen engagement in governance, through a "Discuss", "Do" and "Disseminate" approach. The mobile App for MyGov would bring these features to users on a mobile phone.
- **Swachh Bharat Mission (SBM) Mobile app** would be used by people and Government organizations for achieving the goals of Swachh Bharat Mission.
- **eSign framework** would allow citizens to digitally sign a document online using Aadhaar authentication.
- The **Online Registration System (ORS)** under the eHospital application has been introduced. This application provides important services such as online registration, payment of fees and appointment, online diagnostic reports, enquiring availability of blood online etc.
- **National Scholarships Portal** is a one stop solution for end to end scholarship process right from submission of student application, verification, sanction and disbursal to end beneficiary for all the scholarships provided by the Government of India.
- DeitY has undertaken an initiative namely Digitize India Platform (DIP) for large scale digitization of records in the country that would facilitate efficient delivery of services to the citizens.
- The Government of India has undertaken an initiative namely **Bharat Net**, a high speed digital highway to connect all 2.5 lakh Gram Panchayats of country. This would be the world's largest rural broadband connectivity project using optical fibre.
- BSNL has introduced Next Generation Network (NGN), to replace 30 year old exchanges, which is an IP based technology to manage all types of services like voice, data, multimedia/ video and other types of packet switched communication services.
- BSNL has undertaken large scale deployment of Wi-Fi hotspots throughout the country. The user can latch on the BSNL Wi-Fi network through their mobile devices.
- To deliver citizen services electronically and improve the way citizens and authorities transact with each other, it is imperative to have ubiquitous connectivity. The government also realises this need as reflected by including **'broadband highways'** as one of the pillars of Digital India. While connectivity is one criterion, enabling and providing technologies to facilitate delivery of services to citizens forms the other.

Meghraj Initiative Computing

Meghraj is the name given to the initiative of Government of India for its new program which is going to take advantage of the Cloud Computing. It will enable the government to leverage cloud computing for effective delivery of e-services.

Advantages of GI Cloud

- Optimum Utilization of Existing infrastructure
- **Rapid Deployment and Reusability:** Any software made available by any government of department in India can be made available to other departments as well without additional costs.
- **Manageability and Maintainability:** It provides single point for maintaining Information & Communication Technology (ICT) infrastructure in India.
- **Scalability:** According to the demands from the citizens of India, infrastructure of the government can be increased accordingly.
  - Efficient Service Delivery
  - **Security:** A security framework for the entire GI Cloud will lead to less environmental complexity and less potential vulnerability

- Increased User Mobility
- Reduced Effort in Managing Technology

➤ **Standardization:** GI Cloud shall prescribe the standards around interoperability, integration, security, data security and portability etc.

Code Free for India

- This initiative is started by International Centre for Free and Open Source Software (ICFOSS).
- The initiative invites free software development community to develop solutions to address local and global needs.
- Programmers would be invited to develop tools and desktop applications, internet applications, mobile applications and enhance the cloud and internet of things technology.
- It will also encourage the use of local language computing tools and contemporary free software technology while keeping in mind bandwidth and device limitations.

e-Kranti: NeGP 2.0

NeGP	e-Kranti
Processes ➤ Computerization without mandatory Process Reengineering ➤ Quantity versus Quality of services **People** ➤ Limitation in terms of skilled manpower **Technology** ➤ Application development lacked integration and interoperability ➤ Creation of Infrastructure/hardware vis-a-vis infrastructure on demand ➤ Emerging Technology like Cloud, Mobile not used as first choice **Business Models** ➤ CAPEX ➤ Less focus on PPP	**Processes** ➤ Process Reengineering Mandatory ➤ Impact Index **People** ➤ CITOs Virtual IT Cardre **Technology** ➤ Cloud by default ➤ Mobile first ➤ Common Application software ➤ Mandatory eGovernance standards **Business Models** ➤ Infrastructure on Demand ➤ OPEX ➤ PPP/PPPP
TRANSFORMATION	

- E-Kranti is an important pillar of the Digital India program.
- Vision of e-Kranti is "Transforming e-Governance for Transforming Governance".
- The Mission of e-Kranti is to ensure a Government wide transformation by delivering all Government services electronically to citizens through integrated and interoperable systems via multiple modes, while ensuring efficiency, transparency and reliability of such services at affordable costs.

The objectives of 'e-Kranti' are as follows:

- To redefine National e-Governance Plan (NeGP) with transformational and outcome oriented e-Governance initiatives.
- To enhance the portfolio of citizen centric services.
- To ensure optimum usage of core Information & Communication Technology (ICT).
- To promote rapid replication and integration of e-Governance applications.
- To leverage emerging technologies.
- To make use of more agile implementation models.

The key principles of e-Kranti are as follows:

- Transformation and not Translation.
- Integrated Services and not Individual Services.
- Government Process Reengineering (GPR) to be mandatory in every Mission Mode Project (MMP).
- Information Communication Technology (ICT) Infrastructure on Demand.
- Cloud by Default.
- Mobile First.
- Fast Tracking Approvals.
- Mandating Standards and Protocols.
- Language Localization.
- National GIS (Geo-Spatial Information System).
- Security and Electronic Data Preservation

WEB PORTALS of the GOVERNMENT

- **e-Pashuhaat:** Govt launched e-pashuhaat portal on the occasion of National Milk Day. Under the scheme National Mission on Bovine Productivity, 'e-pashuhaat' portal has been developed for connecting breeders and farmers regarding availability of bovine germplasm. Through the portal breeders/farmers can sell and purchase breeding stock, information on all forms of germplasm including semen, embryos and live animals with all the agencies and stakeholders in the country has been uploaded on the portal. Through this portal, farmers will be aware about the availability of quality disease free bovine germplasm with different agencies in the country. The portal will lead to propagation of high genetic merit germplasm.
- **e-Pathshala:** e-Pathshala has been developed by NCERT for showcasing and disseminating all educational e-resources including textbooks, audio, video, periodicals and a variety of other print and non-print materials through website and mobile app. The platform addresses the dual challenge of reaching out to a diverse clientele and bridging the digital divide (geographical, socio-cultural and linguistic), offering comparable quality of e-contents and ensuring its free access at every time and every place.
- **NAM:** National Agriculture Market (NAM) is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities. The NAM Portal provides a single window service for all APMC related information and services. This includes commodity arrivals & prices, buy & sell trade offers, provision to respond to trade offers, among other services.

- **'ShaGun':** Govt launched a dedicated web portal 'ShaGun' for the Sarva Shiksha Abhiyan. 'ShaGun' aims to capture and showcase innovations and progress in Elementary Education sector of India by continuous monitoring of the flagship scheme – Sarva Shiksha Abhiyan (SSA).
- **AirSewa Portal:** To provide a hassle-free and comfortable air travel experience to people, it is necessary to recognize the pattern of problems that people face, and make suitable systemic improvements in our working. So the Government launched the AirSewa portal to offer people a convenient and hassle-free air travel experience. It will be operated through an interactive web portal as well as through a mobile app for both android and iOS platforms. The portal will include a mechanism for grievance redressal, back office operations for grievance handling, flight status/ schedule information, airport Information and FAQs.

Bharat Net Project

- Government has achieved a significant milestone under the BharatNet by completing Phase-1 of the project by connecting over **one lakh Gram Panchayats** (GP) across the country with high speed optical fibre network as per the declared deadline of 31 Dec 2017. BharatNet network built under Phase 1 envisages delivery of high-speed broadband services in over 2.5 lakh villages benefitting more than 200 million rural Indians.

About Bharat net Project

- Broadband access to every citizen is a key pillar of Digital India. The issue is more significant for the rural population.
- This project has evolved from the earlier National Optical Fibre Network (NOFN) project of providing 100 Mbps to all gram panchayats (GPs). At present, a special purpose vehicle, Bharat Broadband Network Ltd (BBNL), under the telecom ministry is handling the roll out of optical fibre network. The project is being executed by BSNL, Railtel and Power Grid.
- One of the main concerns of this was the slow implementation by three central public-sector undertakings (CPSUs)— BSNL, PGCIL and Railtel, diffused control and the relation between Bharat Broadband Network Ltd, the company managing the project and the CPSUs, and lack of appropriate ownership by BBNL.

Funding

- Bharat Net is being funded through **Universal Service Obligation Fund (USOF)**. The Universal Service Obligation Fund(USOF) was established with the fundamental objective of providing access to 'Basic' telegraph services to people in the rural and remote areas at affordable and reasonable prices. Subsequently the scope was widened to provide subsidy support for enabling access to all types of telegraph services including mobile services, broadband connectivity and creation of infrastructure like OFC in rural and remote areas.
- Under the second phase, the government will lay down optical fibre network across 1.5 lakh village panchayats. The first phase of Bharat Net will be completed by the end of the year.

About optical fibres

- **Fiber-optic communication** is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information.
- Fiber is preferred over electrical cabling when high bandwidth, long distance, or immunity to electromagnetic interference are required.

- **Optical fibres are made up of three components:**
  - **Core –** Thin glass centre of the fibre where the light travels
  - **Cladding –** Outer optical material surrounding the core that reflects the light back into the core.
  - **Buffer coating –** Plastic coating that protects the fibre from damage and moisture.

Bharat QR

Government has launched the world's first interoperable payment acceptance solution as part of efforts to move towards cash-less economy at an "insignificant cost". It is developed by National Payments Corporation of India (NPCI), MasterCard, and Visa.

About QR codes

- QR code or Quick Response code is a two-dimensional machine-readable code made up of black and white squares and is used for storing URLs or other information. These can be read by the camera of a smartphone. The reader interprets the code, which typically contains a call to action such as an invitation to download a mobile application, a link to view a video or an SMS message inviting the viewer to respond to a poll. The phone's owner can choose to act upon the call to action or click cancel and ignore the invitation.

About BharatQR codes

- BharatQR code enables merchants to accept electronic payments without the need for an EDC (Electronic Data Capture)/POS (Point of Sale) machine.
- BharatQR code based payment allows customers of any bank to use their smartphones to make payments through the Pockets app using their ICICI Bank Debit Card or Pockets Prepaid Card. This new facility allows customers to use their smartphone to scan Bharat QR code at the merchant outlet. The transaction is completed with enhanced security and speed and the card details remain in control of the customer.

Benefits to merchants

- It allows merchants to receive money without the use of POS swipe machine.
- Merchant don't need to invest into POS machine.
- There would not be any transaction fees for using POS machine of banks.
- Money will be credited into the account immediately.
- Unlike mobile wallet there would not be any limit to transfer money into the bank account.

Benefits to customers

- A customer can pay to merchant without using debit card. There is no need to carry card.
- There would be less chance of fraud as your card details does not get exposed. The card swipe exposes your card number, CVV and expiry date.

Other Initiatives

Google Project Loon

- To improve the broadband services in the rural areas Google has initiated Project Loon.
- Google defines Project Loon as a "network of balloons travelling on the edge of space, designed to connect people in rural and remote areas, help fill coverage gaps, and bring people back online after disasters".

- Project Loon balloons will travel in the stratosphere, approximately 20 km above the Earth's surface, latching on to layers of wind as directed by software algorithms to determine where they need to go.
- In the end, they will form one large communications network. Each balloon can provide connectivity to a ground area about 40 km in diameter using wireless communication Long Team Evolution (LTE) or 4G.
- Project Loon partners with telecom companies to share cellular spectrum.
- It has already tested this technology in New Zealand, California and Brazil. To use LTE or 4G, Project Loon partners with telecom companies to share cellular spectrum so that people will be able to access the Internet everywhere directly from their phones and other LTE-enabled devices.
- Google uses solar panel and wind to power electronic equipment in the balloon throughout the day.

White Space

- Microsoft India is ready with a plan to provide free last-mile internet connectivity across the country. It proposes to use the "white space" – the unused spectrum between two TV channels – to provide free connectivity to large sections of the Indian population.
- Wifi has a range of only about 100 metres, whereas the 200-300 MHz spectrum band available in the white space can reach up to 10 km. This spectrum belongs **mainly to Doordarshan and the government** and is not used at all. Pilot project is planned in two districts. If the pilots are successful, the project can be quickly rolled out across the country and could give a huge boost to Digital India initiative, which proposes to use technology to deliver governance to every citizen of India, even in remote areas.
- The challenge is the lack of digital infrastructure across India. This initiative addresses this challenge in a cost-effective manner and creates an eco-system that will benefit everyone, including manufacturers of routers and other technology devices, other technology companies, besides Microsoft.
- Microsoft's initiative also take forward the PM's slogan of "IT + IT = IT", which is Indian talent plus information technology equals India tomorrow and also give a push to the 'Make in India' campaign by encouraging the manufacture of equipment locally.

5G trial and its importance for Indian telcos

About the 5G or fifth generation technology

- 5G or fifth generation is the latest upgrade in the long-term evolution mobile broadband networks.
- 5G mainly works in 3 bands, namely low, mid and high-frequency spectrum.
  - All of these 3 bands have uses and limitations.

5 G and its band spectrum potential

Low Band Spectrum:

- The low band spectrum has shown great promise in terms of coverage and speed of internet and data exchange.
- Its maximum speed is limited to 100 Mbps (Megabits per second).
- The telcos can use and install it for commercial cellphone users who may not have specific demands for very high speed internet.

- The low band spectrum may not be optimal for specialised needs of the industry.

Mid-band spectrum:

- It offers higher speeds compared to the low band, but has limitations in terms of coverage area and penetration of signals.
- Telcos and companies, which have taken the lead on 5G, have indicated that this band may be used by industries and specialised factory units for building captive networks that can be moulded into the needs of that particular industry.

High-band spectrum:

- It offers the highest speed of all the three bands, but has extremely limited coverage and signal penetration strength.
- Internet speeds in the high-band spectrum of 5G has been tested to be as high as 20 Gbps (giga bits per second), while, in most cases, the maximum internet data speed in 4G has been recorded at 1 Gbps.

Significance of the trials for 5G technology for telecos

- The telecom market in India is left with only three private telcos, with the rest having surrendered to the low returns on investments over the years along with the two state-run companies, MTNL and Bharat Sanchar Nigam Limited (BSNL).
- It is pertinent for telcos to start offering the new 5G technology to increase the average revenue.
- For that, however, they will have to conduct trials in a variety of circumstances, including in semi-urban and rural areas, which remains an untapped market for them.
- It is also important that the government remain also ready to roll out the new technology as soon as possible.
- A standing committee of Lok Sabha on Information Technology has already warned that India could miss the 5G bus.

What will 5G trials in India entail for now?

- In the initial phase, these trials will be for 6 months, including a 2 month period for procurement and setting up of the equipment.
- In these 6 months, telcos will be required to test their set up in urban areas, semi-urban areas as well as rural areas.
- During this period, the telcos will be provided with experimental spectrum in various bands, such as the mid-band of 3.2 GHz to 3.67 GHz, the millimeter wave band of 24.25 GHz to 28.5 GHz, and others.

Where does India stand in the 5G technology race?

- On par with the global players, India had, in 2018, planned to start 5G services as soon as possible, with an aim to capitalise on the better network speeds and strength that the technology promised.

What is the global progress on 5G?

- More than governments, global telecom companies have started building 5G networks and rolling it out to their customers on a trial basis.

Net Neutrality–issues & significance

- Net neutrality is the principle that Internet service providers and governments should treat all data on the Internet equally, not discriminating or charging differentially by user, content, site, platform, application, type of attached equipment, or mode of communication.

Net Neutrality is about:

- No telecom-style licensing of Internet companies
- No gateways (Internet.org, Airtel OneTouch Internet, Data VAS), censorship or selection;
- No speeding up of specific websites
- No "zero rating" or making some sites free over others

Background

- In India, tremendous growth in telecommunications and convergence of communication and information technologies has created a unique digital platform for advancing the developmental goals. India has demonstrated to the world its capacity to develop innovative business models in affordable mobile telephony suited to the requirements of a developing country. Currently, both broadband and internet penetration in India is comparatively low in the global context.
- In India, Internet traffic is likely to increase manifold in the next few years. There is a constant pressure for investment in network infrastructure and to expand capacities and increase penetration. Telecom infrastructure, being a capital intensive industry, will require significant investments by operators to meet the network capacity demands brought about by increasing broadband penetration, increasing speeds and increasing data usage. Telecom service providers have also started facing competition from unlicensed application platforms, termed Over-the-Top (OTT) players, in their traditional voice communication field.
- With an objective of enhancing revenue streams and to face competition from OTT players, telecom service providers have been exploring new opportunities for generating revenues from users and the content providers. Some of the models attempted by TSPs, such as charging higher data tariffs for VoIP services, charging content application providers and providing the content free to users (called "zero rating" plans), have raised concerns about Net Neutrality. This phenomenon is not unique to India but has been witnessed across the world.

Arguments in favor	Arguments against
If there is no net neutrality, ISPs will have the power (and inclination) to shape internet traffic so that they can derive extra benefit from it.	Prioritize IoT communications: Internet providers will be able to prioritize internet traffic to optimize the user experience. For example, communication between autonomous cars or life-saving medical devices could be prioritized and put on the fast lane, while non-essential traffic could be placed with regular internet communications.
Without Net neutrality, the new start-ups would be at a disadvantage. ISPs will charge web companies to enable faster access to their websites. Those who don't pay may see that their websites will open slowly. The startup can't compete with the existing company as they will be short on fund	The economic principle of paying differently for different levels of service and experience is recognized by Differential Pricing. Investment loss will curtail future investments in telecommunications infrastructure.

Arguments in favor	Arguments against
Absence of net-neutrality also makes us susceptible to monopolistic behavior.	For people who are not on the internet having some connectivity and some ability to share is always much better than having no ability to connect and share at all. That's why programs like Internet.org are important and can co-exist with net neutrality regulations.
Higher bills and "tolls": Broadband providers could charge service providers or consumers higher prices for faster Internet lanes which will make it costlier and more difficult for city governments to deploy IoT technologies related to services like safety and smart street light and hence affect smart city project.	It is ethically questionable because operators have to invest in maintaining and expanding the internet's infrastructure to support new services while most benefits are reaped by Internet content companies like Google, Facebook

Stakeholders in internet space

- To understand the concept of net neutrality, it is important to note the **four different kinds** of stakeholders in the internet space that may be affected by the issue. They are: (i) the consumers of any internet service, (ii) the Telecom Service Providers **(TSPs)** or Internet Service Providers **(ISPs)**, (iii) the over-the-top **(OTT)** service providers (those who provide internet access services such as websites and applications), and (iv) the government, who may regulate and define relationships between these players. **TRAI** is an independent regulator in the telecom sector, which mainly regulates TSPs and their licensing conditions, etc.
- OTT services and applications are basically online content. These are accessible over the internet and made available on the network offered by TSPs. OTT providers may be hosted by TSPs or ISPs such as Bharti Airtel, Vodafone, Idea, VSNL (government provided), etc. They offer internet access services such as Skype, Viber, WhatsApp, Facebook, Google and so on. Therefore, OTT services can broadly be of three types: (i) e-commerce, (ii) video or music streaming and, (iii) voice over internet telephony/protocol services (or VoIP communication services that allow calls and messages). Prior to the recent TRAI regulations prohibiting discriminatory tariffs, there was no specific law or regulation directly concerning the services provided by OTT service providers.

Significance of Net Neutrality

- Without Net Neutrality, cable and phone companies could carve the Internet into fast and slow lanes. An ISP could slow down its competitors' content or block political opinions it disagreed with.
- ISPs could charge extra fees to the few content companies that could afford to pay for preferential treatment — relegating everyone else to a slower tier of service. This would destroy the open Internet.
- Net Neutrality is crucial for small business owners, startups and entrepreneurs, who rely on the open Internet to launch their businesses, create a market, advertise their products and services, and distribute products to customers.

The Department of Telecom has formed a panel headed by A K Bhargava to examine economic impact of implementation of net-neutrality principle on the sector.

- **Highlights of report are:**
  - Legitimate traffic management practices may be allowed but should be tested against the core principles of Net Neutrality. Further, Improper (Paid or otherwise) Prioritization may not be permitted.

- India specific Net Neutrality approach should be formulated by taking into account international best practices that serve specific needs of the country.
- The primary goals of public policy in the context of Net Neutrality should be directed towards achievement of developmental aims of the country by facilitating Affordable Broadband, Quality Broadband and Universal Broadband for its citizens.
- User rights on the Internet need to be ensured so that Telecom or Internet Service Providers do not restrict the ability of the user to send, receive, display, use, post any legal content, application or service on the Internet, or restrict any kind of lawful Internet activity or use.
- Over-the-top (OTT) application services should be actively encouraged and any impediments in their expansion and growth should be removed.
- There should be a separation of application layer from network layer as application services are delivered over a licensed network.
- Specific OTT communication services dealing with messaging should not be interfered with through regulatory instruments.
- In case of OTT VoIP international calling services, a liberal approach may be adopted. However, in case of domestic calls (local and national), communication services by TSPs and OTT communication services may be treated similarly from a regulatory angle for the present.
- Content and application providers cannot be permitted to act as gatekeepers and use network operations to extract value in violation of core principles of Net Neutrality, even if it is for an ostensible public purpose. In this regard, the committee expressed its objections to Facebook's internet.org.
- In order to deal with the complexities of the new digital world, a think-tank with best talent may also be set up.

Benifits of Internet of Things

What is IoT?

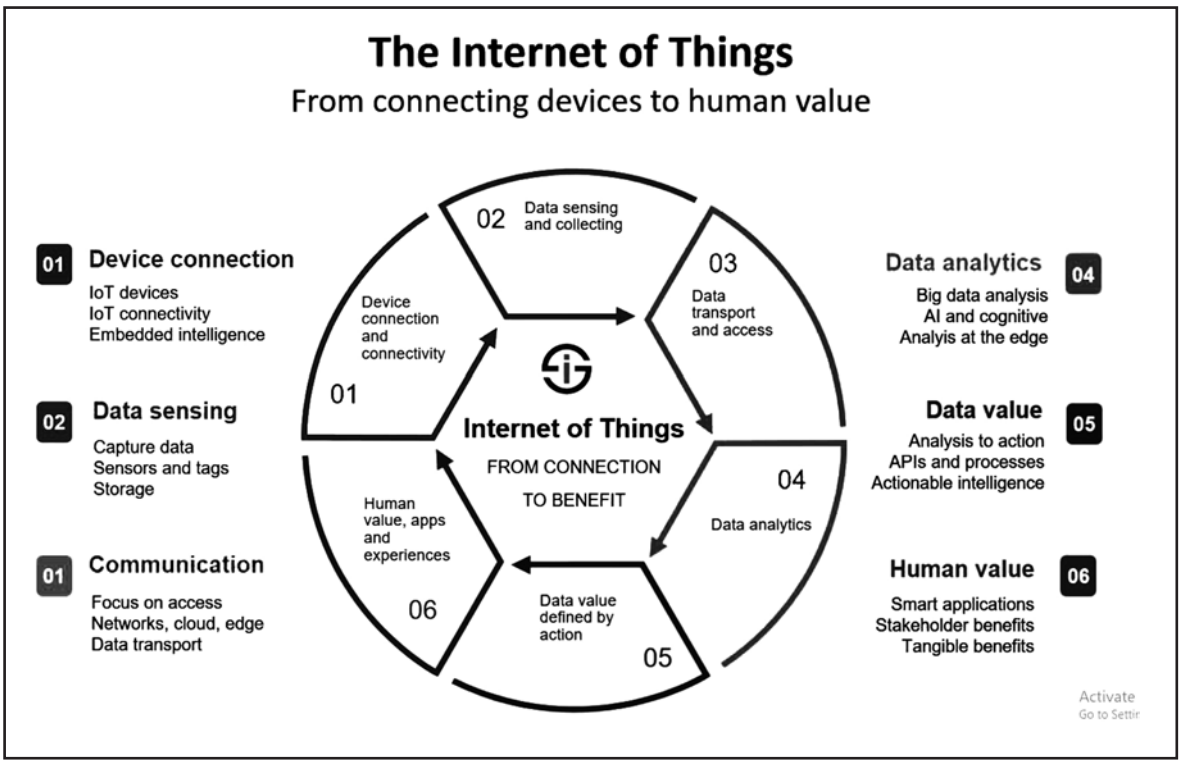
- The internet of things (IoT) is the network of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. It is also known as "the infrastructure of the information society."
- "Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist firefighters in search and rescue operations. Legal scholars suggest to look at "Things" as an "inextricable mixture of hardware, software, data and service".

Benefits of IoT

- An overview of some of the most prominent application areas is provided here:
  - **Media:** Internet of things creates an opportunity to measure, collect and analyse an ever-increasing variety of behavioural statistics. Big data and the IoT work in conjunction. From a media perspective, data is the key derivative of device interconnectivity, whilst being pivotal in allowing clearer accuracy in targeting. The internet of things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness.
  - **Environmental monitoring:** Environmental monitoring applications of the IoT typically use sensors to assist in environmental protection by monitoring air or water quality, atmospheric or soil conditions, and can even include areas like monitoring the movements of wildlife and their habitats.

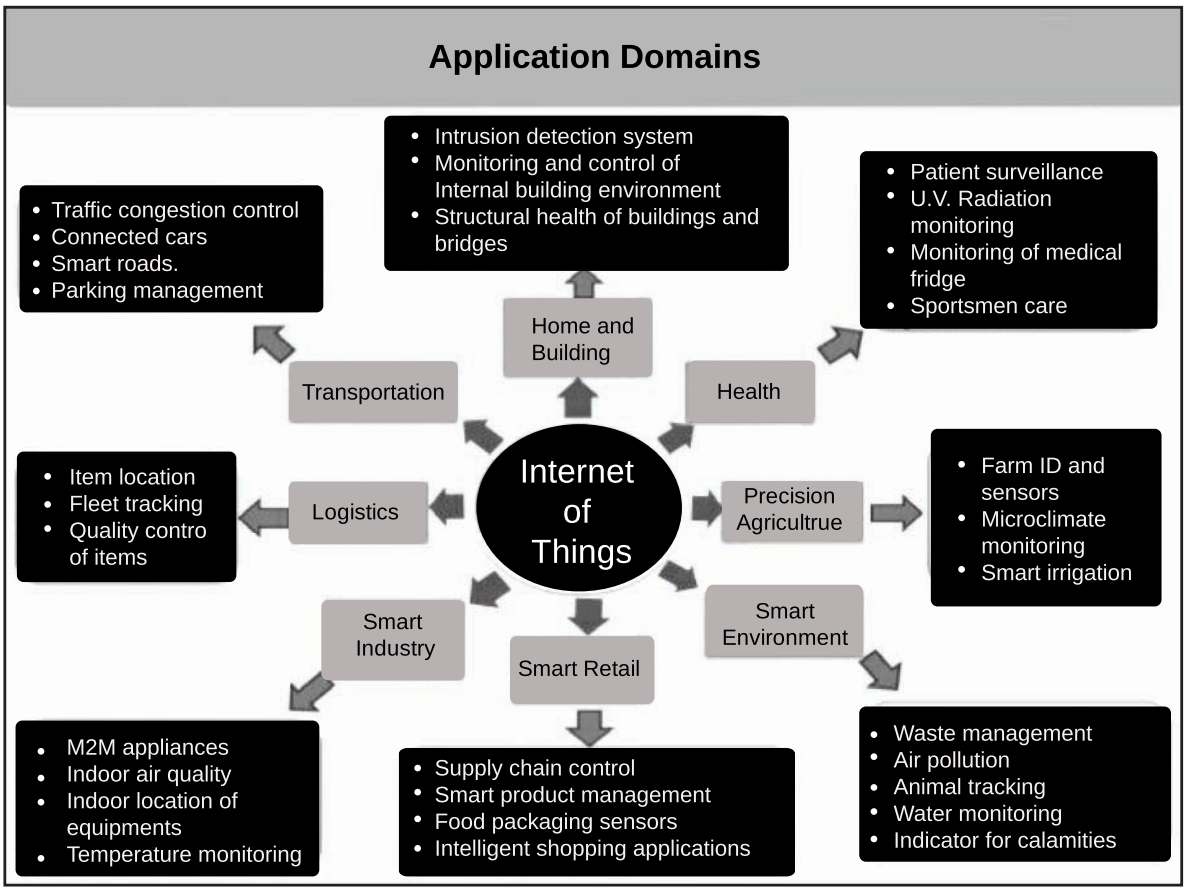
- **Infrastructure management:** Monitoring and controlling operations of urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IoT. Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas.
- **Manufacturing:** The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together.
- **Energy management:** It is expected that IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage.
- **Medical and healthcare systems:** IoT devices can be used to enable remote health monitoring and emergency notification systems.
- **Building and home automation:** IoT devices can be used to monitor and control the mechanical, electrical and electronic systems used in various types of buildings (e.g., public and private, industrial, institutions, or residential) in home automation and building automation systems.
- **Transportation:** The IoT can assist in integration of communications, control, and information processing across various transportation systems. Application of the IoT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user).

- **Potential applications:**



- **Smart home:** this is the most used application, where household appliances are connected over the internet, which can manage everything from sleep timing, monitoring the grocery in the fridge to regulating the lighting, etc.
- **Smart City:** Smart city spans a wide variety of use cases, from traffic management to water distribution, to waste management, urban security, and environmental monitoring. IoT solutions in the area of Smart City solve traffic congestion problems, reduce noise and pollution and help make cities safer.

- **Smart grids:** Smart grids promise to use information about the behaviors of electricity suppliers and consumers in an automated fashion to improve the efficiency, reliability, and economics of electricity.
- **Smart supply chain:** Supply chains have been getting smarter for some years already. Solutions for tracking goods while they are on the road, or getting suppliers to exchange inventory information have been on the market for years.
- **Smart farming and agriculture:** this sector has the largest potential of IoT, from monitoring the soil moisture to timing the sprinklers, to measure the soil nutrition, to monitoring large livestock, IoT can revolutionize the way agriculture is done.



- **Smart transport and mobility:** IoT has the potential of interconnected cars and transport systems which can talk to each other and chart the shortest route and prevent traffic congestion and accidents.

Status of IoT in India

- Indian IoT market is expected to reach $15 billion by 2020 and accounts for 5% of the global market.
- Investing in IoT will provide a major boost to our economy on par with global leaders and it will also attract investments, create jobs and improve public infrastructure in the country.

Measures taken by the government to promote IoT

- The central government launched a plan to utilize IoT as part of the Digital India mission.
- The government came up with National Digital Communications Policy 2018 to satisfy the modern realities of the telecom such as 5g technology, Internet of Things (IoT), Machine to Machine (M2M) communication, etc.

- The government also allowed 100% FDI in the telecom sector. This will help in the development and growth of the IoT.
- Department of Electronics and Information Technology (DeITY) has published a draft policy for IoT. The target is to establish an IoT market of USD 15 billion by 2020 and having a share of 5-6% in the global IoT industry.

How Digitization will help IoT?

- Digitization is increasing in India under Digital India mission and market of IoT too is growing day by day. Both are useful in the following ways –
  - **Data provision –** Internet of things bringing the physical, digital, cyber and virtual worlds together requires extensive information processing capabilities provided by digitization.
  - **Connectivity –** With complete and proper digitization more and more people will be connected with the internet that makes people aware of the internet of things and its uses.
  - **Standardize the economy-** usage of them would modernize our business practices, banking structure, and trade market. They develop a hedge against adversity and soothes the process of a landmark transformation.
  - **Easier mode of payment –** Anyone can make the transaction very easily without any physical contact between consumer and producer.
  - **Reduce tax theft –** By promoting digitization one cannot hide its expenditure and gain so that will come under the eye of govt.
  - **Facilitating and enabling environment-** IoT would ease the process of work by managing areas like insurance, bills, regulation of energy usages, loan installment and other periodical liabilities. It would save man hours and would increase their economic productivity ultimately boosting the growth of the Indian economy.
  - **Easier lives –** Example: Healthcare system- better tracking of cholesterol level, blood pressure level and sugar level would enable early tracking of health changes and would make India a country of healthy people with reduced health expenditures.

Challenges, Criticism and Controversies

- **Privacy, autonomy and control:** The concern over the privacy was led many to consider the possibility that Big Data infrastructures such as the IoT and Data Mining are inherently incompatible with privacy.
- **Security:** In particular, as the internet of things spreads widely, cyber attacks are likely to become an increasingly physical (rather than simply virtual) threat. In a January 2014 article in Forbes, listed many Internet-connected appliances that can already "spy on people in their own homes" including televisions, kitchen appliances, cameras, and thermostats.
- **Design:** Successful execution of the internet of things requires consideration of the interface's usability as well as the technology itself. These interfaces need to be not only more user-friendly but also better integrated: "If users need to learn different interfaces for their vacuums, their locks, their sprinklers, their lights, and their coffeemakers, it's tough to say that their lives have been made any easier."

Way forward

- The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer based systems, and resulting in improved efficiency, accuracy and economic benefit.
- When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities.

- Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications.
- Policy-makers, regulators, device manufacturers, supporting industries and service providers will all have to join hands in creating a safer space online.
- The Internet Society's Online Trust Alliance (OTA) Trust Framework provides strategic principles to increase the security of IoT devices and data.
- The Justice Srikrishna Committee had recommended some provisions for personal data protection including a consumer's right to information, consent, and right to request companies to erase their data if preferred.
- However, it leaned heavily towards greater regulations and did not specify how to protect consumer data from unnecessary government surveillance.
- Despite these challenges, India must drive full speed ahead towards IoT technology for the greater good of our citizens

Big Data Initiative and Privacy

What is Big Data?

- By definition, Big Data is data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it. In other words, big data is characterized by volume, variety (structured and unstructured data) velocity (high rate of changing) and veracity (uncertainty and incompleteness).
- ***The Indian government has launched a Big Data Initiative, with the following aims:***
  - Promoting and fostering big data science, technology and applications in India and developing core generic technologies, tools and algorithms for wider applications in the government.
  - Understanding the present status of the industry in terms of market size, different players providing services across sectors/ functions, opportunities, SWOT of industry, policy framework (if any), present skill levels available etc.
  - Carrying out market landscape surveys to assess the future opportunities and demand for skill levels in next 10 years.
  - Carrying out gap analysis in terms of skills levels and policy framework.
  - Evolving a strategic road map and action plan clearly defining of roles of various stakeholders – government, industry, academia, industry associations and others with clear timelines and outcome for the next 10 years.
- **Some of the key actions required for successful implementation of initiative are:**
  - **Talent Pool -** Create industry academia partnership to groom the talent pool in universities as well as develop strong internal training curriculum to advance analytical depth.
  - **Collaborate -** Form analytics forum across organization boundaries to discuss the pain-points of the practitioner community and share best practices to scale analytics organizations.
  - **Capability Development -** Invest in long term skills and capabilities that forms the basis for differentiation and value creation. There needs to be an innovation culture that will facilitate IP creation and asset development.
  - **Value Creation -** Building rigor to measure the impact of analytics deployment is very critical to earn legitimacy within the organization.

Big Data Initiative and Concern for Privacy

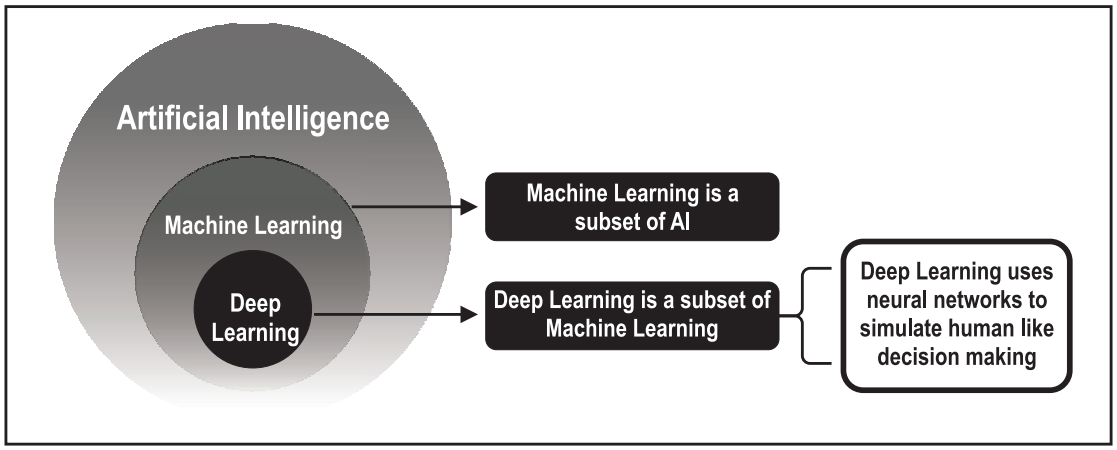
- While there are many benefits to the growth of big data analytics, traditional methods of privacy protections often fail. Many notions of privacy rely on informed consent for the disclosure and use of an individual's private data. However, big data means that data is a resource that can be used and reused, often in ways that were inconceivable at the time the data was collected. Anonymity is also eroded in a big data paradigm. Even if every individual piece of information is stripped of personal information, the relationships between the individual pieces can reveal the individual's identity.
- Another quality issue is the way that Internet search terms or phrases can be misinterpreted, when this type of data is collected. Examples of poor enterprise use of big data would include using Internet search terms to evaluate product pricing or, perhaps, target potential customers. There can be multiple users on a household computer, and there are many reasons why someone might research a subject on the Internet that is not directly relevant to them. This type of data collection, analysis and usage can result in flawed analytic results leading to bad decisions, a lose-lose scenario for both individuals and the organizations acting upon that data. This lack of big data quality control points to another well-established privacy principle, which is to collect personal data that is consistent and appropriate for the intended purpose.
- Big data has the potential to discriminate in two ways. First, it can be used to identify aberrant data amongst larger sets, leading to the use of big data to discriminate against specific groups and activities. Second, big data will be used to draw conclusions about large groups of people, and yet some will be excluded because their data is not included in the sets, or the quality of their data is poorer. It is important to remember that data does not equal truth. It only offers correlations — for example, links between two different types of activities.
- **Thus for respecting Right to Privacy following principles should be followed:**
  - To respect the principle of purpose specification.
  - To limit the amount of data collected and stored to the level that is necessary for the intended lawful purposes.
  - To obtain, where appropriate, a valid consent from the data subjects in connection with use of personal data for analysis and profiling purposes.
  - To be transparent about which data is collected, how the data is processed, for which purposes it will be used and whether or not the data will be distributed to third parties.
  - To carry out a privacy impact assessment, especially where the big data analytics involves novel or unexpected uses of personal data.
  - To exercise great care, and act in compliance with applicable data protection legislation, when sharing or publishing pseudonymised, or otherwise indirectly identifiable, data sets. If the data contains sufficient detail that is, may be linked to other data sets or, contains personal data, access should be limited and carefully controlled.

Artificial Intelligence and Impact on Society

Introduction

- Artificial Intelligence is a way of **making a computer, a computer-controlled robot, or a software think intelligently,** in the similar manner the intelligent humans think.
- These processes include learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions), and self-correction.

- In the recent times, this revolution has come accompanied by massive investment and increasing anxiety about the future of jobs. AI could usher in an era of unprecedented prosperity or unprecedented inequality. Bill Gates, Stephen Hawking and Elon Musk, have a deeper fear—That we may be, "summoning the demon".



AI: Advantages and Disadvantages

- Artificial intelligence can help scientists solve "hard problems" like climate change.
- Artificial intelligence helps us in reducing the error and the chance of reaching accuracy with a greater degree of precision is a possibility. Artificial intelligence is applied in various studies such as exploration of space. Intelligent robots are fed with information and are sent to explore space. Since they are machines with metal bodies, they are more resistant and have greater ability to endure the space and hostile atmosphere. They are created and acclimatized in such a way that they cannot be modified or get disfigured or breakdown in the hostile environment.
- Using artificial intelligence alongside cognitive technologies can help make faster decisions and carry out actions quicker.

AI and the Inequality

- Globalization has certainly benefited large segments of humanity, but there are signs of growing inequality both between and within societies. As some groups increasingly monopolize the fruits of globalization, billions are left behind.
- In the present times as artificial intelligence (AI) outperforms humans in more and more skills, it is likely to replace humans in more and more jobs. True, many new jobs might appear, but that won't necessarily solve the problem.
- Humans basically have just two types of skills – physical and cognitive – and if computers outperform us in both, they might outperform us in the new jobs just as in the old ones. Consequently, billions of humans might become unemployable, and we will see the emergence of a huge new class: the useless class. This is one reason why human societies in the 21st century might be the most unequal in history.

Concerns

- Another worry is AI's possible effect on inequality. Anything that reduces labour costs is likely to disproportionately benefit holders of capital. If the race to develop artificial intelligence depends on huge amounts of data and computing power, a big chunk of the future economy could be controlled by a handful of companies. What would happen after that? We have absolutely no idea – we literally can't imagine it. A super-intelligent computer will by definition have a far more fertile and creative imagination than that which we possess. In the 21st century, the rise of AI and biotechnology will

certainly transform the world – but it does not mandate a single, deterministic outcome. How to use them wisely is the most important question humankind is facing today.

National strategy on artificial intelligence

- NITI Aayog in its recent discussion paper addresses the national strategy on artificial intelligence.
- It identifies 5 cores areas for the application of artificial intelligence:
  - **Healthcare:** increased access and affordability of quality healthcare
  - **Agriculture:** enhanced farmers' income, increased farm productivity, and reduction of wastage
  - **Education:** improved access and quality of education
  - **Smart Cities and Infrastructure:** efficient and connectivity for the burgeoning urban population
  - **Smart Mobility and Transportation:** smarter and safer modes of transportation and better traffic and congestion problems

Challenges to Adoption in India

- Unavailability of the proper data ecosystem
- Insufficient funding and research in AI.
- Inadequate availability of AI expertise, manpower and skilling opportunities
- High resource cost
- Low awareness for adopting AI in business processes
- Lack of proper privacy, security, and ethical regulations
- Unattractive Intellectual Property Regime. This hinders research and adoption of AI
- Unemployment issues

Need for regulating Artificial Intelligence (AI)

- With popularization of a new technology, its virtues are not guaranteed. For instance, the internet made it possible to connect with anyone and get information from anywhere, but also easier for misinformation to spread.
- There are real concerns about the potential negative consequences of AI, from deep fakes to nefarious uses of facial recognition technology.
- Data Management- as there is lack of clarity on data flow and data ownership which might result into data colonialism (data generated by developing countries yet not benefitting them).
- Further, data collection for feeding AI algorithms has its associated privacy concerns e.g. mass surveillance.
- AI could contribute to the forgery of documents, pictures, audio recordings, videos, and online identities which can and will occur with unprecedented ease.
- The algorithms used in artificial intelligence are discrete and, in most cases, trade secrets. They can be biased, for example, in the process of self-learning, they can absorb and adopt the stereotypes that exist in society or which are transferred to them by developers and make decisions based on them.
- If an AI system fails at its assigned task, someone should be made responsible for it. e.g. an anti-terrorism facial recognition program revoked the driver's license of an innocent man when it confused him for another driver.
- Similarly, when any AI algorithm takes a decision related to social dimensions, it is crucial is taken on transparent parameters. These AI algorithms can and do make decisions that create significant and serious issues in people's lives.

AI & Ethics

- The increasing scale of AI in terms of its size of neural networks, the energy use, size of data sets and its authenticity, and the prevalence of the technology in society is raising the major ethical questions.
  - The availability of a vast amount of big data, the speed and stretch of cloud computing platforms, and the advancement of machine learning algorithms have given birth to a good number of innovations in Artificial Intelligence(AI).
  - **Benefits:** The beneficial impact of AI systems on government which translates into improving healthcare services, education, and transportation in smart cities. Along with some other applications that benefit from the implementation of AI systems in the public sector which include food supply chain, energy, and the environmental management.
    - The benefits that AI systems bring to society are grand, and same with the challenges and worries.
    - The evolving technologies learning give rise to the miscalculations and mistakes, which results in unanticipated harmful impacts.
    - This brings the ethical concerns related to the AI.

What is Ethical AI?

- Ethics in AI is essentially questioning, constantly investigating, and not taking for granted the technologies which are being rapidly imposed upon human life.
- **Concern Areas:** The questioning of AI is made all the more urgent because of scale of its use and data.
  - **Sheer Size:** AI systems are reaching tremendous size in terms of the compute power they require, and the data they consume.
  - **Prevalence:** And their prevalence in society, both in the scale of their deployment and the level of responsibility they assume, dwarfs the presence of computing in the PC and Internet eras.
  - **Outreach:** At the same time, increasing scale means several aspects of the technology, especially in its deep learningform that escape the comprehension of even the most experienced practitioners.

Reasons for ethical concern in the AI field

AI ethics: a new urgency and controversy

- Another area of concern is AI applied in the area of military and policing activities.
  - For example, ImageNet has been used to enhance the U.S. military's surveillance systems.
  - With the point of view of safety it is encouraging but with the point of view of unchecked surveillance it is not safe and causes concerns.

Mass surveillance backlash

- Calls are rising for mass surveillance, enabled by technology such as facial recognition, not to be used at all.
  - The backlash against surveillance for example the monitoring of ethic Uyghurs in China's Xianxjang region and in February military coup in Myanmar, Human Rights Watch reports that human rights are in the balance given the surveillance system.
- There are fears that the AI tools will be weapons of first resort in future conflicts for the mass surveillance and would reduce the freedom of inidividuals.

Ethics of compute efficiency

- The risk of the huge cost of compute for ever-larger models has been a topic of debate for some time now.
- The measures of performance including the energy consumption, are often cloaked in secrecy.

AI ethics: a history of racial recognition

- It also demonstrates that how commercially available facial recognition systems had high accuracy while dealing with images of light-skinned men, but catastrophically bad inaccuracy when dealing with images of darker-skinned women.
- Such inaccuracy was tolerated in commercial systems and raised racial questions.
- AI in its machine learning form makes extensive use of principles of statistics. In statistics, bias is when an estimation of something turns out not to match the true quantity of that thing.

The rise of the fake

- The ethical issues of bias are the fact that neural networks are more and more "generative,".
- It means they are not merely acting as decision-making tools, such as a classic linear regression machine learning program. They are flooding the world with creations.
  - The software can be used to generate realistic faces: It has spawned an era of fake likenesses.
  - AI systems can now compose text, audio, and images to a sufficiently high standard that humans have a hard time telling the difference between synthetic and non-synthetic outputs for some constrained applications of the technology.

Societal biases

- There is the propagation of text that increases the societal biases, as pointed out by the Parrot paper.
- But there are other kinds of biases which can be created by the algorithms that act on that data.
- This includes, for example, algorithms whose goal is to classify human faces into categories of "attractiveness" or "unattractiveness." The so-called generative algorithms, such as GANs. It can be used to endlessly reproduce a narrow formulation of what is purportedly attractive in order to flood the world with that particular aesthetic to the exclusion of all else.
  - Artificial Intelligence systems implementation and its design must be held accountable. In general the AI might become moral agents with attributed moral responsibility. The engineers and designers of AI systems must assume responsibility and should be held accountable for the creation, design, and the program.

Cyber Crimes and Security

Cyber-crime encompasses any criminal act dealing with computers and networks.

Some common cyber-crimes are:

- **Stalking:** Cyber stalking is use of the Internet or other electronic means to stalk someone
- **Hacking:** "Hacking" is a crime, which entails cracking systems and gaining unauthorized access to the data stored in them.
- **Phishing:** Phishing refers to the receipt of unsought emails by customers of financial institutions, asked them to enter their username, password or other personal information to access their account for some reason.

- **Squatting:** Cyber-squatting is the act of registering a famous domain name and then selling it for a fortune.
- **Software Piracy:** It is an illegal reproduction and distribution of software for business or personal use. This is considered to be a type of infringement of copy right and a violation of a license agreement.
- **Cyber pornography:** This would include pornographic websites; pornographic magazines produced using computers (to publish and print the material) and the Internet (to download and transmit pornographic pictures, photos, writings etc).
- **Sale of illegal articles:** This would include sale of narcotics, weapons and wildlife etc., by posting information on websites, auction websites, and bulletin boards.
- **Cyber-terrorism:** Cyber-terrorism is the adaptation of terrorism to computer resources, whose purpose is to cause fear in its victims by attacking electronic resources.
- **Cyber Defamation:** This occurs when defamation takes place with the help of computers and / or the Internet. E.g. someone publishes defamatory matter about someone on a website or sends e-mails containing defamatory information to all of that person's friends.

Issue of WannaCry Malware

- Malware, or malicious software, is any program or file that is harmful to a computer user. Malware includes computer viruses, worms, Trojan horses and spyware. These malicious programs can perform a variety of functions, including stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission.
- Wannacry is a malware which is spreading across the globe since May 12, 2017 and has hit government & private companies and universities in nearly 100 countries.
- WannaCry (also known as WCry or WanaCryptor) malware is a self-propagating (worm-like) ransomware that spreads through internal networks and over the public internet by exploiting a vulnerability in Microsoft's Server Message Block (SMB) protocol, MS17-010.

What is a Ransom-ware?

- Ransom-ware is a malware that encrypts the files on an infected system and then demands a ransom to decrypt them, with escalation in the demand over time.
- The ransom demand is in Bitcoins.
- It often reaches victims as mail attachment. Once opened, it spreads to other computers in the network exploiting the Windows vulnerability. It spreads using a flaw in older Microsoft windows system.

Case of Credit/ Debit Card Crimes

- A cashless economy is one in which all the transactions are done using cards or digital means. The circulation of physical currency is minimal. India uses too much cash for transactions. Most of the cash in advanced economies is floating around in the "world underground economy".
- However, **the biggest threat to cashless economy is Plastic card fraud.**
- **Plastic card fraud involves the compromise of any personal information from credit, debit or store cards.** The personal information stolen from a card, or the theft of a card itself, can be used to commit fraud. Fraudsters might use the information to purchase goods in your name or obtain unauthorised funds from an account. Plastic card fraud can also include 'card not present' fraud, such as the use of a card online, over the phone or by mail order, and counterfeit card fraud.

- **The techniques used are:**
  - **Application fraud:** This type of fraud occurs when a person falsifies an application to acquire a credit card.
  - **Fake and counterfeit cards:** The creation of counterfeit cards, together with lost / stolen cards pose highest threat in credit card frauds.
  - **Skimming:** Most cases of counterfeit fraud involve skimming, a process where genuine data on a card's magnetic stripe is electronically copied onto another.
  - **Site cloning:** Site cloning is where fraudsters clone an entire site or just the pages from which you place your order.
- Plastic card frauds are rising thus the government came up with idea of smart cards. Smart credit cards operate in the same way as their magnetic counterparts, the only difference being that an electronic chip is embedded in the card. These smart chips add extra security to the card. Smart credit cards contain 32-kilobyte microprocessors, which is capable of generating 72 quadrillion or more possible encryption keys and thus making it practically impossible to fraudulently decode information in the chip.
- **The advantages are listed below:**
  - Stores many times more information than a magnetic stripe card.
  - Reliable and harder to tamper with than a magnetic stripe card.
  - Performs multiple functions in a wide range of industries.
  - Compatible with portable electronic devices such as phones and personal digital assistants (PDAs), and with PCs.
  - Stores highly sensitive data such as signing or encryption keys in a highly secure manner
  - Performs certain sensitive operations using signing or encryption keys in a secure fashion.

Challenges in Monitoring Cyber Crimes

- **Server Location and Laws of Different Countries:** Lack of Geographical Boundaries makes social media regulation an arduous task. Major Complicating Factors to secure the networks and Media Much of the hardware and software that make up the communications ecosystem is sourced externally.
- **Encrypted Message:** Use of phones/whatsapp to send and receive messages, concerns the government because the communications sent via such devices and applications are encrypted and could not be monitored and consequently hinders the country's efforts to fight terrorism and crime.
- **Complicated Networks:** The task of securing the networks is also complicated by the fact that much of the infrastructure is in the hands of private companies who see measures such as security auditing and other regulations and frameworks as adding to their costs. Source of Origin is difficult to find out.
- GOI has launched National Cyber Security Policy 2013 which aims at protection of information infrastructure in cyberspace, reduce vulnerabilities, build capabilities to prevent and respond to cyber threats and minimize damage from cyber incidents through a combination of institutional structures, people, process, technology and cooperation.

Set up of cyber-security engagement centre

- US tech giant Microsoft has set up a cyber-security engagement centre (CSEC) in the Delhi-NCR region that will help it work with partners to identify and respond to cyber threats in the country.
- The CSECs mission is to help build a trusted and secure computing environment, a critical enabler for India's digital transformation. It will works towards fostering deeper cyber-security collaborations with public and private sector organisations for this.

Steps taken by government for Cyber-security

- Strengthened CERT-In. It is nodal department under the aegis of the Indian Department of Information Technology, Ministry of Electronics and IT. According to the provisions of the IT Amendment Act, 2008, CERT-In is responsible for overseeing administration of the Act. Purpose of CERT-In: (i) Protect Indian cyberspace and software infrastructure against destructive and hacking activities, (ii) Respond to computer security incidents, report on vulnerabilities and promote effective IT security practices throughout the country and (iii) Issue guidelines, vulnerability notes, advisories, and whitepapers regarding to information security practices, prevention, procedures, response and reporting of cyber security incidents.
- It has been made mandatory for all organisations having a significant IT infrastructure will need to appoint cyber security officers.
- Three sectoral CERTs in power sector viz. generation, transmission and distribution also have been set up in addition to the existing banking sector one.
- National cyber coordination centre (NCCC) is being set up to provide near real time situational awareness and rapid response.

Supercomputer and Its Applications

- A type of computer which is used to focus the applications that require large mathematical and difficult calculations at the front line of processing capacity is known as Supercomputer.
- Great speed and great memory are the two prerequisites of a supercomputer. While the performance of ordinary computers are generally quoted in MIPS (million instructions per second) supercomputer are measured according to how many floating point operations per second (FLOPS)

Unit	Flops	Examples	Decade (s)
Hundred FLOPS	10^2	Eniac	1940
KFLOPS (kilo flops)	10^3	IBM 704	1950
MELOPS (mega flops)	10^6	CDC 6600	1960
GELOPS (giga flops)	10^9	Cray-2	1980
TELOPS (teraflops)	10^{12}	ASCI Red	1990
PFLOPS (peta flops)	10^{15}	Jaguar	2010
EFLOPS (exa flops)	10^{18}	Under development	2020

World's top 3 supercomputers

- Sunway TaihuLight – developed in China with the computing power of a 93 petaflop/s.
- The Tianhe-2 (MilkyWay-2) – from China. This supercomputer is capable of 33.8 petaflop/s.
- Titan – from the US. Computing capacity is 17.5 petaflop/s.

Applications of Supercomputers

- **Weather research:** supercomputers use the data from space satellites, airplanes and ground weather stations for accurate prediction of future weather conditions.

- **Academic research:** supercomputers are used for academic research in astrophysics, quantum mechanics etc.a
- **Space exploration:** for accurate analysis of data from space satellites, space research stations, etc., requires supercomputing speed. The supercomputer was used for predicting the collision of a comet with Jupiter in 1994.
- **Aerodynamics:** supercomputers are used for stimulating the passage of air around different parts of the aircraft. This is necessary for proper designing of aircraft.
- **Big data mining:** supercomputers are used for big data mining and analyzing its results.
- **Medical science:** supercomputers are used for decoding the genetic data, and for research and development of new drugs for different diseases.
- **Nuclear research:** simulation using supercomputing speed is used for simulating the results of nuclear bombs. Supercomputers used for research purposes for nuclear power plants. They simulate nuclear fission and fusion processes for developing better nuclear infrastructure.
- **Oil exploration:** Oil Companies use supercomputers for analyzing a large amount of data for determining the most productive oil exploration sites.
- **Movies:** special effects in many movies are produced using supercomputers. Movies like Lord of the Rings, Star Trek, Babylon 5, Asteroid, Jurassic Park, etc., used supercomputers for generating special effects.
- **Molecular dynamics:** supercomputer simulations allow scientists to dock two molecules together to study their interaction which may lead to the development of innovative materials for future generation technologies.

National Supercomputing Mission

- The **Mission, launched in 2015,** envisages **empowering our national academic and R&D institutions** spread over the country by installing a **vast supercomputing grid comprising** of more than **70 high-performance computing facilities.**
- These supercomputers will also be networked on the **National Supercomputing grid over the National Knowledge Network (NKN).**
- The Mission would be implemented jointly by the **Department of Science and Technology (DST)** and **Department of Electronics and Information Technology (DeitY)** for over a period of seven years, through the **C-DAC and Indian Institute of Science (IISc), Bengaluru**

Supercomputers in India

- **Pratyush Supercomputer**
  - India's Pratyush is its first multi-petaflop supercomputer to date that is a part of the efforts made by Ministry of Earth Sciences to grow 'High-Performance Computing' (HPC) in the country.
  - The sole purpose of installing such a high-capacity supercomputer in India is to accelerate the weather forecasting in the country, primarily before the arrival of Monsoon season in India.
  - Pratyush is set up at the Indian Institute of Tropical Meteorology (IITM) in Pune
  - Processing speed-4 petaflop
- **Mihir supercomputer-**
  - Mihir, a 2.9 petaflop supercomputer which is operational at the National Centre for Medium-Range Weather Forecast in Noida
- **Param Shivay**
  - It is a supercomputer of 833 teraflop capacity.

- It was built at the cost of Rs 32.5 crore under the National Super Computing Mission at the Indian Institute of Technology (IIT), Banaras Hindu University (BHU).

Next generation supercomputing–

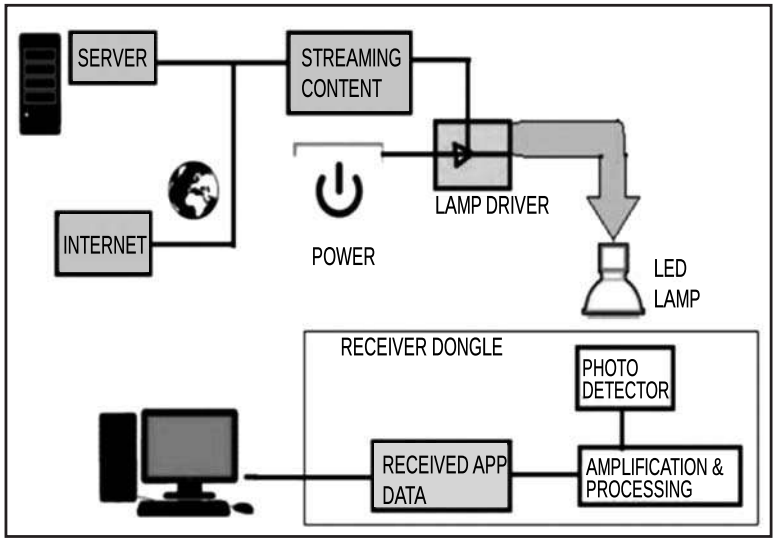
- **Optical computing-** calculations with the near speed of light by using optical devices and connections in place of transistors. Latest developments in this field have already taken place with the optical equivalent of transistors being switched on using photons and not electrons. Since photons travel at speed of light, therefore, calculations may be done at sub-light speed.
- **DNA computing** -calculations by recombining DNA in a parallel environment. Numerous possibilities are tried at the same time; the most optimal solution will be "the strongest to survive."
- **Quantum computing** -not in practical use yet only conceptual proofing done but think of it as calculations being done before you have thought of them. Work is done in the blink of an eye since time is of no essence here.

Li-Fi Technology and its Application

Li-Fi, or light fidelity, invented by the German physicist and professor Harald Haas, is a wireless technology that makes use of visible light in place of radio waves to transmit data at terabits per second speeds—more than 100 times the speed of Wi-Fi.

How does it work?

- Li-Fi is a Visible Light Communications (VLC) system. A simple Visible Light Communication (VLC) system has two qualifying components:
  - At least one device with a photodiode able to receive light signals
  - A light source equipped with a signal processing unit.



- Here, data is fed into an LED light bulb (with signal processing technology), it then sends data (embedded in its beam) at rapid speeds to the photo-detector (photodiode). [An LED lightbulb is a semiconductor light source meaning that the constant current of electricity supplied to an LED lightbulb can be dipped and dimmed, up and down at extremely high speeds, without being visible to the human eye.]
- The tiny changes in the rapid dimming of LED bulbs are then converted by the 'receiver' into an electrical signal.

- The signal is then converted back into a binary data stream that the user would recognize as web, video and audio applications that run on internet enables devices.

Advantages:

- Li-Fi could make a huge impact on the internet of things too, with data transferred at much higher levels with even more devices able to connect to one another.
- Li-Fi offers great promise to overcome the existing limitations of Wi-Fi by providing for data-heavy communication in short ranges.
- Due to its shorter range, Li-Fi is more secure than Wi-Fi.
- Since it does not pollute, it can be called a green technology for device-to-device communication in the Internet of Things (IoT).
- Li-Fi systems consume less power.

Limitations of Li–Fi:

- As visual light can't pass through opaque objects and needs line of sight for communication, its range will remain very restricted to start with. In order to enjoy full connectivity, more capable LED bulbs will need to be placed at various places.
- Li-Fi requires the lightbulb is on at all times to provide connectivity, meaning that the lights will need to be on during the day.
- Li-Fi is likely to face interference from external light sources, such as sunlight and bulbs, and obstructions in the path of transmission, and hence may cause interruptions in communication.
- Also, initially, there will be high installation costs of visual light communication systems as an add-on to lighting systems.

Potential Applications

- **RF Spectrum Relief:** Excess capacity demands of cellular networks can be off-loaded to Li-Fi networks where available. This is especially effective on the downlink where bottlenecks tend to occur.
- **Smart Lighting:** Any private or public lighting including street lamps can be used to provide Li-Fi hotspots and the same communications and sensor infrastructure can be used to monitor and control lighting and data.
- **Mobile Connectivity:** Laptops, smartphones, tablets and other mobile devices can interconnect directly using Li-Fi. Short range links give very high data rates and also provides security.
- **Hazardous Environments:** Li-Fi provides a safe alternative to electromagnetic interference from radio frequency communications in environments such as mines and petrochemical plants.
- **Hospital & Healthcare:** Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners.
- **Aviation:** Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-Flight Entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.
- **Underwater Communications:** Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides a solution for short-range communications.
- **Vehicles & Transportation:** LED headlights and tail-lights are being introduced. Street lamps, signage, and traffic signals are also moving to LED. This can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road safety and traffic management.

- **RF Avoidance:** Some people claim they are hypersensitive to radio frequencies and are looking for an alternative. Li-Fi is a good solution to this problem.
- **Location Based Services (LBS):** Highly accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate, pertinent information in a timely manner and location.
- **Toys:** Many toys incorporate LED lights and these can be used to enable extremely low-cost communication between interactive toys

Challenges and opportunity in India:

- The lack of ubiquitous broadband access, which thereby restricts data access, and chaotic traffic management leading to traffic jams and pollution are just two of the many problems in India. Li-Fi has the scope to help with both.
- By converting traffic lights into LED-based access points, traffic management can be made intelligent, adaptive and real-time—and so, more efficient and effective.
- In the same way, street lights can also be converted into Li-Fi access points, making them broadband access transmitters to mobile Li-Fi enabled smartphones, converting areas into seamless hot spots.

In-flight wi-fi

- Union government recently issued a notification to announce that all airlines operating in India can now provide in-flight wi-fi services to its passengers.

How doe it works

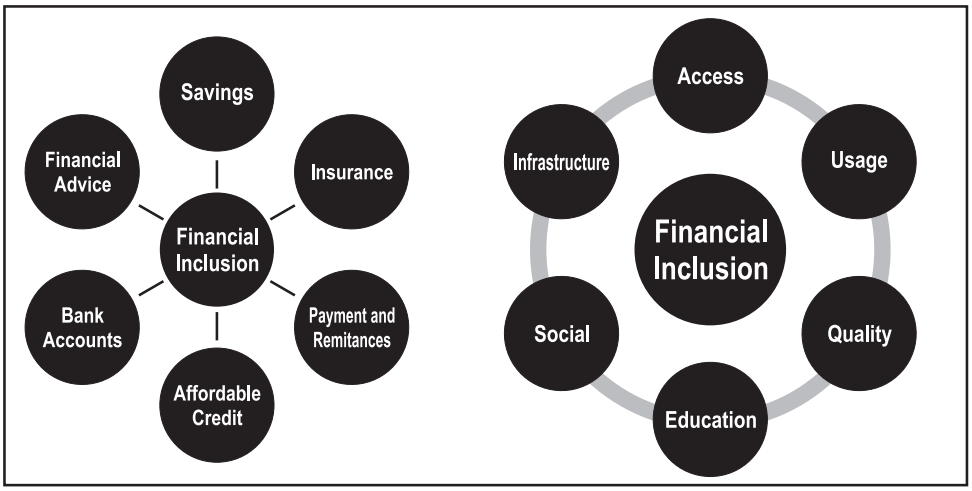
- There are two operating systems for airplane WiFi:
  - **Air-to-ground WiFi System**
    - It works in a similar way to a cell phone.
    - Airplanes have an antenna located underneath their body, which links up with cell towers on the ground.
    - As the aircraft travels, it simply connects to the nearest transmitter/towers on a rolling basis.
    - The airplane becomes a hotspot, so passengers can access internet.
    - However, this system can't work when the plane is flying over large expanses of water or particularly remote terrain, like on transatlantic routes.
  - **Satellite based WiFi System**
    - It uses a network of orbiting satellites to allow a connection.
    - Information is passed between the ground and the plane via the satellite. o The satellite is linked to ground stations.
    - The airplane connects to the satellite using a satellite antenna on the top of the fuselage.
    - Wi-Fi signal is distributed to plane passengers via an on board router.
    - The plane uses whichever satellite is nearest as it travels and thus can operate over large expanses of water or remote terrain as well.
    - Satellite WiFi operates on two different bandwidths: narrowband and broadband. Both allow passengers full Internet access, although the narrower options are less suitable for streaming movies.

Use of IT in Financial Inclusion

- Financial inclusion is the process of ensuring access to financial services and timely and adequate credit whenever needed by vulnerable groups such as weaker sections and low-income groups at an affordable cost".
- Financial refers to all types of financial services, including savings, payments, and credit from all types of formal financial institutions.

Reasons for low financial inclusion in India:

- The financial health of low-income segments in India shows that the reliance on financial products from non-institutional sources is high because these tend to be more tailored to their economic lives
- Most people especially the lower income groups find it inconvenient to understand different product offerings, financial jargon, and related terms and conditions.



- They don't see the bank as welcoming and often believe they are not for them.
- Households also lack an avenue to receive credible, low-cost and high-quality financial advice.
- Illiteracy and low-income savings and lack of bank branches in rural areas continue to be a roadblock to financial inclusion.
- Inadequate legal and financial structure.

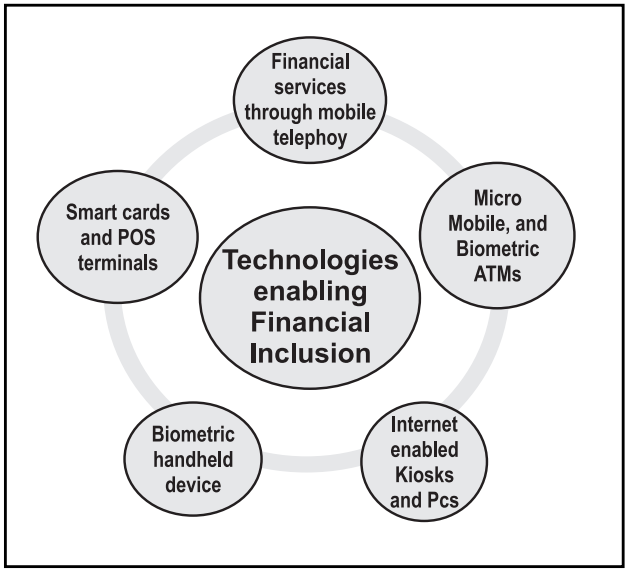
How technology can help to overcome these barriers?

- Technology can provide more tailored financial products to the mass-market consumer.
- Technology can offer a simpler and seamless user experience. Banks and new entrants like payments banks are jockeying to win this user interface/user experience game.
- Public good tech infrastructure is dramatically reducing the cost to serve. Electronic know your customer, for example, that builds on the Aadhaar platform has already reduced time to onboard a customer from a few days to a few minutes. Other innovations like e-Sign, which does away with the need for a "wet signature", are beginning to proliferate.
- With the rise of fintech, financial inclusion seeks to promote the betterment of the world's population through the use of financial services and tools available in an increasingly digital-based economy.

- Short Message Service (SMS), Unstructured Supplementary Services Delivery (USSD), Wireless Application Protocol (WAP), General packet radio service (GPRS), phone-based applications such as Java 2 Micro Edition (J2ME)/Binary Runtime Environment for Wireless (BREW), Subscriber Identity Module (SIM) - based application, and Near Field Communication (NFC) are the various technology applications available, which can help improve the level of financial inclusion in the country

Commonly promoted distribution technologies for financial inclusion in India

- IT-enabled Kiosks for Financial Inclusion (They are small and self-operated IT-enabled centres that provide the customers with banking features such as cheque or cash deposit, internet banking, non-cash ATM transaction, and teller inquiries.)
- Mobile phone-based financial services: Mobile banking (m-banking) and Mobile payments (m-payments)



  - Automated Teller Machines (ATM): Biometric ATM, Mobile ATM, and Micro ATM.
  - Biometric handheld device
  - Smart cards and POS (point-of-service)

Digital Transaction Methodologies

  - **Banking cards:**
    - Different types of cards available are- credit, debit, and prepaid.
    - Banking cards offer consumers more security, convenience, and control than any other payment method.
    - The cards provide 2-factor authentications for secure payments e.g. secure PIN and OTP
    - RuPay, Visa, MasterCard are some of the examples of card payment systems.
  - **Unstructured Supplementary Service Data (USSD):**
    - This payment service *99# works on USSD channel, allowing mobile banking transactions using basic feature mobile phone without any need of mobile internet data facility.
    - It is envisioned to provide financial deepening and inclusion.
  - **Point of Sale (POS):**
    - A point of sale (POS) is the place where sales are made.
    - POS may be a mall, a market, or a merchant trader.
  - **Aadhaar Enabled Payment System (AEPS):**
    - AEPS is a bank-led model which allows online interoperable financial transaction at POS through the Business Correspondent (BC) of any bank using the Aadhaar authentication.
    - AadhaarPay connects the Aadhaar-enabled biometric identification as an authentication process for mobile banking.

- **Internet Banking:**
  - Internet banking (online banking, e-banking or virtual banking) is an electronic payment system that enables customers of a financial institution to conduct a range of financial transactions through its website.
  - **Different types of Internet Banking are:**
    - **National Electronic Fund Transfer (NEFT):**
      - It is a nation-wide payment system facilitating one-to-one electronic funds transfer among individuals, firms, and corporates. NEFT facilitates originators or remitters to initiate funds transfer transactions even without having a bank account.
    - **Real Time Gross Settlement (RTGS):**
      - The real-time settlement of large funds transfers individually without netting. As the settlement takes place in the books of the Reserve Bank of India, they are final and irrevocable. There is no upper ceiling for RTGS transactions.
    - **Electronic Clearing System (ECS):** It is an alternative method for effecting transactions in respect of the utility-bill-payments such as telephone bills, electricity bills, etc.
    - **Immediate Payment Service (IMPS):**
      - IMPS offers instant and 24X7 interbank electronic fund transfer service through mobile phones.
      - It enables bank customers to use mobile as a channel for making payments India, and helps RBI in Digitization of retail payments and building the foundation for mobile-based Banking services.
- **Unified Payment Interface (UPI):**
  - UPI is a system that powers multiple bank accounts into a single mobile application (of the participating bank), merging several banking features for seamless fund routing.
  - BHIM app utilizes UPI to provide instant bank transfers.
- **Mobile Banking:**
  - It is a service provided by a financial institution allowing its customers to conduct financial transactions using a mobile device.
  - Banks provide their own mobile banking Apps for different mobile platforms.
  - **Mobile Wallets:** A mobile wallet is a way to carry cash in digital format. e.g. Paytm, Freecharge, etc.
  - **Micro ATM:** It is a device that is used by a Business Correspondents (BC) or local traders to deliver basic banking services to customers, like, deposit, withdrawal, fund transfer, and balance enquiry.

Credit/Debit Card Crimes

- Cashless Economy can be defined as a situation in which the flow of cash within an economy is non-existent and all transactions must be through electronic channels such as direct debit, credit cards, debit cards, electronic clearing, and payment systems such as Immediate Payment Service (IMPS), National Electronic Funds Transfer (NEFT) and Real Time Gross Settlement (RTGS) in India.

Advantages of a cashless economy –

- **Tackling Black Money:**
  - The main advantage of a cashless society is that a record of all economic transactions through electronic means makes it almost impossible to sustain black economies or underground markets that often prove damaging to national economies.
  - It is also much riskier to conduct criminal transactions. An economy that is largely cash-based facilitates a rampant underground market which abets criminal activities such as drug trafficking, human trafficking, terrorism, extortion, etc. Cashless transactions make it difficult to launder money for such nefarious activities.
- Circulation of Fake Currency notes can be curbed.
- A cashless economy will help reduce corruption.
- **Increase Tax base:** It is difficult to avoid the proper payment of due taxes in a cashless society, such violations are likely to be greatly reduced. The increased tax base would result in greater revenue for the state and greater amount available to fund the welfare programmes.
- Digital transactions bring in better transparency, scalability, and accountability.
- Digital transactions are convenient and improve market efficiency
- Transaction costs will come down in the long run
- It would bring down the logistics & cost involved in printing, managing and moving money around.
- It will eliminate the risks associated with carrying and transporting huge amounts of cash

Challenges in transitioning to a Cashless society –

- **Acceptance infrastructure and digital inclusion:** Lack of adequate infrastructure is a major hurdle in setting up a cashless economy. Inefficient banking systems, poor digital infrastructure, poor internet connectivity, lack of robust digital payment interface and poor penetration of PoS terminals are some of the issues that need to be overcome. Increasing smartphone penetration, boosting internet connectivity and building a secure, seamless payments infrastructure is a prerequisite to transition into a cashless economy.
- **Financial Inclusion –** For a cashless economy to take off the primary precondition that should exist is that there should be universal financial inclusion. Every individual must have access to banking facilities and should hold a bank account with a debit/credit card and online banking facilities.
- **Digital and Financial Literacy –** Ensuring financial and digital inclusion alone are not sufficient to transition to a cashless economy. The citizens should also be made aware of the financial and digital instruments available and how to transact using them.
- **Cyber Security –** Digital infrastructure is highly vulnerable to cyber-attacks, cyber frauds, phishing, and identity theft. Off late cyber-attacks have become more sophisticated and organized and poses a clear and present danger. Hence establishing secure and resilient payment interfaces is a prerequisite for going cashless. This includes enhanced defenses against attacks, data protection, addressing privacy concerns, robust surveillance to pre-empt attacks and institutionalized cyber security architecture.
- **Changing habits and attitude –** Indian economy functions primarily on cash due to lack of penetration of e-payment modes, digital illiteracy of e-payment and cashless transaction methods and thirdly habit of handling cash as a convenience. In this scenario, the ideal thing to do is to make people adopt e-payments in an incremental fashion and spread awareness to initiate behavioral change in habits and attitude.
- Urban-Rural Divide – While urban centers mostly enjoy high-speed internet connectivity, semi-urban and rural areas are deprived of a stable net connection. Therefore, even though India has more than 200 million smartphones, it is still some time away for rural India to seamlessly transact through

mobile phones. Even with regard to the presence of ATM's, PoS terminals and bank branches there exists a significant urban-rural divide and bridging this gap is a must to enable a cashless economy.

Plastic Card Fraud

- Plastic card fraud involves the compromise of any personal information from credit, debit or store cards. The techniques used are:
  - **Application fraud:** This type of fraud occurs when a person falsifies an application to acquire a credit card.
  - **Fake and counterfeit cards:** The creation of counterfeit cards, together with lost/stolen cards pose the highest threat in credit card frauds.
  - **Skimming:** Most cases of counterfeit fraud involve skimming, a process where genuine data on a card's magnetic stripe is electronically copied onto another.
  - **Site cloning:** Site cloning is where fraudsters clone an entire site or just the pages from which you place your order

Smart Credit Cards

- Plastic card frauds are rising thus the government came up with the idea of smart cards. Smart credit cards operate in the same way as their magnetic counterparts, the only difference being that an electronic chip is embedded in the card.
- These smart chips add extra security to the card. Smart credit cards contain 32-kilobyte microprocessors, which is capable of generating 72 quadrillion or more possible encryption keys and thus making it practically impossible to fraudulently decode information in the chip.
- The smart chip has made credit cards a lot more secure; however, the technology is still being run alongside the magnetic strip technology due to the slow uptake of smart card reading terminals in the world market.

Advantages

- Stores many times more information than a magnetic stripe card.
- Reliable and harder to tamper with than a magnetic stripe card.
- Performs multiple functions in a wide range of industries.
- Compatible with portable electronic devices such as phones and Personal Digital Assistants (PDAs), and with PCs.
- Stores highly sensitive data such as signing or encryption keys in a highly secure manner
- Performs certain sensitive operations using signing or encryption keys in a secure fashion.
- Steps were taken by the government for Cyber-security
- Government has taken a number of legislative, technical and institutional measures for addressing issues related to cybersecurity. These include National Cyber Security policy (2013), enactment of Information Technology (IT) Act, 2000 and setting up of Indian Computer Emergency Response Team (CERT-In). Some specific measures taken by the Government of India to strengthen cybersecurity system in the country are as under:
- National Cyber Security Coordinator (NCSC) under National Security Council Secretariat (NSCS) coordinates with different agencies at the national level for cybersecurity matters.
- Information Technology Act, 2000 was enacted to provide legal recognition for electronic communication, electronic commerce, and cyber crimes, etc. IT Act has deterrent provisions to deal with cyber threats and cyber attacks.
- The Indian Computer Emergency Response Team (CERT-In) issues alerts and advisories regarding the latest cyber threats and countermeasures on a regular basis.

- National Critical Information Infrastructure Protection Centre (NCIIPC) has been established for the protection of critical information infrastructure in the country.
- Cybersecurity exercises are being conducted regularly to enable assessment of preparedness of organizations in Government and critical sectors.
- Guidelines have been issued for Chief Information Security Officers (CISOs) regarding their key roles and responsibilities for securing applications/infrastructure and compliance.
- Cyber Swachhta Kendra (Botnet Cleaning and Malware Analysis Centre) has been launched for the detection of malicious programs and provide free tools to remove the same.
- National Cyber Coordination Centre (NCCC) has set up to generate necessary situational awareness of existing and potential cybersecurity threats and enable timely information sharing for proactive, preventive and protective actions by individual entities.
- All the new government websites and applications are audited prior to their hosting and on a regular basis after hosting.
- CERT-In conducts regular training programs for network/system administrators and Chief Information Security Officers (CISOs) of Government and critical sector organizations regarding securing the IT infrastructure and mitigating cyber attacks.
- A Division has been established under the Ministry of Home Affairs to deal with Cyber and Information Security.

Wanna Cry Malware

- Malware is the shortened form of malicious software.
- Malware is an umbrella term used to refer to a variety of forms of hostile or intrusive software including Ransom wares, Computer Viruses, Worms, Trojan Horses, Spyware, Adware, Scareware, etc.
- These malicious programs can perform a variety of functions, including stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission.
- WannaCry (also known as WCry or WanaCryptor) malware is a self-propagating (worm-like) ransomware that spreads through internal networks and over the public internet by exploiting a vulnerability in Microsoft's Server Message Block (SMB) protocol, MS17-010.
- WannaCry is Encrypting Ransomware designed to block access to a computer system until a sum of money is paid.

Common Malware types

- **Adware:** The least dangerous and most lucrative Malware. Adware displays ads on your computer.
- **Spyware:** Spyware is software that spies on you, tracking your internet activities in order to send advertising (Adware) back to your system.
- **Virus:** A virus is a contagious program or code that attaches itself to another piece of software, and then reproduces itself when that software is run. Most often this is spread by sharing software or files between computers.
- **Spam:** Spamming is a method of flooding the Internet with copies of the same message. Most spams are commercial advertisements which are sent as an unwanted email to users. Spams are also known as Electronic junk emails or junk newsgroup postings. These spam emails are very annoying as it keeps coming every day and keeps your mailbox full.
- **Worm:** A program that replicates itself and destroys data and files on the computer. Worms work to "eat" the system operating files and data files until the drive is empty.

- **Trojan:** A Trojan horse or Trojan is a type of malware that is often disguised as legitimate software. Trojans are written with the purpose of discovering your financial information, taking over your computer's system resources, and in larger systems creating a "denial-of-service attack" which is making a machine or network resource unavailable to those attempting to reach it. Example: Google, AOL, Yahoo or your business network becoming unavailable.
- **Backdoors:** Backdoors are much the same as Trojans or worms, except that they open a "backdoor" on a computer, providing a network connection for hackers or other Malware to enter or for viruses or SPAM to be sent.
- **Rootkit:** This one is likened to the burglar hiding in the attic, waiting to take from you while you are not home. It is the hardest of all Malware to detect and therefore to remove; many experts recommend completely wiping your hard drive and reinstalling everything from scratch. It is designed to permit the other information gathering Malware in to get the identity information from your computer without you realizing anything is going on.
- **Keyloggers:** Records everything you type on your PC in order to glean your log-in names, passwords, and other sensitive information, and send it on to the source of the keylogging program. Many times keyloggers are used by corporations and parents to acquire computer usage information.
- **Rogue security software:** This one deceives or misleads users. It pretends to be a good program to remove Malware infections, but all the while it is the Malware. Often it will turn off the real Anti-Virus software.
- **Ransomware:** If you see this screen that warns you that you have been locked out of your computer until you pay for your cybercrimes. Your system is severely infected with a form of Malware called Ransomware. Even if you pay to unlock the system, the system is unlocked, but you are not free of it locking you out again.
- **Browser Hijacker:** When your homepage changes to one that looks like those in the images inserted next, you may have been infected with one form or another of a Browser Hijacker. This dangerous Malware will redirect your normal search activity and give you the results the developers want you to see. Its intention is to make money off your web surfing. Using this homepage and not removing the Malware lets the source developers capture your surfing interests.

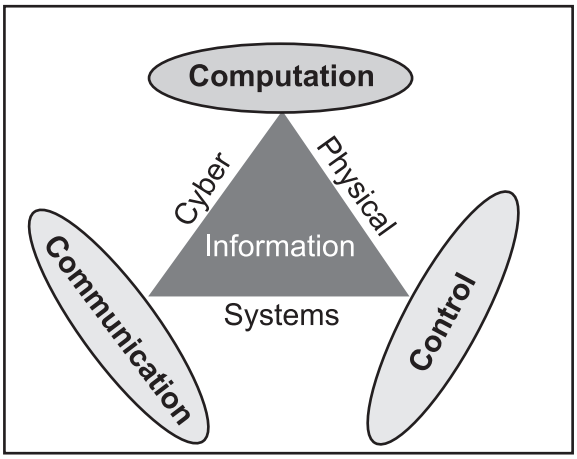
Some Initiatives by Government of India

- The National Cyber Security Policy 2013 outlines a roadmap to create a framework for a comprehensive and collective response to deal with the issue of cybersecurity and hence create a robust and strong cybersecurity framework.
- Computer Emergency Response Team (CERT-In) has been designated to act as a nodal agency for coordination of crisis management efforts in case of cyber threats.
- The government has also tried a collaboration with industry partners and development of Public-Private Partnerships when it comes to cybersecurity.
- The Cyber Swachhta Kendra is a Botnet Cleaning and Malware Analysis Centre, operated by the Indian Computer Emergency Response Team.
- Setting up of National Cyber Security Agency (NCSA) and National Cyber Coordination Centre (NCCC) as a cybersecurity and e-surveillance agency has been a proposal of the government.
- The government launched a dedicated cloud and digital lockers for defence personnel under its Digital Army programme. This would help in the security of the defence products and data.
- NASSCOM has been spreading and creating training programmes to spread awareness of cyber threats and the need for cybersecurity. Cyber Labs have been set up for the same.
- Research & development activities are promoted under Cyber Security R&D.
- Government of India enacted the Information Technology Act, 2000 (IT Act 2000) on 9th June 2000 that provided a legal framework for transactions carried out by means of electronic data interchange. Hence any cyber threat can be dealt with under this law.

- GoI established in 2014 National Critical Information Infrastructure Protection Centre (NCIIPC) to safeguard critical cyber infrastructure.
- The IT Act provides for the Controller of Certifying Authorities (CCA) to license and regulate the working of Certifying Authorities which issue digital signature certificates for electronic authentication of users.
- Cyber Appellate Tribunal has been established under the Information Technology Act under the aegis of Controller of Certifying Authorities

Concept of Cyber–Physical Systems

- Cyber-Physical Systems are the integrations of computation, networking, and physical processes. It has seamless integration of algorithms and physical components.
- In these systems, embedded computers monitor and control the physical processes such as natural and man-made systems governed by laws of physics.
- The CPSs have feedback loops where physical processes affect computations and vice versa.
- CPS is an interdisciplinary field that deals with the deployment of computer-based systems that do things in the physical world. For example, self-driven cars produced by Google and Tesla



Need for such a program:

- CPS is an important technological evolutionary area that needed to be addressed as it has the potential to pose unprecedented challenges and also stresses to India's demographic dividend.
- It can be turned into a huge opportunity by ensuring that India's future workforce is skilled in robotics, artificial intelligence, digital manufacturing, big data analysis, quantum communication, and IoTs.

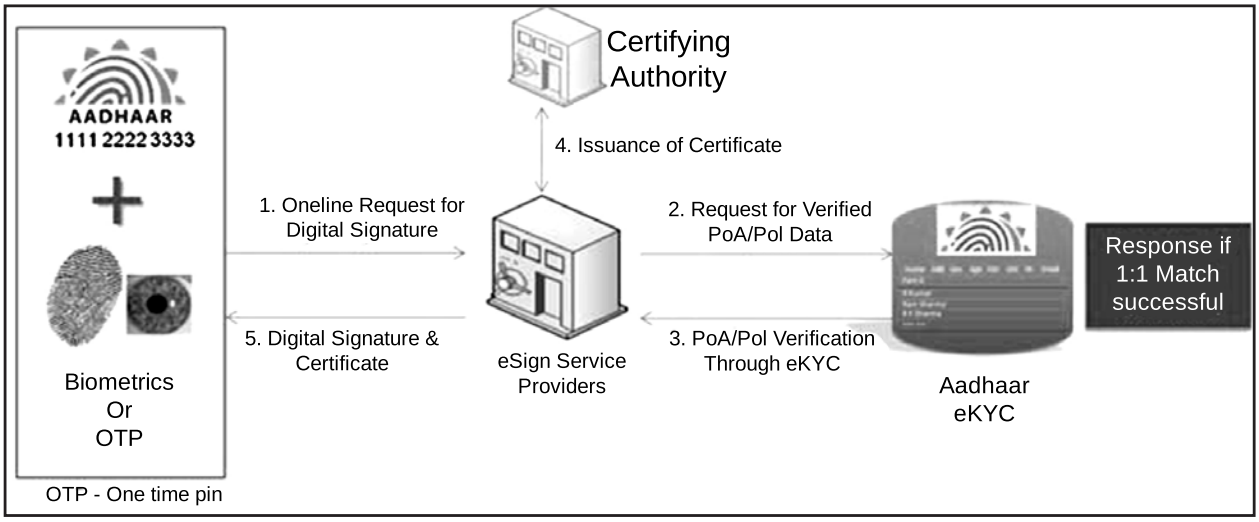
CPS significance:

- **Smart city:** CPS will integrate all physical systems with each other and connected to the network.
- **Agriculture:** Will increase efficiency throughout the value chain, improving environmental footprint and creating employment opportunities.
- **Infrastructure Management:** To provide technology for condition monitoring and predictive maintenance of infrastructure.
- **Internal & External security:** Expedite design and delivery of trustworthy, adaptable and affordable systems in cyberspace and autonomous systems to augment security operations.

- **Disaster Management:** by including CPS technologies for next-generation public safety communications, sensor networks, and response robotics which can increase situational awareness of emergency responders.
- **Energy:** Integration of intermittent and uncertain wind and solar sources and plug-in devices necessitates not only new sensors, switches, and meters but also a smart infrastructure for realizing a smart grid.
- **Healthcare:** Ever growing population combined with opportunities provided by inexpensive sensing, communication and computation and demand for 24/7 care needs CPS.
- **Manufacturing and Industry:** It can enable predictive maintenance models, help in convergence of global industrial system with the power of advanced computing, analytics and new levels of connectivity and new paradigm called the Industrial Internet.
- **Transportation:** Eliminate accidents caused by human error, congestion control, traffic based grid jams including road, air and highway networks.

Esign Electronic Signature Service: Significance & Applications

- eSign Electronic Signature Service is an innovative initiative for allowing easy, efficient, and secure signing of electronic documents by authenticating signer using Aadhaar e-KYC services.
- A digital signature takes the concept of traditional paper-based signing and turns it into an electronic "fingerprint." This "fingerprint," or coded message, is unique to both the document and the signer and binds them together.
- With this service, any eSign Online Electronic Signature Service user can digitally sign an electronic document without having to obtain a physical digital signature dongle.
- Application Service Providers (ASP) can integrate this service within their application to offer eSign Online Electronic Signature Service user a way to sign electronic forms and documents.



Benefits

- Easy and secure way to digitally sign information anywhere, anytime - eSign is an online service without using physical dongles that offers application service providers the functionality to authenticate signers and perform the digital signing of documents using Aadhaar e-KYC service.

- Facilitates legally valid signatures - eSign process involves consumer consent, Digital Signature Certificate generation, Digital Signature creation and affixing and Digital Signature Certificate acceptance in accordance with provisions of Information Technology Act
- Flexible and easy to implement - eSign provides configurable authentication options in line with Aadhaar e-KYC service and also record Aadhaar id to verify the identities of signers. The signature option includes biometric or OTP authentication (optionally with PIN) through a registered mobile in the Aadhaar database. eSign enables millions of Aadhaar holders an easy way to access legally valid Digital Signature service.
- Respecting privacy - eSign ensure the privacy of the consumer by submitting only the thumbprint (hash) of the document for signature function instead of the whole document.
- Secure online service - The eSign Service is governed by e-authentication guidelines. While authentication of the signer is carried out using Aadhaar e-KYC, the signature on the document is carried out on a backend server, which is the e-Sign provider. eSign services are offered by the trusted third party service provider, currently Certifying Authority. To enhance the security and prevent misuse, certificate holder private keys are created on Hardware Security Module (HSM) and destroyed immediately after one-time usage.

Difference between traditional digital Signatures eco-system and new eSign online Electronic Signature Service

- In the traditional Digital Signature system, an individual is responsible for applying for a Digital Signature Certificate to CA, key pair generation and safe custody of keys.
- The Certifying Authorities issue Digital Signature Certificate to individuals after verification of credentials submitted in the application form. Such Digital Signature Certificates are valid for 2-3 years.
- An individual can affix a digital signature any time during the validity of the Digital Signature Certificate.
- The certificates are revoked in case of loss or compromise of keys. The verification of the individual's signature requires the verification of whether the DSC is issued under India PKI and also ascertaining the revocation status of the DSC.
- Key pairs are stored in Crypto Tokens which comply with standards mentioned in the Information Technology Act & Rules to prevent the duplication of keys. It is an individual's obligation for the safe custody of Crypto Tokens. The signatures are created using the keys certified by CA.
- In the new eSign online Electronic Signature Service, on successful authentication of individual using Aadhaar e-KYC services, the key pairs generation, the certification of the public key based on authenticated response received from Aadhaar e-KYC services, and digital signature of the electronic document are facilitated by the eSign online Electronic Signature Service provider instantaneously within a single online service.
- The key pairs are used only once and the private key is deleted after one-time use.

Blockchain technology

- Blockchain is a Distributed Ledger technology, where data and transactions are stored in blocks linked to the Blockchain that are secured against tampering using Cryptographic Hash Algorithms thus enabling a layer of trust and eliminating the need for a third party to validate the transactions.
- Mainly used to manage Bitcoin and other cryptocurrencies it is growing due to its characteristics like tamper-evidence, consensus based transaction validation, secured data storage etc.

Application of block chain

- **Payment processing and money transfers:** Transactions processed over a blockchain could be settled within a matter of seconds and reduce (or eliminate) banking transfer fees.
- **Monitoring of supply chains:** Using blockchain, businesses could pinpoint inefficiencies within their supply chains quickly, as well as locate items in real time and see how products perform from a quality-control perspective as they travel from manufacturers to retailers.
- **Digital Ids:** Microsoft is experimenting with blockchain technology to help people control their digital identities, while also giving users control over who accesses that data.
- **Data sharing:** Blockchain could act as an intermediary to securely store and move enterprise data among industries.
- **Copyright and royalties protection:** Blockchain could be used to create a decentralized database that ensures artists maintain their music rights and provides transparent and real-time royalty distributions to musicians. Blockchain could also do the same for open source developers.
- **Internet of Things network management:** Blockchain could become a regulator of IoT networks to "identify devices connected to a wireless network, monitor the activity of those devices, and determine how trustworthy those devices are" and to "automatically assess the trustworthiness of new devices being added to the network, such as cars and smartphones."
- **Healthcare:** Blockchain could also play an important role in healthcare: "Healthcare payers and providers are using blockchain to manage clinical trials data and electronic medical records while maintaining regulatory compliance."

Negative aspect

- **Mature:** Blockchain technologies aren't mature yet. They are developing and evolving every day. A lot of products that are being developed as a POC on a Blockchain aren't even Blockchain secure.
- **Lack of technical understanding:** There is not much understanding of the Blockchain technologies and the advantages they provide over existing technologies.
- **Limited Scalability:** Blockchains like Bitcoin, Ethereum have consensus mechanisms which require every participating node to verify the transaction. This limits the total number of transactions a blockchain network can process.
- **Privacy:** In the case of public Blockchains, transactions on blockchains might appear private since it is not directly tied to your identity.
- **Access to external data:** Blockchain services cannot inherently make arbitrary network requests to access data outside the network.
- **Unavoidable security flaws:** There is one notable security flaw in Bitcoin and other Blockchains, if more than half of the computers working as nodes to service the network tell a lie, the lie will become the truth.

Business benefits of blockchain

- The primary benefit of blockchain is as a database for recording transactions, but its benefits extend far beyond those of a traditional database. Most notably, it removes the possibility of tampering by a malicious actor, as well as providing these business benefits:
  - **Time savings:** Blockchain slashes transaction times from days to minutes. Transaction settlement is faster because it doesn't require verification by a central authority.
  - **Cost savings:** Transactions need less oversight. Participants can exchange items of value directly. Blockchain eliminates duplication of effort because participants have access to a shared ledger.
  - **Tighter security:** Blockchain's security features protect against tampering, fraud, and cybercrime.

Effort by India

- India has a National strategy on blockchain which aims to evolve a vigilant and trusted collaborative digital ecosystem to provide a consensus based, tamper-evident, transparent and open framework for offering eGovernance services to citizens and businesses involving multiple organizations in a participating environment assuring trust, security, track and trace, integrity and regulatory compliance.

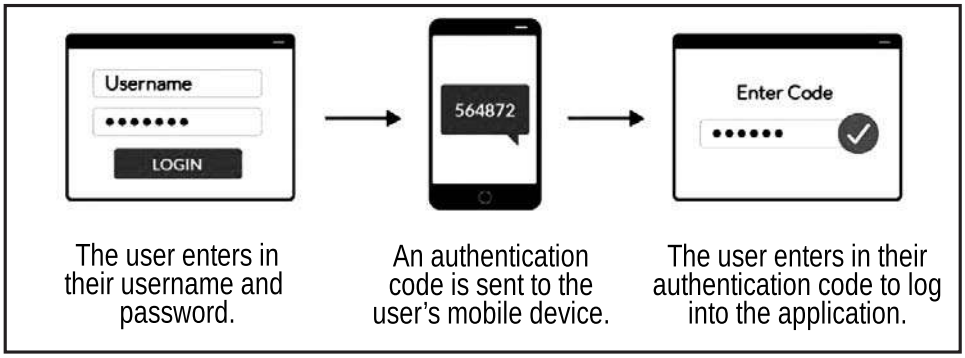
- **The National strategy on blockchain states–**
  - Creation of a trusted digital platform by evolving a national Blockchain infrastructure that can be used for development and deployment of applications.
  - Encouraging development of standards in the area of Blockchain technology.
  - Strengthening India's collaboration with global organizations and innovation and research centers working in the area of Blockchain technologies.
  - Contribution towards creation of Intellectual Property Rights (IPR).
  - Focus on capacity building and skill development to ramp-up technology insight and encourage innovation across various stakeholders including students, practitioners, management executives, policy and decision makers, etc
  - To enable global access to the developed technology as necessary and contribute towards development of cross-border solutions.

Two Authentication Procedure

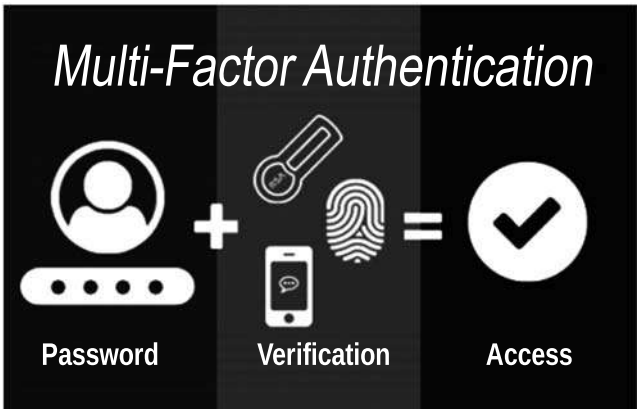
- Two-factor authentication (2FA), sometimes referred to as two-step verification or dual factor authentication, is a security process in which the user provides two different authentication factors to verify themselves to better protect both the user's credentials and the resources the user can access.
- Two-factor authentication adds an additional layer of security to the authentication process by making it harder for attackers to gain access to a person's devices or online accounts as compare to single-factor authentication (SFA), in which the user provides only one factor -- typically a password or passcode.
- Web portals and cloud/mobile applications are the biggest targets for cyber attacks and hence two-factor authentication would be better able to contribute towards the organisation's ability to comply with data protection regulations and pass security audits.
- There are several different ways in which someone can be authenticated using more than one authentication method.
- A **knowledge factor** is something the user knows, such as a password, a PIN or some other type of shared secret.
- A **possession factor** is something the user has, such as an ID card, a security token, a smartphone or other mobile device.
- An **inherence factor**, more commonly called a biometric factor, is something inherent in the user's physical self. Eg-fingerprint
- A **location factor**, usually denoted by the location from which an authentication attempt is being made
- A **time factor** restricts user authentication to a specific time window in which logging on is permitted and restricting access to the system outside of that window.
  - Biometric and one-time password-based authentication is the preferred mode for Two-factor authentication

- Multi-factor authentication (MFA) is an authentication method in which a computer user is granted access only after successfully presenting two or more pieces of evidence (or factors) to an authentication mechanism: knowledge (something the user and only the user knows), possession (something the user and only the user has), and inherence (something the user and only the user is).
- Two-factor authentication (2FA) is a type, or subset, of multi-factor authentication.

- **2FA-**

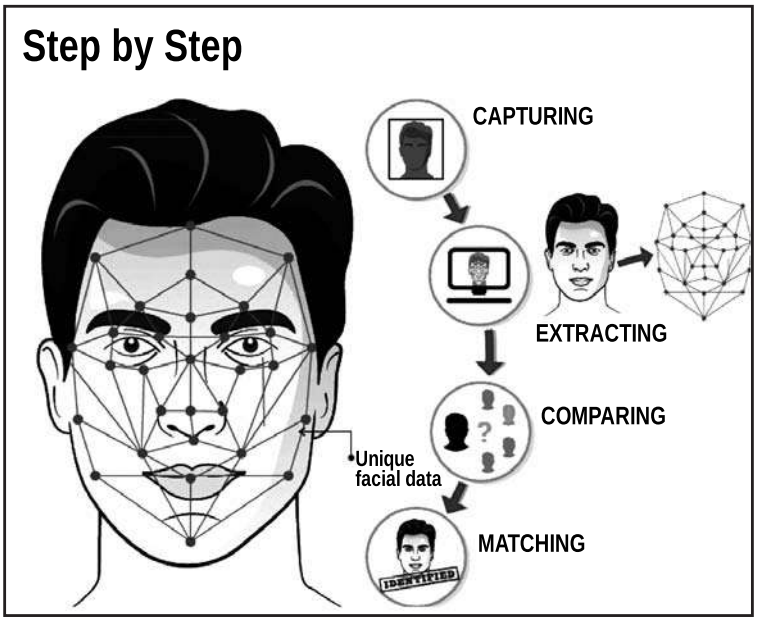


- **MFA-**



Facial Authentication Working

- Facial Recognition Technology (FRT) is a biometric technology for identifying a person by analyzing the characteristics of a person's face images taken with a digital camera.
- **Working:** The mathematical algorithms of FRT follow the following stages of image processing:
  - **Capture:** The first step is to capture the image by using cameras or by scanning existing images.
  - **Extraction:** Unique facial data is then extracted from the sample.
  - **Comparison:** The data is then compared with the database.
  - **Matching:** The software then decides whether the sample matches any picture in the database or not.
  - The Unique Identification Authority of India has allowed Face Authentication for validating Aadhaar cards.
  - This move comes on the back of reports that beneficiaries of government schemes were not able to avail themselves of their entitlements in the absence of Aadhaar authentication.



- The new method will be used in combination with already existing ways such as fingerprint or iris scan.
- Aadhaar authentication is also being used as the primary identity verification mechanism by many systems such as Banks, Telecom companies, PDS, Income Tax, etc and also by a number of private entities.
- Benefit- This facility will help in inclusive authentication of those who are not able to biometrically authenticate their Aadhaar numbers because their fingerprints are worn out owing to old age or hard working conditions

Advantages of FRT–

- **Greater Accuracy:** 3D mapping, deep learning, and other advances make FRT more reliable and harder to trick.
- **Better Security:** Research shows a 1-in-50,000 chance of a phone with touch ID being unlocked with the wrong fingerprint. With 3D facial modeling, the probability drops to nearly 1-in-1,000,000.
- **Convenient and Frictionless:** FRT is easy. It can be used passively without a user's knowledge; or actively, such as having a person "smile for the camera."
- **Smarter Integration:** Face recognition tools are generally easy to integrate with existing security infrastructures, saving time and cost on software redevelopment.
- **Automation:** Automated and accurate 24/7 security eliminates the need for security guards to visually monitor entry points, perform security checks and view security cameras.

Issue of Internet Governance

- Internet Governance can be defined as the evolving policies and mechanisms under which the Internet community's many stakeholders make decisions about the development and use of the Internet.
- **It encompasses:**
  - Technical aspects such as control over DNS servers etc
  - Civil aspects such as privacy, freedom of expression, etc
  - Political aspects such as maintenance of sovereignty

- Security aspects such as data security, cyber security, etc

Background

- No one person, company, organization or government runs the Internet.
- It is a globally distributed network comprising many voluntarily interconnected autonomous networks.
- It operates without a central governing body with each constituent network setting and enforcing its own policies.
- However, to help ensure interoperability and the principal namespaces are administered by the Internet Corporation for Assigned Names and Numbers (ICANN)
- ICANN oversees the assignment of globally unique identifiers on the Internet, including domain names, Internet protocol addresses, and many other parameters.
- ICANN is governed by an international board of directors drawn from across the Internet's technical, business, academic, and other non-commercial communities.

ICANN– Internet Corporation for Assigned Names and Numbers

- It is a non-profit body founded in 1998 that administrates domain names and Internet protocol addresses (IPs) globally.
- ICANN has been assigned the task to manage the Internet by the US Commerce Department's National.
- ICANN is guided by an international board of directors, which is elected by members of the ICANN community and holds final decision-making authority. The board is advised by a committee composed of representatives from more than 110 national governments.
- However, ICANN's architecture renders it answerable only to U.S. law and courts.
- The main issue that non-U.S. actors have with the U.S. control over ICANN is that it can unilaterally interfere with the ICANN's policy process and the Internet's root server

Problem with ICANN's role currently:

- It is transnational but not global in its current avatar
- It is dominated by nonstate actors which are hugely problematic for countries like China, Russia, etc which are trying to maintain state control over the internet
- It is one of the few centralized points of control over the internet
- It is overseen by the US

Why internet governance is important?

- Despite being an American invention, the Internet has now become a global architecture that forms an integral part of the daily functioning world over. The need of the hour is a globalized diverse peaceful cybernetic architecture built on transnational collaboration. The internet of today needs to be a diverse space inclusive of race gender, ethnicity, and class.
- Given the changing demographics of internet usage and the proliferation of technology, it is essential to reconfigure the internet into a more inclusive mould reflective of the globalized world order we inhabit today. Creating an accessible Cybernetic discourse is the first step towards building a secure and smooth functioning Internet architecture.
- There is still hope since the ICANN "is largely independent of national governments." The board is elected by outside organizations composed of businesses, non-profits, and Internet users from around the world. And those organizations can recall individual board members or the entire board. While the ICANN has addressed some of these claims and issues, the path ahead remains convoluted.

Internet Governance Forum

- The Internet Governance Forum is an international group of governments and nongovernmental entities created in 2006 at the World Summit on the Information Society.
- The Internet Governance Forum (IGF) is a multi-stakeholder forum for policy dialogue on issues of Internet governance
- It brings together all stakeholders in the Internet governance debate, whether they represent governments, the private sector or civil society, including the technical and academic community, on an equal basis and through an open and inclusive process.
- Control of the Internet is in a few hands. The challenge for developing countries, therefore, is to propose the framework and agenda of alternative multilateral Internet governance institutions that would be fair towards them and are run democratically.

Quantum Computing

- Quantum computing takes advantage of the strange ability of subatomic particles to exist in more than one state at any time. Due to the way the tiniest of particles behave, operations can be done much more quickly and use less energy than classical computers.
- In classical computing, a bit is a single piece of information that can exist in two states – 1 or 0.
- Quantum computing uses quantum bits, or 'qubits' instead. These are quantum systems with two states. However, unlike a usual bit, they can store much more information than just 1 or 0, because they can exist in any superposition of these values. They function according to two key principles of quantum physics: superposition and entanglement.

Superposition and entanglement

- Superposition means that each qubit can represent both a 1 and a 0 at the same time.
- Entanglement means that qubits in a superposition can be correlated with each other; that is, the state of one (whether it is a 1 or a 0) can depend on the state of another.
- Using these two principles, qubits can act as more sophisticated switches, enabling quantum computers to function in ways that allow them to solve difficult problems that are intractable using today's computers.

Uses of Quantum Computing

- **Research in medicine and organic materials –** It would help researchers to test the new materials in a much faster way as compared to classical computers. It has been found that quantum computers would require 3.5 million fewer steps as compared to a traditional machine.
- **Supply chain and logistics –** It will find better solutions by finding ultra-efficient logistics and efficient delivery mechanism.
- **Financial Services –** It would also help to find better models to process financial data and reduce the global risk factor in investment worldwide.
- **Artificial Intelligence –** It will revolutionize AI by creating faster processing of complicated data such as images or videos.
- **Faster Communication –** It would help to decode complicated security keys in a very simple manner.

Challenges

- Quantum computing holds the potential to decode and crack the world's encrypted data by breaching the security measures easily and very quickly. It will pose a threat to data as well as the internal

security of the nation. At present, the researchers have also pointed out to the hardware difficulties in developing a system as qubits such as those made from silicon atoms only work at a very low temperature, near zero degrees Kelvin.

- **Steps were taken for quantum computing in India–**
  - The DST's Mission-Mode scheme, called "Quantum Science and Technology (QuST)", will fund research for the development and demonstration of quantum computers, quantum communication, and cryptography, besides demonstration of quantum teleportation.
  - ISRO, in collaboration with Raman Research Institute, has initiated a mega project called "Quantum Experiments Using Satellite Technology (QUEST)".

Way Forward

- Developing quantum computational capacity should be India's "top national priority" as acquiring such technologies from outside the country will be too difficult and expensive. The use of quantum computing can lead to many fundamental scientific breakthroughs and new technologies with wide-ranging societal and commercial applications such as data encryption, new drug discovery, and weather prediction.

National Supercomputing Mission

- The Mission, launched in 2015, envisages empowering our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than 70 high-performance computing facilities.
- These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network (NKN).
- The Mission would be implemented jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) for over a period of seven years, through the C-DAC and Indian Institute of Science (IISc), Bengaluru
- Under NSM, the long-term plan is to build a strong base of 20,000 skilled persons. PARAM Shavak is one such machine that has been deployed to provide training.

Objective

- To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance.
- To empower our scientists and researchers with state-of-the-art supercomputing facilities and enable them to carry out cutting-edge research in their respective domains.
- The Mission also includes the development of High-Performance Computing (HPC) aware human resource for meeting challenges of development of these applications.
- To minimize redundancies and duplication of efforts, and optimize investments in supercomputing.
- To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology.

Why in News?

- India recently awarded French technology firm Atos the contract to build a network of 70 supercomputers across India under the National Supercomputing Mission.

- The first supercomputer designed and built under National Supercomputing Mission (NSM) by C-DAC at Indian Institute of Technology (BHU), Varanasi is named "Param Shivay". It uses more than one lakh twenty thousand compute cores (CPU + GPU cores) to offer a peak computing power of 833 TeraFlops.
- The Indian Institute of Technology, Kharagpur is the first academic institution to get a supercomputing facility under the National Supercomputing Mission (NSM). Others will be set up in IIT BHU and IIITM Pune. While IIT BHU will get a one Petaflop supercomputer, the other two institutes will have 650 Teraflops each.
- This will provide large computational support to users to carry out both research and teaching activities that involve state-of-the-art High-Performance Computing (HPC) at an estimated cost of Rs. 4500 crore over a period of seven years.

Application Areas

- Climate Modelling.
- Weather Prediction.
- Aerospace Engineering including CFD, CSM, CEM.
- Computational Biology.
- Molecular Dynamics.
- Atomic Energy Simulations.
- National Security/Defence Applications.
- Seismic Analysis.
- Disaster Simulations and Management.
- Computational Chemistry.
- Computational Material Science and Nanomaterials.
- Discoveries beyond Earth (Astrophysics).
- Large Complex Systems Simulations and Cyber-Physical Systems.
- Big Data Analytics.
- Finance.
- Information repositories/Government Information Systems.

Benefits

- This mission will bring India, a step closer, to be in the select league of few top nations (USA, China, Japan, etc.), having a large supercomputing power and improve its presence in the world of supercomputers.
- It supports the government's vision of **'Digital India'** and 'Make in India' initiatives.
- India's large Scientific & Technology community will have access to SUPERCOMPUTING POWER necessary for developing applications in **Artificial Intelligence, Big Data, Cybersecurity, etc**.
- These machines will be part of the National Supercomputing grid over the **National Knowledge Network (NKN),** which will have wide-scale applications in the fields of climate modeling, weather prediction, aerospace engineering, computational biology, molecular dynamics, atomic energy simulations, national security, and defence applications.
- NSM will improve the R&D ecosystem of Science & Technology within the country by satisfying the infrastructure need of the R&D sector. It will increase foreign investment (FDI) in India in the R&D (services) sector by attracting foreign research companies to invest in India, especially in the Pharmaceutical sector.

- Under NSM, the long-term plan is to build a strong base of 20,000 skilled persons who will be equipped to handle the complexities of supercomputers. They will be trained over the next five years and will become one of the largest ever dedicated human resource bases equipped to use these mighty computers.

Challenges

- **Multiple Agencies Involved:** There had been a number of delays over the past three years, largely because the project still doesn't have one dedicated person heading it. The NSM is to be jointly implemented by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) at an estimated cost of Rs 4,500 crore over a period of seven years. (2015-2022).
- **Funding:** Despite launching its supercomputer program in the late 1980s, public awareness and interest have remained lukewarm, resulting in little funding in Research and development.
- **Import Dependent:** India's stronghold is in the field of software development, it has to depend on imports to procure the hardware components required for building supercomputers, and this is a drain on the resources.

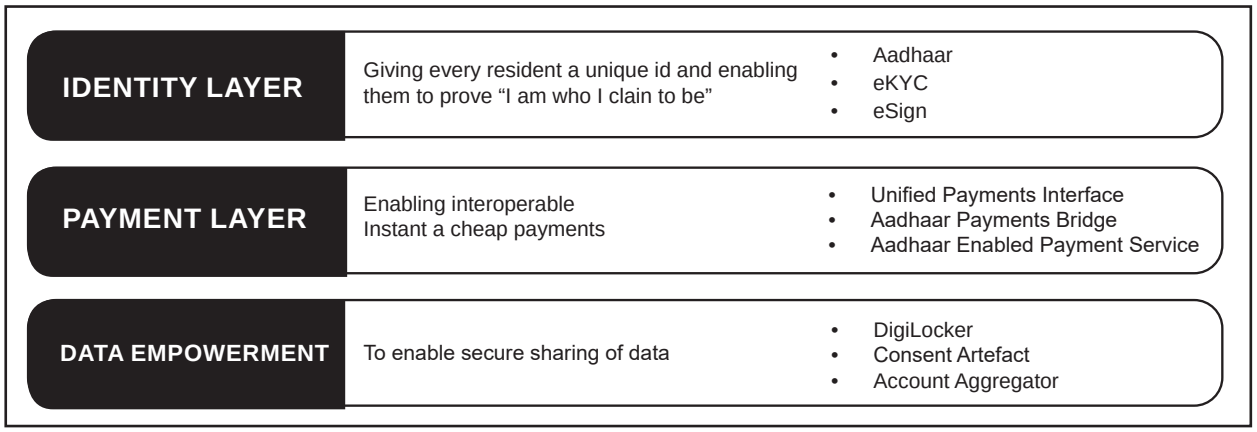
Data Empowerment & Protection Architecture

- NITI Aayog has presented a draft policy that allows individuals to "seamlessly and securely access their data and share it with third party institutions."\
- The new draft policy, titled 'Data Empowerment And Protection Architecture' (DEPA) argues "India needs a paradigm shift in personal data management".
- It proposes a consent framework that would allow individuals and small businesses to "access, control and share personal data" with third party institutions.
- The reports seeks to enable organisations to share the personal data of an individual with one another through the concept of "consent managers" - that will manage people's consent for data sharing.
- This policy, published by NITI Aayog and set to launch in 2020.
- It involves four regulators across banking, securities, insurance, and pensions - RBI, SEBI, IRDAI, PFRDA - and the Ministry of Finance coming together to implement this model.
- DEPA is founded on the premise that individuals themselves are the best judges of the 'right' uses of their personal data, rather than competing institutional interests."
- DEPA seeks to move away from an organisation-centric system of personal data sharing to an individual-centric approach where a person provides consent to, say a bank to share her data with a credit company or a tax/GST platform to share data with a wealth management company.

Layers of authentication

- DEPA "as a layer of secure digital data sharing through consent" forms the final layer of India Stack
- The other key layers of India Stack include the 'identity layer' (Aadhaar, launched 2010), and a 'payments layer' for digital payments (the Unified Payments Interface, launched 2016).
- DEPA will form a part of the 'data empowerment' layer "to enable secure sharing of data" as the NITI Aayog describes it.
- DEPA identifies three building blocks in order to facilitate this new model of data sharing:
  - Enabling regulations

- cutting edge technology standards
- new types of public and private organisations



What Are the Primary Concerns?

- A number of concerns arise from a privacy, transparency and accountability perspective.
- First, DEPA is yet another data policy that comes in the absence of a law to protect the personal data of citizens.
- Second, a recurring issue with the development of data-related policies is regarding the transparency and accountability of private players who are intrinsic to the preparation of policies and digital infrastructure.
- Third, while the draft policy has been presented for comments from the public till 1 October, another recurring issue has been the lack of consultations with all the relevant stakeholders prior to the development of such policies.
- Fourth, While DEPA seeks to empower individuals with control over her personal data, there was no prior involvement of the public in shaping this policy.

Data Protection–B N Srikrishna Committee

- **Why do we need data protection law?**
  - India does not have any dedicated legal framework for data protection. Presently some acts cover the data protection in general.
  - Sec 43 A of Information technology act 2000 protects user data from misuse but it is applicable to only corporate entities and not on a government agency. Also, the rules are restricted to sensitive personal data only — medical history, biometric information among other things.
  - Other acts like consumer protection Act 2015, copyrights act 1957 among others also attempt to
  - protect personal information
  - Efficient management of data in the age of Big Data
  - Right to privacy is now a fundamental right. The right to privacy encompasses the right to have data protected.
  - Unauthorized leaks, hacking, cyber-crimes, and frauds. The economic cost of data loss/theft is high
  - Improve business process, and secure digital payments

Key Recommendations of the committee

- **Fiduciary relationship:** The relationship between the individual and the service provider must be viewed as a fiduciary relationship.
- **Definition of personal data:** Personal data is information that relates to an identified or identifiable individual. The committee has categorized into data into two – Personal data and sensitive personal data Sensitive personal data will include passwords, financial data, health data, official identifier, sex life, sexual orientation, biometric and genetic data, and data that reveals transgender status, intersex status, caste, tribe, religious or political beliefs or affiliations of an individual
- Consent-based data processing except in certain cases like public welfare, law, and order, emergency situations where the individual is incapable of providing consent, employment, and Reasonable purpose.
- **Ownership of personal data:** Through rights such as the right to access, confirm & correct data, right to object data processing and right to be forgotten
- **Regulatory authority:** a Data Protection Authority which will be an independent regulatory body responsible for the enforcement and effective implementation of the law.
- **Amendments to other laws:** Committee has identified at least 50 laws such as Aadhar act, RTI act, IT act which have a "potential overlap" with the data protection framework. The proposed framework, therefore, suggests amendments in these laws
- A data protection fund and a data protection awareness fund to be set up through proceeds from penalties and fines.
- The Central Government shall establish an appellate tribunal or grant powers to an existing appellate tribunal to hear and dispose of any appeal against an order of the DPA.

Issues/challenges

- Amendment in existing 50 laws/ regulation would be a tough task for Government
- Amendment in RTI and Aadhar act may dilute the existing laws
- Critics say the inclusion of a provision of bill treating violations as criminal offenses along with fine and compensation is excessive and would impact the enforcement mechanism greatly.
- The storage of one copy of personal data in India will impose an additional cost to companies
- Under the bill, all financial data has been classified as sensitive personal data which may be detrimental to Financial institutions
- Restriction on cross border flow of data may prove detrimental in the era of the digital global economy

Way Ahead

- It is important to strike the right balance between the digital economy and privacy protection
- The government must incorporate suggestions from various stakeholder over the draft bill before finalizing the bill
- The privacy should not be used to undermine government transparency. Data protection law should be framed such that it does not make government opaque and unaccountable

The Personal Data Protection Bill, 2019

- The Personal Data Protection Bill, 2019 was introduced in Lok Sabha by the Minister of Electronics and Information Technology, Mr. Ravi Shankar Prasad, on December 11, 2019. The Bill seeks to provide for protection of personal data of individuals, and establishes a Data Protection Authority

for the same.

- **Applicability:** The Bill governs the processing of personal data by: (i) government, (ii) companies incorporated in India, and (iii) foreign companies dealing with personal data of individuals in India. Personal data is data which pertains to characteristics, traits or attributes of identity, which can be used to identify an individual. The Bill categorises certain personal data as sensitive personal data. This includes financial data, biometric data, caste, religious or political beliefs, or any other category of data specified by the government, in consultation with the Authority and the concerned sectoral regulator.
- **Obligations of data fiduciary:** A data fiduciary is an entity or individual who decides the means and purpose of processing personal data. Such processing will be subject to certain purpose, collection and storage limitations. For instance, personal data can be processed only for specific, clear and lawful purpose. Additionally, all data fiduciaries must undertake certain transparency and accountability measures such as: (i) implementing security safeguards (such as data encryption and preventing misuse of data), and (ii) instituting grievance redressal mechanisms to address complaints of individuals. They must also institute mechanisms for age verification and parental consent when processing sensitive personal data of children.
- **Rights of the individual:** The Bill sets out certain rights of the individual (or data principal). These include the right to: (i) obtain confirmation from the fiduciary on whether their personal data has been processed, (ii) seek correction of inaccurate, incomplete, or out-of-date personal data, (iii) have personal data transferred to any other data fiduciary in certain circumstances, and (iv) restrict continuing disclosure of their personal data by a fiduciary, if it is no longer necessary or consent is withdrawn.
- **Grounds for processing personal data:** The Bill allows processing of data by fiduciaries only if consent is provided by the individual. However, in certain circumstances, personal data can be processed without consent. These include: (i) if required by the State for providing benefits to the individual, (ii) legal proceedings, (iii) to respond to a medical emergency.
- **Social media intermediaries:** The Bill defines these to include intermediaries which enable online interaction between users and allow for sharing of information. All such intermediaries which have users above a notified threshold, and whose actions can impact electoral democracy or public order, have certain obligations, which include providing a voluntary user verification mechanism for users in India.

Data Localisation and Related Issues

Data localization is **the act of storing data on any device that is physically present within the borders of a specific country where the data was generated.**

Why data localization is necessary for India?

- **For securing citizen's** data, data privacy, data sovereignty, national security, and economic development of the country.
- **Recommendations by the RBI, the committee of experts led by Justice BN Srikrishna,** the draft e-commerce policy and the draft report of the cloud policy panel show signs of data localization.
- The extensive data collection by technology companies has allowed them to process and monetize Indian users' data outside the country. Therefore, **to curtail the perils of unregulated and arbitrary use of personal data, data localization is necessary.**
- Digital technologies like machine learning (ML), artificial intelligence (AI) and Internet of Things (IoT) **can generate tremendous value out of various data.** It can turn disastrous if not contained within certain boundaries.

- With the advent of cloud computing, Indian users' data is outside the country's boundaries, **leading to a conflict of jurisdiction in case of any dispute.**
- Data localization is an opportunity for Indian technology companies **to evolve an outlook from services to products**. International companies will also be looking at the Indian market, and this will benefit the growth of the local ecosystem.
- More data centers in India could mean new, power-hungry customers for India's renewable energy market. That means **Data localization could boost India's renewable energy.**

Advantages of Data Localisation

- Secures citizen's data and provides data privacy and data sovereignty from foreign surveillance. Example - Facebook shared user data with Cambridge Analytica to influence voting.
- Unfettered supervisory access to data will help Indian law enforcement ensure better monitoring.
- Ensures National Security by providing ease of investigation to Indian Law Enforcement agencies as they currently need to rely on Mutual Legal Assistance Treaties (MLATs) to obtain access to data.
- It will give local governments and regulators the jurisdiction to call for the data when required.
- Data center industries are expected to benefit due to the data localization which will further create employment in India.
- Greater accountability from firms like Google, Facebook, etc. about the end use of data.
- Minimizes conflict of jurisdiction due to cross border data sharing and delay in justice delivery in case of a data breach.

Arguments for Data Localisation

- Data localization will help Indian law enforcement agencies access data.
- Recently lynching across the country was linked to WhatsApp rumors and in this context, localization of data assumes significance.
- It gives security against foreign attacks and surveillance.
- Domestic companies support data localization citing examples of China and Russia.
- Data is the new oil, data is strategic and foreign entities could cripple India in event of war or sanctions.
- India's data localization push can give rise to a new business opportunity.
- India is an ideal location for lower cost of operations and availability of quality talent.
- National wealth creation relies on in-house data storage.
- It champions domestic innovation.

Arguments against Data Localisation

- It will create a domino effect of protectionist policy and other countries may also follow it. This leads to fragmentation of the internet.
- US-India Business Council is also against Data localization.
- It may affect India's young start-ups that are attempting global growth.
- It may affect big firms like TCS and Wipro because they are processing foreign data in India.
- Even if the data is stored in the country, encryption keys may remain out of reach of national agencies.
- It can act as "barriers" to the expansion of services in India, impacting not only consumers but also the growth of the Indian payments market.
- Infrastructure in India for efficient data collection and management is lacking

Recommendations for Data Localisation

- Reserve Bank of India (RBI) has firmly stated that all financial transactions' data must be locally stored.
- Data protection draft law by Justice B N Srikrishna recommended that all personal data of Indians should have at least one copy in India. Critical personal data must be stored and processed only in India.
- Draft of the e-commerce policy indicates localization for community data generated by users in India through various e-commerce platforms, social media and search engines.
- Draft report on cloud computing recommended localization of data.

International Practice

- Many countries have implemented or are in the process of implementing data localization laws, including — China, United States, Brazil, Indonesia, and Russia.
- Russia has the most restrictive regulation for data flows with strict localization.
- Europe's new data protection regime puts limits on cross-border data flows to countries that don't have data protection laws.
- China mandates localization for all important data held by critical information infrastructure and any cross-border personal data transfer must undergo a security assessment.
- US President Donal Trump signed the Clarifying Lawful Overseas Use of Data Act (CLOUD Act), which established data sharing with certain countries.
- European Centre for International Political Economy found a surge in data localization measures worldwide over the last decade.

Way Forward

- There is an urgent need to have an integrated, long-term strategy for policy creation for data localization. Devising an optimal regulatory and legislative framework for data processors and data centers operating in the country in the need of the hour. Also, Adequate attention needs to be given to the interests of India's Information Technology Enabled Services (ITeS) and Business Process Outsourcing (BPO) industries, which are thriving on cross border data flow.

National Digital Literacy Mission and Digital NE vision

- Digital Literacy is the ability of individuals and communities to understand and use digital technologies for meaningful actions within life situations.
- The Digital Saksharta Abhiyan (DISHA) or National Digital Literacy Mission (NDLM) Scheme has been formulated to impart IT training to 52.5 lakh persons, including Anganwadi and ASHA workers and authorized ration dealers in all the States/UTs across the country
- National Digital Literacy Mission (NDLM) was launched to realize the vision of 'Digital
- India', which aims for transforming India into a digitally empowered society and economy.
- Under the mission, beneficiaries undergo a 20-hour training programme in using computers and other digital devices, browsing the Internet and sending and receiving emails.
- The original deadline for the NDLM was 18 months but it was extended to 27 months before it was scrapped in June 2016. While the programme was still running, the government introduced the Digital

Saksharta Abhiyan, or DISHA, in January 2015.

- In 2017, the government launched the Pradhan Mantri Gramin Digital Saksharta Abhiyan by improving upon previous two schemes.

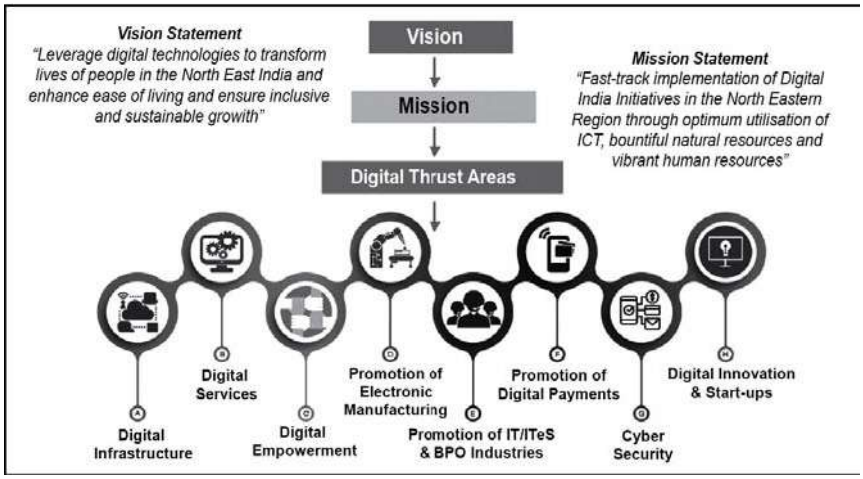
Pradhan Mantri Gramin Digital Saksharta Abhiyan' (PMGDISHA)

- It was launched in 2017 to make 6 crore rural households digitally literate by March 2019.
- It is expected to be one of the largest Digital Literacy Programmes in the world.
- Under the scheme, 25 lakh candidates will be trained in the FY 2016-17; 275 lakh in the FY 2017-18; and 300 lakh in the FY 2018-19.
- To ensure equitable geographical reach, each of the 250,000 Gram Panchayats would be expected to register an average of 200-300 candidates.

Digital North East Vision 2022

- The government has released 'Digital Northeast Vision 2022' in which it is spending around Rs. 10,000 crores in the next four years.
- Under this vision, the government is expected to roll out 400 programmes in the next four years; 8,621 unconnected villages in the region to get special attention.
- The idea is to leverage digital technologies to transform the lives of the people of the north-eastern region and ensure inclusive and sustainable growth.
- This is the first time that the central government has conducted an in-depth analysis of the strength and weaknesses of the various states in the north-eastern region before finalizing a comprehensive investment programme as part of the 'Digital North-East Vision 2022.
- The motto of the government is "reform, perform and transform" and it is working to bridge the gap between "digital haves and have-nots" and improve digital inclusion.

Objectives:



- Emphasizes on leveraging digital technologies to transform the lives of people of the North East
- Enhance the ease of living
- Empower the people of the North Eastern region
- State-wise roadmaps for implementing digital initiatives have been developed

- **Eight digital thrust areas**
  - Digital infrastructure
  - Digital services
  - Digital empowerment
  - Promotion of electronics manufacturing
  - Promotion of IT and ITes including BPOs
  - Digital payments
  - Innovation & start-ups
  - Cybersecurity

State-wise roadmaps for implementing digital initiatives in the NE States

- Foundation stone was laid for four NIELIT (National Institute of Electronics & Information Technology) permanent centers in Guwahati, Shillong, Lunglei, and Gangtok.
- Simultaneously, a foundation was laid for the Common Facilitation Centre and Smart Meter Manufacturing facility in Electronics Manufacturing Cluster (EMC) in Tech City, Bongara Village in Assam for promotion of electronics manufacturing in the North East.
- NIC (National Informatics Centre) is launching the Secure, Scalable and Sugamya Website as a Service (SwaaS) websites for Arunachal Pradesh and Tripura.
- To take participative governance to last mile citizen, State MyGov portals are being launched for Arunachal Pradesh, Manipur, and Tripura.
- STPI (Software Technology Park of India) incubation facility is being inaugurated in Agartala, Aizawl, and Shillong.
- A BPO center under the North East BPO Promotion Scheme (NEBPS) is being inaugurated in Majuli, Assam.
- Manipur State Data Centre is being migrated to the Cloud Platform. ERNET (National Research and Education Network) India is enabling virtual classroom facility in Tripura.
- Digital Locker is being integrated with Secondary Education Board Assam and with Nagaland e-District.
- A comprehensive GIS-based Decision Support System for the North East States and North Eastern District Resource Plan Geo-Portal is also being launched.
- Six medical colleges including Gauhati Medical College, Dibrugarh Medical College will get the benefits of E-class
- This vision will play the role of a catalyst to energize the communication of the North East with the ASEAN and BBN countries in the face of Act East Policy

Way Forward

- Integrating North East has always been critical to the digitization of the socio-economic sphere of the country. This is a unique territory in many aspects including geographical terrain, rich and variegated culture of the people and their requirements. Each State has its set of critical requirements demanding special attention. It is in this context that the Government's resolve should be commended. The opportunities for growth and development would be leaping now and the youth are on par with the rest of India and improving their skills and securing jobs.

National Urban Digital Mission

- In a latest development, the Housing and Urban Affairs Ministry launched the National Urban Digital Mission.

What is National Urban Digital Mission (NUDM)?

- The National Urban Digital Mission (NUDM) has been launched by the **Ministry of Housing and Urban Affairs** along with the **Ministry of Electronics and Information Technology.**
- It will institutionalize a citizen-centric and ecosystem-driven approach to urban governance and service delivery in 2022 cities by 2022, and across all cities and towns in India by 2024.
- It will help in supplementing **Digital India initiative along with Smart Cities Mission.**
- **Objective:** The mission will create a shared digital infrastructure for urban India, working across the three pillars of people, process, and platform to provide holistic support to cities and towns.

Features

- NUDM is **citizen-centric, ecosystem-driven, and principles-based** in both design and implementation.
- NUDM has **articulated a set of governing principles.**
- It inherits **the technology design principles** of the National Urban Innovation Stack (NUIS).

Other initiatives

- The Ministry also launched other initiatives: India Urban Data Exchange (IUDX), SmartCode, Smart Cities 2.0 website, and Geospatial Management Information System (GMIS)

India Urban Data Exchange (IUDX)

- IUDX is an open-source software platform which facilitates the secure, authenticated, and managed exchange of data amongst various data platforms.
- **Partnership program:** The India Urban Data Exchange has been developed in partnership between the Smart Cities Mission and the Indian Institute of Science (IISc), Bengaluru.

Smart Code Platform

- SmartCode is a platform designed to address the challenges that ULBs face in the development and deployment of digital applications.

Digital India Program

- Digital India was launched **in 2015.**
- It is an initiative of **Ministry of Electronics and Information Technology** and **Finance Ministry.**
- **Objective:** To **ensure the Government's services are made available to citizens electronically.**
- **Components:** Digital India consists of three core components:
  - the development of secure and stable digital infrastructure
  - delivering government services digitally
  - universal digital literacy

- The Government of India's entity **Bharat Broadband Network Limited (BBNL) is the custodian** of Digital India (DI) project.

National Mission on Interdisciplinary Cyber-Physical Systems (Nm-Icps)

The Union Cabinet has approved the launching of NM-ICPS to be implemented by the Department of Science and Technology.

NM-ICPS

- The NM-ICPS is a comprehensive mission which would address technology development, application development, human resource development, skill enhancement, entrepreneurship and start-up development in CPS and associated technologies.
- The NM-ICPS is a pan India mission and covers the entire gamut of the country that includes central ministries, state governments, industry, and academia.

Cyber-Physical Systems (CPS)

- CPS are integrations of computation, networking, and physical processes.
- Embedded computers and networks are used to monitor and control the physical processes, with feedback loops where physical processes affect computation and vice versa.

Aim of the Mission:

- **Structural changes:** The mission aims at the establishment of:
  - 15 Technology Innovation Hubs,
  - 6 Application Innovation Hubs and
  - 4 Technology Translation Research Parks (TTRP).
  - **Boost to Advanced Research:** The project is also aimed to give impetus to advanced research in CPS, technology development and higher education in science, technology and engineering disciplines.
  - **Impact:** The mission implementation would
  - Develop and bring Cyber-Physical Systems (CPS) and associated technologies within reach in the country, adoption of CPS technologies to address India specific National / Regional issues.
  - Produce Next Generation skilled manpower in CPS.
  - Catalyze Translational Research.
  - Accelerate entrepreneurship and start-up ecosystem development in CPS.
  - Place India at par with other advanced countries and derive several direct and indirect benefits.

Benefit of NM-ICPS

- **One stop solution:** CPS technologies provide a cutting edge to a Nation's scientific, engineering, and technological innovative capabilities.
- Support other missions of the government will provide industrial and economic competitiveness

- **Act as an engine of growth:** The proposed Mission would act as an engine of growth that would benefit national initiatives in health, education, energy, environment, agriculture, strategic cum security, and industrial sectors, Industry 4.0, SMART Cities, Sustainable Development Goals (SDGs), etc.
- **Create jobs:**
  - It is estimated that about 40,000 jobs will be created in the short term and about 2,00,000 in the long term.
  - Start-ups will also create a number of technology-driven job opportunities in CPS and allied areas.

Way Forward

- CPS and its associated technologies, like Artificial Intelligence (Al), Internet of Things (loT), Machine Learning (ML), Deep Learning (DP), Big Data Analytics, Robotics, Quantum Computing, Quantum Communication, Quantum Encryption (Quantum Key Distribution), Data Science & Predictive Analytics, Cyber Security for physical infrastructure and other infrastructure, have pervaded and is playing a transformative role in almost every field of human endeavor all most in all sectors.
- It has become imperative for government and industries to be prepared to adopt these emerging and disruptive technologies in order to remain competitive, drive societal progress, generate employment, foster economic growth and to improve the overall quality of life and sustainability of the environment.

Technology And Innovation Report 2021

- India was the biggest 'overperformer' in frontier technologies than the country's per capita Gross Domestic Products (GDP) would suggest, according to a recent country-readiness index.
- The report was released by the United Nations Conference on Trade and Development (UNCTAD).
- The report examines the likelihood of frontier technologies widening existing inequalities and creating new ones.
- It also addresses the **national and international policies,** instruments and institutional reforms that are needed to create a more equal world of opportunity for all, leaving no one behind.

Key Takeaway:

- **Frontier Tech Market:** The report shows that frontier technologies already represent a USD 350 billion market, which could grow to **USD 3.2 trillion by 2025.**
- **International Cooperation:** It calls for strengthened international cooperation to build innovation capacities in developing countries, facilitate technology transfer.
- **Inclusive:** Envisages increase women's participation in digital sectors, conduct technological assessments and promote an inclusive debate on the impact of frontier technologies on sustainable development.
- **Humans and Machines At Work:** Technological change affects inequalities through its impact on jobs, wages and profits in following ways:

Automation taking jobs

- **Job displacement** can also be accompanied by **job polarization**, which refers to an expansion in high- and low-wage jobs combined with a contraction in middle-wage jobs.
- Frontier technologies are being used to provide services via digital platforms that have spurred the creation of a **'gig economy'.**

India Specific Findings:

- India's actual index ranking is 43, while the estimated one based on per capita income is 108.
- This meant that **India over performed** other countries by 65 ranking positions. India was followed by the Philippines, which over performed by 57 ranking positions.
- India performed well in research and development.
- This is reflected in its abundant supplies of qualified and highly skilled human resources available at a comparatively low cost.
- **However countries such as the United States, Switzerland and the United Kingdom were "best prepared" for frontier technologies.**

Challenges for Developing Countries:

- Low-income- and lower-middle-income countries have expanding and younger populations which will increase the supply of labour and depress wages, reducing the incentives for automation.
- Low-income countries have fewer skilled people and depend to a large extent on agriculture which tends to be slower to take advantage of new technologies.
- Developing countries typically innovate by emulating industrialized countries, diversifying their economies, and absorbing and adapting new technologies for local use, but this process is slowest in the poorest countries.
- Most developing countries have increased their R&D expenditures, but these are still relatively low. There is very little private funding of industrial technologies for productive applications.
- Stringent intellectual property protection will restrict the use of frontier technologies that could be valuable in SDGs related areas such as agriculture, health and energy.

The Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules 2021

What are IT Rules, 2021?

- The Rules aim to empower ordinary users of social media and OTT platforms with a mechanism for redressal and timely resolution of their grievance with the help of a Grievance Redressal Officer (GRO) who should be a resident in India.
- **Safety measures:** Special emphasis has been given on the protection of women and children from sexual offences, fake news and other misuse of the social media.
- **Source identification:** Identification of the "first originator of the information" would be required in case of an offence related to sovereignty and integrity of India.
- **Appointment of Chief Compliance Officer:** A Chief Compliance Officer, a resident of India, also needs to be appointed and that person shall be responsible for ensuring compliance with the Act and Rules.
- **Complaint monitoring:** A monthly compliance report mentioning the details of complaints received and action taken on the complaints would be necessary.
- **Code of Ethics:** The OTT platforms, online news and digital media entities, on the other hand, would need to follow a Code of Ethics.

- **Self-classification:** OTT platforms would be called as 'publishers of online curated content' under the new rules.
  - They would have to self-classify the content into five categories based on age and use parental locks for age above 13 or higher. They also need to include age verification mechanisms for content classified as 'Adult'.
- **Redressal mechanism:** A three-level grievance redressal mechanism has been mandated. This includes the appointment of a GRO, self-regulatory bodies registered with the Ministry of Information & Broadcasting (MIB) to look after the Code of Ethics and a Charter for the self-regulating bodies formulated by MIB.

Grounds for Challenge

- While the new rules were challenged by many on grounds of **violation of free speech**, the government has clarified that these rules permit social media platforms to operate in India freely but with due accordance to the law.
- Every entity has to abide by the Constitution of the country and the Rule of Law.
- Also, as per **Article 19** of the Constitution, freedom of speech and expression is not absolute and is subject to reasonable restrictions, especially in case of a threat to national sovereignty and security.
- Failure to comply with any one of these requirements would take away the indemnity provided to social media intermediaries under **Section 79** of the Information Technology Act.

Section 79 of the IT Act, 2000

- It says any intermediary shall not be held legally or otherwise liable for any third party information, data, or communication link made available or hosted on its platform.
- This protection, the Act says, shall be applicable only if the intermediary acts just as the messenger carrying a message from point A to point B, without interfering in any manner. It will be safe from any legal prosecution brought upon due to the message being transmitted.
- The protection accorded under **Section 79**, however, is not granted if the intermediary, despite being informed or notified by the government or its agencies, does not immediately disables access to the material under question.
- The intermediary must not tamper with any evidence of these messages or content present on its platform, failing which it lose its protection under the Act.
- Like **Section 79 of India's IT Act, Section 230** of the **Communications Decency Act** of the US states that "no provider or user of an interactive computer service shall be treated as the publisher or speaker of any information provided by another information content provider".

Need for the new Rules

The rules come at a time when the country is constantly striving to ensure the safety and sovereignty of the cyberspace and of personal data.

- **Wide coverage:** Social media is increasingly becoming an important part of our life.

For example, WhatsApp currently has a user base of 340 million in the country, accounting for the largest number of subscribers in the world, even more than the US. Facebook has 290 million, Twitter 17.5 million, YouTube 265 million and Instagram, 120 million.

- **Bundle of issues:** With such a huge population dependent on social media platforms, the tech-giants cannot ignore the new and emerging challenges like-
  - persistent spread of fake news
  - rampant abuse of the platforms to share morphed images of women
  - deep fakes and other contents that threaten the dignity of women
  - child pornography
  - threat to security
- **Hate speech:** Instances of use of abusive language, defamatory contents and hate speech in these platforms have become very common.

Supreme Court's take on emerging challenges of social media

- In view of such emerging challenges, the Supreme Court in 2018, in the **Tehseen S. Poonawalla v/s Union of India case,** directed the government to curb and stop dissemination of explosive messages and videos on various social media platforms.
- The Court in 2017 also observed that the government may frame necessary guidelines to eliminate child pornography, rape and gang rape imageries, videos and sites in content hosting platforms and other applications.
- The new rules are thus in accordance with the previous Supreme Court observations.
- As per the rules, intermediaries are mandated to remove or disable contents that are against the safety and dignity of individuals within 24 hours of receiving of complaints. Such complaints can be filed either by the individual or a person on his/her behalf.
- According to the government, knowing the "first originator of information" (also known as "traceability") of messages that cause violence, riots, terrorism, rape or threat to national security fall under reasonable exceptions to Right to Privacy - which again is not absolute as per the Constitution.

IT Act, 2000

- The Act provides a legal framework for electronic governance by giving recognition to electronic records and digital signatures.
- It also defines cybercrimes and prescribes penalties for them.
- The Act directed the formation of a Controller of Certifying Authorities to regulate the issuance of digital signatures.
- It established a Cyber Appellate Tribunal to resolve disputes arising from this new law.
- The Act amended various sections of the Indian Penal Code, 1860, the Indian Evidence Act, 1872, the Banker's Book Evidence Act, 1891, and the Reserve Bank of India Act, 1934 to make them compliant with new technologies.

- The IT Rules 2021 seek to address concerns of the citizens without infringing on their privacy and personal liberties, while maintaining digital sovereignty at the same time.

Non-Fungible Token (NFT)

- Non-fungible Tokens (NFT) are a type of data that is held in a digital ledger (locker) and can be sold and traded. They are based on block chain technology. Each NFT has a different underlying digital asset that demonstrates ownership, and the unit data represents a digital file i.e. Photos, movies, and audio.

- NFTs are a major word these days, with sales recently reaching USD 25 billion (2021) and crypto-assets gaining massive popularity; similarly, Taiwan puppeteers are looking towards NFTs to keep their craft alive.

The mechanism of NFT is as follows:

- Artist creates the product & then the Artist retains copyright & Right to reproduce.
- Artist opens Crypto currency wallet to indulge in transaction
- After this, the Digital object is minted and assigned a unique Digital Token (NFT). It attaches historical ownership data with it.
- The product is then listed on the marketplace for sale.
- Buyer purchases the NFT with crypto currency & now the buyer owns the NFT is the Digital Art.

Benefits of Non-Tangible Tokens are:

- **Exclusive ownership rights:** NFTs can only have one owner at any given moment.
- **Digital Signature :** NFT owners can also digitally sign their artwork;
- **Option to save unique information:** Unique information can be integrated into their NFT's metadata, which is only viewed by the person who purchased the NFT.
- **New Platform:** Blockchain technology and NFTs provide a unique possibility for artists and content providers to monetise their work. Artists, for example, are no longer reliant on galleries or auctions. Instead, the artist can sell it as an NFT directly to the customer.
- **Complete ownership:** NFT allows users complete ownership of a digital asset that no one, even the marketplace owner, may change or modify.
- **Monetising opportunities:** NFTs provide artists and content creators with a unique opportunity to monetise their work by allowing them to sell their work directly to consumers.
- **Royalties:** Artists can encode royalties into their work so that they receive a percentage of revenues anytime their work is sold to a new owner.

However, the Risk associated with digital asset copying are:

- NFT frauds, the emergence of fraudulent marketplaces, and unauthentic vendors posing as legitimate artists and selling copies of their artworks at lower prices are all risks/challenges with NFT.
- Growing sharing potential phishing URLs during the sale in order to deplete the participants' cryptocurrency wallets.
- Hacking the NFT collections through cyberspace. The trading platforms and exchanges where NFT transactions or exchanges take place aren't totally safe.
- **Environment:** determining if assets based on blockchain, such as NFTs, are sustainable is tough. Validation of transactions necessitates crypto mining, which necessitates high-powered computers that operate at a rapid rate, causing environmental damage.
- Other difficulties include: technology concerns such as non-attachment of a purchased item to the NFT, global chip shortages, and ownership issues such as forgetting the login credential, which could result in the irreversible loss of owned works. Furthermore, the true benefit of NFT has yet to be realised.

Way forward

- NFTs are a step ahead in the reinvention of this infrastructure since they enable digital representations of physical assets. Budget 2022-23 proposes the implementation of a taxation scheme for virtual digital assets, which includes emerging forms of crypto currencies, codes, and non-fungible tokens. NFTs are

part of a new sort of financial system known as Decentralized Finance (DeFi), which does away with banks and other financial organisations' indulgence.

- In the year 2021, NFT became popular as a way for artists to monetise their work. A wide range of digital commodities can be "tokenized," such as artwork or live broadcast films.

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3D printing (additive manufacturing)

- 3D printing or additive manufacturing uses computer-aided designing to make prototypes or working models of objects by laying down successive layers of materials such as plastic, resin, thermoplastic, metal, fiber or ceramic.
- With the help of software, the model to be printed is first developed by the computer, which then gives instructions to the 3D printer.
- This technology makes use of CAD (Computer-Aided Design) or 3D object scanners to take precise measurements of the product to be custom designed.
- Additive Manufacturing has its applications in several industries like defence, automotive industry, surgical equipment's' design segment, etc.

Types of 3D Printing:

Binder Jetting:

- Binder jetting, also known as material jetting or inkjet powder printing is among the most common additive manufacturing types.
- This method works similarly to your run-of-the-mill office printer except it prints three-dimensional objects.
- **Directed Energy Deposition (DED):**
- Directed energy deposition (DED) utilizes welding principles to create three-dimensional objects.
- The material typically metal wire or powder is melted by a focused energy source like a laser or electron beam.
- The liquid material is then precisely poured onto the build platform, where it quickly hardens, forming a layer. This process repeats until the object is finished printing.

Material Extrusion:

Material extrusion works similarly to a hot glue gun.

- The material feeds into the printer from a coil.
- The tip of the nozzle heats and melts the material.
- The liquid material is then placed layer by layer on the build platform, where it can cool and solidify, forming the object.
- Powder Bed Fusion (PBF):
- Powder bed fusion, otherwise known as electron beam melting (EBM), starts with a large bed of powdered material, typically plastic, metal, sand, or ceramic powders mixed with sand.
- The powder is selectively fused together using a laser or electron beam.

- Once a layer of material is fused, the working area moves down, and the new layer is built on top using the same process.

Sheet Lamination:

- Sheet lamination, otherwise known as ultrasonic additive manufacturing (UAM) or laminated object manufacturing (LOM) is an additive manufacturing process that stacks thin sheets of material and bonds them together through ultrasonic welding, bonding, or brazing.

Vat Polymerization:

- Vat polymerization is similar to powder bed fusion, except instead of a bed of powder, it uses a vat of photopolymer resin, which is hardened in layers by an ultraviolet laser.

Material Jetting:

- Similar to binder jetting, material jetting layers material to construct an object.
- However, instead of layering adhesive on a bed of powder, material jetting melts wax-like materials and precisely deposits droplets onto the build platform.

Global Market Scenario:

- The global market revenue generated by this sector accounts for USD 12 Billion in the year 2020 and it is anticipated to reach around USD 78 Billion by the year 2028.
- The market growth dynamics accounts for around CAGR of 26%- 32% during the forecast period, 2020-2028.
- North America dominates the global market with a market value of USD 24 Billion owing to the increasing R&D investment in this sector coupled with an infrastructure that supports the same.
- Europe is the second-largest segment; this is due to the growing industrialization of this market coupled with the low production cost of additive manufacturing.

Potential in India:

- Additive Manufacturing (AM) has immense potential to revolutionize India's manufacturing and industrial production landscape through digital processes, communication, imaging, architecture and engineering.
- It could likely add $ 1 billion to the GDP by 2025.
- The Strategy aspires to achieve 5% of Global AM market share.

Goals of National Strategy for Addictive Manufacturing:

- The key goals include positioning India as a global hub for Additive Manufacturing development and deployment, create and protect the integrity of India's AM intellectual properties.
- Our goal is to have 50 India specific technologies, 100 new startups, 500 products, 10 new manufacturing sectors, 1 lakh skilled manpower."

Aim and Objective of the National Strategy on Additive manufacturing (AM):

- The National Strategy on Additive manufacturing (AM) aims to create a conducive ecosystem for design, development, and deployment, and to overcome technical and economic barriers for Global AM leaders to set up their operations with supporting ancillaries in India, facilitating development of the domestic market and enhancement of global market share.

- The mission is to ensure creation of a sustainable ecosystem for the AM industry to compete globally, encourage AM transformation and driving capabilities in the country for developing core competencies, position India as a global Innovation and Research hub for Additive Manufacturing, ensure AM manufactured end-user functional components for domestic and export markets, promote creation of Indian IPR and ensure adequate measures for the protection of AM technology.
- The use of smart manufacturing processes to develop products and the predominant role of 3D printing in Industry 4.0 is one of the upcoming applications of this technology.
- Industry 4.0 is a rising trend that is anticipated to shift the global market dynamics and bring a radical change to manufacturing processes.

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Chapter

4

DEFENCE

Missile System and their Classification

- A missile is an intelligent unmanned rocket designed to carry the payload to a designated point with an aim of destroying the object/target. The missile is designed keeping in mind its target, trajectory, warhead, range, velocity and launch platform.
- **Major Technologies used in a missile are as follows:**
  - Propulsion system
  - Guidance system
- Aerodynamic features to include air frame, wings and fins
- Terminal guidance in case of precision guided weapons
- Warhead
  - The **propulsion system** in a missile is required to achieve terminal conditions like range, speed and warhead carrying capability. The missile is propelled either by rockets or jet engines using solid or liquid fuel. Some missiles use hybrid technology for propelling it to its intended point.
  - The function of the **guidance system** is to maintain the missile in its desired of light path by using altitude control mechanism. This is done by controlling the pitch, roll and yaw of the weapon. The guidance system operates as an autopilot, damping out fluctuations that tend to deflect the missile from its intended flight path.
  - In some missiles, the guidance commands are generated internally by the missile's computer. In others, the commands are transmitted to the weapon by some external source.
  - The **aerodynamic features of a missile**, also called Cont Rolling Surf Aces, are used to control the Missile's Flight. The fins, wings and tail are the three major aerodynamic control surf aces used to steer the missile. The missile's course can be altered by moving these controlling surfaces.
  - In case of **precision weapons**, the target seeker comes into picture when the missile starts detecting its target. The mechanism also works to determine the time of activating the warhead. After finding out the target, the device sends an electrical impulse to trigger the activation system. The target seeker is based either on radar or InfraRed (IR) or laser devices.
  - The **warhead** of a missile is selected keeping in mind its target type. It inflicts damage on the target and hence determines the missile's let hality. An optimum position of burst is used to achieve the desired effect on the target limits – the closer the burst to the target, the smaller the warhead needed.

- In other cases where the missile is required to cause destruction on hard targets, before detonation of warhead, penetration is achieved by employing a variety of technologies.

Classification of Missiles on the basis of Type

- **Cruise Missile:** A cruise missile is an unmanned selfpropelled (till the time of impact) guided vehicle that sustains flight through aerodynamic lift for most of its flight path and whose primary mission is to place an ordnance or special payload on a target. They fly within the earth's atmosphere and use jet engine technology. Cruise missiles can be categorised by size, speed (subsonic or supersonic), range and whether launched from land, air, surface ship or submarine. Depending upon the speed such missiles are classified as:
- **Subsonic cruise missile:** It flies at a speed lesser than that of sound. It travels at a speed of around 0.8 Mach. The well-known subsonic missile is the American Tomahawk cruise missile. Some other examples are Harpoon of USA and Exocet of France.
- **Supersonic cruise missile:** Supersonic cruise missile travels at a speed of around 23 Mach i.e. it travels a kilometre approximately in a second. The modular design of the missile and its capability of being launched at different orientations enable it to be integrated with a wide spectrum of platforms like warships, submarines, different types of aircraft, mobile autonomous launchers and silos. BRAHMOS is the only known versatile supersonic cruise missile system which is in service.
- **Hypersonic cruise missile:** Hypersonic cruise missile travels at a speed of more than 5 Mach. Many countries are working to develop hypersonic cruise missiles. BrahMos Aerospace is also in the process of developing a hypersonic cruise missile, BRAHMOSII, which would fly at a speed greater than 5 Mach.
- **Ballistic Missile:** A ballistic missile is a missile that has a ballistic trajectory over most of its flight path, regardless of whether or not it is a weapon delivery vehicle. Ballistic missiles are categorized according to their range, maximum distance measured along the surface of earth's ellipsoid from the point of launch to the point of impact of the last element of their payload. The missile carries a huge payload. The carriage of a deadly warhead is justified by the distance the missile travels. Ballistic missiles can be launched from ships and land based facilities. For example, Prithvi I, Prithvi II, Agni I, Agni II and Dhanush ballistic missiles are currently operational in the Indian defense forces.

Classification of Missiles on the basis of Launch Mode

- **Surface-to-Surface Missile:** A surface-to-surface missile is a guided projectile launched from a handheld, vehicle mounted, trailer mounted or fixed installation. It is often powered by a rocket motor or sometimes fired by an explosive charge since the launch platform is stationary.
- **Surface-to-Air Missile:** A surface-to-air missile is designed for launch from the ground to destroy aerial targets like aircrafts, helicopters and even ballistic missiles. These missiles are generally called air defence systems as they defend any aerial attacks by the enemy.
- **Surface (Coast)-to-Sea Missile:** A surface (coast)-to-sea missile is designed to be launched from land to ship in the sea as targets.
- **Air-to-Air Missile:** An air-to-air missile is launched from an aircraft to destroy the enemy aircraft. The missile flies at a speed of 4 Mach.
- **Air-to-Surface Missile:** An air-to-surface missile is designed for launch from military aircraft and strikes ground targets on land, at sea or both. The missiles are basically guided via laser guidance, infrared guidance and optical guidance or via GPS signals. The type of guidance depends on the type of target.
- **Sea-to-Sea Missile:** A sea-to-sea missile is designed for launch from one ship to another ship.
- **Sea-to-Surface (Coast) Missile:** A sea-to-surface missile is designed for launch from ship to land based targets.

- **AntiTank Missile:** An antitank missile is a guided missile primarily designed to hit and destroy heavilyarmoured tanks and other armoured fighting vehicles. Antitank missiles could be launched from aircraft, helicopters, tanks and also from shoulder mounted launcher.

Classification of Missiles on the basis of Range:

- This type of classification is based on maximum range achieved by the missiles. The basic classification is as follows:
  - Short Range Missile
  - Medium Range Missile
  - Intermediate Range Ballistic Missile
  - Intercontinental Ballistic Missile
  - Classification of Missiles on the basis of Propulsion:
  - **Solid Propulsion:** Solid fuel is used in solid propulsion. Generally, the fuel is aluminium powder. Solid propulsion has the advantage of being easily stored and can be handled in fuelled condition. It can reach very high speeds quickly. Its simplicity also makes it a good choice whenever large amount of thrust is needed.
  - **Liquid Propulsion:** The liquid propulsion technology uses liquid as fuel. The fuels are hydrocarbons. The storage of missile with liquid fuel is difficult and complex. In addition, preparation of missile takes considerable time. In liquid propulsion, propulsion can be controlled easily by restricting the fuel flow by using valves and it can also be controlled even under emergency conditions. Basically, liquid fuel gives high specific impulse as compared to solid fuel.
  - **Hybrid Propulsion:** There are 2 stages in hybrid propulsion solid propulsion and liquid propulsion. This kind of propulsion compensates the disadvantages of both propulsion systems and has the combined advantages of the 2 propulsion systems.
  - **Ramjet:** A Ramjet engine does not have any turbines unlike turbojet engines. It achieves compression of intake air just by the forward speed of the air vehicle. The fuel is injected and ignited. The expansion of hot gases after fuel injection and combustion accelerates the exhaust air to a velocity higher than that at the inlet and creates positive push. However, the air entering the engine should be at supersonic speeds. So, the aerial vehicle must be moving in supersonic speeds. Ramjet engines cannot propel an aerial vehicle from zero to supersonic speeds.
  - **Scramjet:** Scramjet is an acronym for Supersonic Combustion Ramjet. The difference between Scramjet and Ramjet is that the combustion takes place at supersonic air velocities through the engine. It is mechanically simple, but vastly more complex aerodynamically than a jet engine. Hydrogen is normally the fuel used.
  - **Cryogenic:** Cryogenic propellants are liquefied gases stored at very low temperatures, most frequently liquid hydrogen as the fuel and liquid oxygen as the oxidizer. Cryogenic propellants require special insulated containers and vents which allow gas to escape from the evaporating liquids. The liquid fuel and oxidizer are pumped from the storage tanks to an expansion chamber and injected into the combustion chamber where they are mixed and ignited by a flame or spark. The fuel expands as it burns and the hot exhaust gases are directed out of the nozzle to provide thrust.

India's Missile System

- The Integrated Guided Missile Development Programme (IGMDP) was conceived by renowned scientist Dr. A.P.J. Abdul Kalam to enable India attain self-sufficiency in the field of missile technology.

Missiles developed under IGMDP

- **The missiles developed under the programme were:**
  - Short-range surface-to-surface ballistic missile Prithvi
  - Intermediate-range surface-to-surface ballistic missile Agni
  - Short-range low-level surface-to-air missile Trishul
  - Medium-range surface-to-air missile Akash
  - Third generation anti-tank missile Nag
- The Agni, which was initially conceived as a technology demonstrator project in the form of a re-entry vehicle, was later upgraded to a ballistic missile with different ranges.
- Dr. Kalam played a major role in the development and operationalisation of Agni and Prithvi missiles.

Quick Reaction Surface to Air Missile

- QR-SAM is an indigenously developed short-range surface to air missile.
- The missile has a strike range of 25 to 30 km.
- It has an all-weather weapon system capable of tracking and firing, and it is the second developmental trial of the state-of-the-art missile with an aerial target.

Barak-8

- It is a missile system jointly developed by DRDO India and M/s Israel Aerospace Industry (IAI).
- It includes Long Range Surface-to-Air Missile (LR-SAM) and Medium Range Surface-to-Air Missile (MRSAM).
- LR-SAM is the Ship Launch Version and Project MR-SAM is the Land Launch Version of Barak-08 Missile system.
- MR-SAM detects incoming enemy aircraft while they are well over 100 km away and destroys them at a range up to 70 km.
- LR-SAM has got long range engagement capability to penetrate in deep water/land to intercept all types of aerial targets (like Subsonic & Supersonic Missiles, Fighter Aircraft, Maritime Patrolling Aircraft (MPA), Helicopter and Sea Skimming Missiles.

National Advanced Surface-to-Air Missile System

- India is planning to procure National Advanced Surface-to-Air Missile System (NASAM-II) from the U.S.
- It is an advanced air defense system.
- It has the ability to quickly identify and destroy enemy aircraft, UAV or emerging cruise missile threats.
- NASAMS-II is an upgraded version of the NASAMS and features new 3D mobile surveillance radars and 12 missile launchers for quicker reaction.
- It is proposed to be deployed to protect the national capital region.
- It will help in preventing 9/11-type attacks in Delhi.

Igla-S missile

- It is a Russian man-portable Surface to Air missile.
- Russia has recently bagged the contract of Indian Army's bid for air defense missile.

BrahMos and its Significance

- The BrahMos Missile is the world's first and only supersonic cruise missile. It is a precision strike weapon for Army, Navy as well as Air Force and can be fitted in Ships, Mobile Launchers, Submarines and Aircraft against land and sea targets. Compared to existing state-of-the-art subsonic cruise missiles, BrahMos has three times more velocity, 2.5 to 3 times more flight range, 3 to 4 times more seeker range and nine times more kinetic energy. The missile has identical configuration for land, sea and sub-sea platforms and uses a Transport Launch Canister (TLC) for transportation, storage and launch.

Basic features of BrahMos:

- Supersonic cruise missile, BrahMos, is being developed with Russia as a private joint-venture.
- BrahMos is a multi-platform cruise missile enabling it to strike from various types of land, sea and air-based platforms.
- It is among the fastest supersonic cruise missiles in the world with speeds ranging between Mach 2.5 - 2.8.
- BrahMos is a 'fire and forget' weapon, requiring no further guidance from the control centre once the target has been assigned and it is launched.
- BrahMos is a two-stage missile with a solid propellant booster engine as its first stage which brings it to supersonic speed and then gets separated. The liquid ramjet or the second stage then takes the missile closer to Mach 3 speed in cruise phase.
- Stealth technology and guidance system with advanced embedded software provide the missile with special features.
- The missile has flight range of up to 290-km with supersonic speed all through the flight, leading to shorter flight time, consequently ensuring lower dispersion of targets, quicker engagement time and non-interception by any known weapon system in the world.
- Its destructive power is enhanced due to large kinetic energy on impact. Its cruising altitude could be up to 15 km and terminal altitude is as low as 10 meters.
- It carries a conventional warhead weighing 200 to 300 kg.

Ship-based variant

- The ship-based variant of Brahmos is capable of hitting sea-based targets that are beyond the radar horizons. The missile can be launched in either inclined or vertical configuration as per the requirement.

Submarine-launched variant

- Brahmos submarine variant can be launched from a depth of 40 to 50 m. The installation of Brahmos missile in submarine increases the offensive power of the submarine without compromising its defensive power. The torpedo tubes can be used for defense of the vessel.

Air-launched variant (Brahmos-A)

- The air-launched variant (Brahmos-A) is the modified version of Brahmos missile which has a range of 400 km. The missile can be launched from India's Sukhoi 30 MKI as a standoff missile.

Brahmos II

- Brahmos II or Brahmos Mark II is a hypersonic cruise missile currently under development and is expected to have a range of 600 km.

- The missile is expected to have a speed of Mach 5-7. This makes it one of the fastest hypersonic cruise missile in the world.
- The missile will be propelled by scramjet airbreathing jet engine during the cruise stage of flight.

Brahmos NG

- Brahmos NG (Next Generation) is a mini version Brahmos missile with an expected range of 300 km. The weight of the missile will be reduced to half to around 1.5 tons and will be made three meters shorter than its producer.
- Brahmos NG has been envisioned to be highly precise, Lethal, more versatile, multi-platform, multi-target, flexible, and lighter Missile system.

Significance

- Advent of the BrahMos gave the Indian armed forces, the much needed capability to undertake deep surgical strikes against a country that attacks India. The high speed of the BrahMos gives it better target-penetration characteristics as compared to slower subsonic cruise missiles such as the Tomahawk. BrahMos is a multi-platform cruise missile enabling it to strike from various types of land, sea and air-based platforms, including mobile and fixed ones. Possession of such weapon systems in the Indian arsenal would successfully prevent any hostile ship close within an operational range of 290 kms at sea. Although BrahMos is primarily an anti-ship missile, it is also capable of engaging land-based targets.
- The Indian Navy too, has already inducted the anti-ship Block I naval version into service with its integration on the destroyer INS Rajput, a Kashin class destroyer acquired from the erstwhile Soviet Union. The ship is used extensively for BrahMos tests.
- BrahMos has now emerged as the main anti-ship strike weapon and is capable of flying from a sea-skimming height of just 10 metres above the waves to an altitude of 15 kms. While it can achieve a maximum velocity of Mach 2 in the denser air at sea level, this goes up to Mach 2.7 in the rarefied upper atmosphere above 7 kms. Moreover, INS Ranjit is next in line among eight warships that the Indian Navy has planned to equip with the BrahMos—fitted with four missile launchers, two on each side of the vessel.
- **BrahMos continues to remain the most cost effective option owing to the following factors:**
  - Technology used
  - R&D effort
  - Dividends in terms of accuracy, speed, reliability, shoot capability and ease at operation
  - Ease of maintenance and comparison of down time
  - Least collateral damage reducing fear of escalation of war beyond threshold level
  - Universality of missile as regards to the use from variety of platforms Shelf life
  - Ability to form part of network centric warfare
  - Capability to engage more than one target with salvo option from the same platform
  - Availability of spares back up
  - Is fired from its storage canister
  - Number of associated sub-systems required to operationalise the complete weapon system
  - Comparison of manpower required to operationalise the system vis-à-vis other systems
- FurthSSermore, cruise missiles fly at low altitudes and have the ability to evade enemy radars and air-defence systems.

India's Ballistic Missile Defence System

- The Indian Ballistic Missile Defence Programme, an initiative to develop and deploy a multi-layered ballistic missile defence system, is a two-tiered system consisting of two interceptor missiles, namely Prithvi Air Defence (PAD) missile for high altitude interception, and the Advanced Air Defence (AAD) missile for lower altitude interception. The two-tiered shield will be able to intercept any incoming missile launched 5,000 km away.
- The Ballistic Missile Defence programme aims to provide an effective missile shield against incoming enemy ballistic and nuclear missiles.
- A hostile missile needs to be intercepted at boost (launch) point, mid-course (flight through space), or terminal phase (during atmospheric descent).

Prithvi Air Defence (PAD)

- Prithvi Air Defence (also known as Pradyumna ballistic missile interceptor) is a ballistic missile interceptor that has been designed for the interception of the inbound **ballistic missiles outside the atmosphere**. Prithvi air defence system is a two-phase missile that has the highest deflection height of 80 km.
- The first stage the missile consists of the solid-fuelled motor, and the second stage consists of a liquid fuelled motor. The movement thrusters of the missile can produce a lateral acceleration of over 5gs at a height of 50 km.
- Prithvi air defence system has a maximum range of 2000 km and the deflection height of 50 to 80 km. It can achieve a speed of Mach 5 that is enough to hit incoming medium-range ballistic missiles.
- PAD uses Swordfish Long Range Tracking Radar (LRTR) as the fire control radar and for target acquisition. It can track 200 targets at a range of 600 km.

Advanced Air Defence (AAD)

- Advanced air defence AAD is ballistic missile interceptor developed by DRDO for deflecting the incoming missiles in the **endo-atmospheric region** at a height of 30 km.
- AAD consists of a single stage solid rocket propelled guided missile.
- Its guidance is the same as that of Prithvi air defence system. The guidance consists of the inertial navigation system, and it receives the mid-course updates from the ground-based radar system. In the terminal phase, it uses active radar homing.

Prithvi Defence Vehicle

- Prithvi defence vehicle is the successor of Prithvi air defence interceptor missile. It is a new exoatmospheric interceptor missile being developed by DRDO codenamed PDV.
- Prithvi defence vehicle will be a two-stage missile powered by solid propellants. It uses an innovative system to control the interceptor missile at an altitude of more than 150 km.
- PDV will replace the existing Prithvi Air Defence interceptor missile in the PAD/AAD combination. It will replace the PAD with more powerful missile interceptor and will complete the Phase 1 of the ballistic missile defence system.

Other developments in the ballistic missile defence system of India

- **S-400 Triumph missile** defence system is being procured from Russia. It will be capable of destroying the incoming ballistic missiles along with other enemy targets such as fighter jets, cruise missiles, UAVs, etc.

- **Barak 8**, the naval long-range surface to air missile (LR-SAM) jointly developed by India and Israel can also destroy the ballistic missiles along with other targets such as anti-ship missiles, aircraft, helicopters, UAVs, cruise missiles, etc. However, its capability to destroy powerful ballistic missiles is limited.

Reasons for the development of ballistic missile defence for India

- India does not have very friendly relations with nuclear-armed neighbors such as China and Pakistan which make it more pragmatic for India to develop ballistic missile defense capability. This reduces the incentive for the nuclear-capable enemy state to attack with nuclear weapons.
- India has the no first use policy for its strategic nuclear weapons. An efficient ballistic missile defence system provides the capability for retaliation and counterattack in case of a nuclear attack by an enemy state.
- The terrorist fractions and non-state actors in Pakistan have made efforts for obtaining missile technology. Ballistic missile defence would provide a shield from missile attacks by these non-state actors and can avoid unnecessary nuclear war between the two nuclear-armed nations.
- The development of indigenous ballistic missile defence capability will also reduce the import bill of defence systems from foreign countries.
- This will also provide the capability for better reconnaissance, tracking, and detection of enemy attacks.

Apprehensions regarding BMD

- It may start the arms race with Pakistan investing in more powerful missiles to thwart BMD disturbing strategic balance.
- BMD is ineffective against Cruise missiles. Both China and Pakistan have cruise missile capable of delivering the nuclear payload.
- No BMD can have a 100% success rate in the interception of the projectile (ballistic missile).
- India has wide and segregated geography. It creates a problem in the protection of all critical center and creation of land infrastructure for BMD in many areas.
- Even after interception there remain chances of damage, especially if the interception is done in the terminal phase of the ballistic missile.

Why need arises?

- India's own indigenous missile defence shield originates from its threat perception from China and Pakistan. Pakistan, with its various short- and medium-range missiles, has the capability to hit major targets in India; and China, with its huge arsenal of solid-fuelled missiles, is the most potent threat to India. The Chinese upper hand in force level and its intermediate range ballistic missiles (IRBM) and medium-range ballistic missiles (MRBM) that can reach India's farthest corners increases India's anxiety. Despite the indigenous development of systems such as Akash and Trishul, and the planned acquisition of foreign air defence and limited-range theatre defence systems, it is clear that these systems would not be adequate to address all conceivable threats. As a result, the requirement for comparatively longer range interception technologies to tackle a large gamut of faster missiles in the neighborhood pushed India's search for systems beyond the realm of indigenous programmes and friendly imports.

Recent initiative

- India achieved a significant milestone in the direction of developing a two-layered Ballistic Missile Defence system by successfully test firing an interceptor missile designed to intercept and destroy hostile ballistic missiles in space. This further enhances India's capability of dealing with a nuclear attack threat.

Indian Submarines and Naval Ships

- A submarine is a special vessel or ship that can go underwater. Inside it has huge tanks that hold water. These are called, ballasts. The sub comes equipped with a power source. These can be an engine, nuclear power, batteries or a combination of the three. To find its way through the dark oceans, submarines use sonar equipment. This puts out a sound wave. When a sound wave hits an object it bounces back a signal to the submarine. Other equipment inside the submarine provides clean water and air for the crew members.

Types of Submarines

- **Attack submarines:** these are submarines used for attacking enemy warships, attacking enemy submarines, infiltrating in the enemy territory, blockading choke points, etc. These submarines are armed with torpedoes, cruise missiles, anti-ship missile, etc.
- **Ballistic missile submarine:** these submarines are used for carrying long-range ballistic missiles that have the capability to carry nuclear warheads. The submarines provide second attack capability against a nuclear attack by the enemy state.
- **Diesel-electric submarines:** these submarines are powered by an internal combustion engine using diesel as its fuel. These submarines use electric batteries for operating underwater which are charged from the power provided by the internal combustion engine powered by diesel fuel. These submarines are very difficult to track especially when operating on their battery.
- **Nuclear powered submarines:** these submarines use the nuclear reactor for powering the submarine. These can operate underwater for several months in the ocean.

Why are submarines so important?

- A submarine is the quietest military platform and extremely tough to detect. Their main cover is their ability to move stealthily under water and keep an eye on enemy movement of vessels. Submarines are the most potent military platforms currently available even ahead of aircraft carriers which need a large entourage to protect it.
- The nations which possess nuclear weapons, base their second strike capability (ability to strike back after being hit first by nuclear strike) on nuclear powered ballistic missile submarines.
  - **Operational Stealth** is afforded to the submarine because it operates below the sea surface in a medium generally unfavourable to counter-detecting sensors. Once fully submerged, a submarine remains virtually invisible to all but the most capable Anti Submarine Warfare (ASW) forces. Operational stealth provides the submarine command with three very significant military advantages; covertness, initiative and survivability.
  - **Operational survivability** is the ability to operate in hostile environments with little or no risk. To avoid most threats, submarines just need to submerge. While surface ships have to be concerned with defence against attack from sub-surface, surface and air launched weapons, submarines rarely do. This relative immunity also allows them to work unassisted. While a surface ship relies on escorts and auxiliaries whenever they put to sea, submarines can operate alone.
  - **Stealth** provides protection for the submarine 24 hours a day and contributes greatly to the probability of mission success.
- Submarines are also characterised by their operational endurance, i.e. the number of days they can remain at sea unsupported. They have an ability to deploy and remain within an area of operation for a lengthy period of time without the need for re-supply.
- A submarine's wide range of sensor and communication payloads, its effectors and its ability to operate covertly and independently across the area of operations provides a Force Commander with an ability to task a submarine with a number of different mission types as the strategic, operational or tactical situation changes.

Light Combat Aircraft

- A light combat aircraft is a light multirole military aircraft most coming from advanced trainers that have been modified or designed for engaging in light combat missions, either in light strike or attack missions, reconnaissance or interdiction roles while some keeping its trainer role

Tejas

- The HAL Tejas is an Indian single-seat, single-jet engine, multi-role light fighter developed by Hindustan Aeronautics Limited (HAL). It is a tailless, compound delta wing design powered by a single engine. It came from the Light Combat Aircraft (LCA) programme, which began in the 1980s to replace India's ageing MiG-21 fighters. Later, the LCA was officially named Tejas meaning Radiant
- It integrates technologies such as relaxed static stability, fly-by-wire flight control system, multi-mode radar, integrated digital avionics system, composite material structures, and a flat rated engine. It is supersonic and highly maneuverable, and is the smallest and lightest in its class of contemporary combat aircraft

Characteristics of Tejas

- Tejas is a Light Combat Aircraft that uses 4th generation technologies
- It is built from **Carbon-Fiber Composite (CFC)** materials and has unstable aerodynamics.
- It is equipped with a quadruplex digital **fly-by-wire flight control system** to ease handling by the pilot.
- It incorporates an advanced glass cockpit that comprises all the round dialed electro-mechanical instruments.
- It is fitted with the **coherent pulse-Doppler Multi Mode Radar** that is designed to operate equally effectively in the Air to Air and Air to Surface domains.
- It is fitted with **Open Architecture Computer (OAC).**

UAVs in India

Drones are Unmanned Aerial Vehicle (UAV) either controlled by 'pilots' from the ground or increasingly, autonomously following a pre-programmed mission. Drones basically fall into 2 categories: those that are used for reconnaissance and surveillance purposes and those that are armed with missiles and bombs.

Categories of UAVs

- UAVs typically fall into one of **6 functional categories (although multi-role airframe platforms are becoming more prevalent):**
  - **Target and decoy:** Providing ground and aerial gunnery a target that simulates an enemy aircraft or missile
  - **Reconnaissance:** Providing battlefield intelligence
  - **Combat:** Providing attack capability for high-risk missions (see Unmanned combat air vehicle)
  - **Logistics:** UAVs specifically designed for cargo and logistics operation
  - **Research and development:** Used to further develop UAV technologies to be integrated into field deployed UAV aircraft
  - **Civil and Commercial UAVs:** UAVs specifically designed for civil and commercial applications

UAV of India

- **Nishant:** Nishant is a multi mission Unmanned Aerial Vehicle with Day/Night capability used for battlefield surveillance and reconnaissance, target tracking & localization, and artillery fire correction.
- **Rustom:** Rustom (Warrior) is a Medium Altitude Long Endurance Unmanned Combat Air Vehicle (UCAV) being developed by Defence Research and Development Organisation.
- **UAV Panchi:** It is the wheeled version of Unmanned Aerial Vehicle (UAV) Nishant, capable of taking-off and landing by using small airstrips. Panchi UAV has autonomous flight capabilities and is controlled from a user friendly Ground Control Station (GCS).
- **AURA:** AURA is stealth UCAV, capable of releasing missiles, bombs and precision-guided munitions.

NETRA

- It is the first indigenously built Airborne Early Warning and Control System (AEW&CS) developed by DRDO.
- It is light-weight autonomous UAV for long-range surveillance and reconnaissance operations.
- This radar system is also mounted on Embraer aircraft which gives 240-degree coverage of airspace.
- It helps to detect and track aircraft, missiles, ships, and vehicles

Benefits of Drone technology

- Drones can perform inspections and surveys more quickly, more cheaply, and safely (which reduces insurance costs) than people or helicopters.
- Their benefit is not just in being able to perform the same task more cheaply but significantly more frequently as well.
- By dramatically increasing the amount of data gathered new forms of analysis are being made possible.
- Drones possess the capability of reaching the most remote areas with little to no manpower needed and require the least amount of effort, time, and energy.

Applications of Drones other than military applications

- Drones are a rapidly growing form of technology, used for numerous purposes outside the military.
  - **Remote sensing:** UAV remote sensing functions include electromagnetic spectrum sensors, gamma ray sensors, biological sensors, and chemical sensors. Biological sensors are sensors capable of detecting the airborne presence of various microorganisms and other biological factors. Chemical sensors use laser spectroscopy to analyze the concentrations of each element in the air.
  - **Commercial aerial surveillance:** Aerial surveillance of large areas is made possible with low cost UAV systems. Surveillance applications include livestock monitoring, wildfire mapping, pipeline security, home security, road patrol, and anti-piracy. Wildlife conservation, including tracking orangutans in Sumatra and monitoring several endangered species. Namibia has teamed up with the WWF (World Wildlife Fund) to fly drones over national national parks, in hopes of spotting poachers, as well as monitoring animals.
  - **News:** Huge, expensive news helicopters might not be the standard for much longer. Drones equipped with cameras can fly lower and into smaller areas than larger manned aircraft. Instead of wide aerial shots of the freeway in a high-speed chase, viewers could one day get a look into the driver's side window of a speeding car on the local news.

- **Sports:** Drones are starting to be used in sports photography and cinematography. Some advantages of using unmanned aerial vehicles in sports are that they allow video to get closer to the athletes, they are more flexible than cable-suspended camera systems
- Domestic policing: UAVs are increasingly used for domestic police work in Canada and the United States:a dozen US police forces had applied for UAV permits by March 2013.
- Oil, gas and mineral exploration and production: UAVs can be used to perform geophysical surveys, in particular geomagnetic surveys where the processed measurements of the Earth's differential magnetic field strength are used to calculate the nature of the underlying magnetic rock structure. A knowledge of the underlying rock structure helps trained geophysicists to predict the location of mineral deposits. The production side of oil and gas exploration and production entails the monitoring of the integrity of oil and gas pipelines and related installations. For above-ground pipelines, this monitoring activity could be performed using digital cameras mounted on one or more UAVs. The InView UAV is an example of a UAV developed for use in oil, gas, and mineral exploration and production activities.
- Disaster relief: UAVs transport medicines and vaccines, and retrieve medical samples, into and out of remote or otherwise inaccessible regions. Drones can help in disaster relief by gathering information from across an affected area. Drones can also help by building a picture of the situation and giving recommendations for how people should direct their resources to mitigate damage and save lives.

Self-Reliance In Defence Manufacturing

- According to the latest report published by the Stockholm International Peace Research Institute, which tracks arm sales around the world, India ranks third-highest globally for its military spending. We spend around 2% of our GDP on defence. And yet, only about 30 percent of India's defence equipment is manufactured in the country.
- In order to make India and its citizens self-reliant in all aspects, the Prime Minister of India, Narendra Modi had launched the Aatmanirbhar Abhiyaan. The Union budget of 2022-23 gave momentum to aatmanirbharta in defence. Around 70% of the defence budget has been reserved for the domestic defence industry.
- The government has over the years also taken various other steps to boost indigenisation and manufacturing of defence equipment like:
  - Defence Procurement Procedure (DPP) - 2016 has been revised as Defence Acquisition Procedure (DAP) 2020, which is driven by the tenets of Defence Reforms announced as part of 'Aatmanirbhar Bharat Abhiyan'.
  - 'Buy {Indian-IDDM (Indigenously Designed, Developed and Manufactured)}' category has been accorded top most priority for procurement of capital equipment.
  - Increasing of Foreign Direct Investment(FDI) policy allowing 74% FDI under automatic route and 100% through approval of the government.
  - Simplification of the Industrial licensing process with a more extended validity period.
  - Government has established two Defence Industrial Corridors, one each in Uttar Pradesh and Tamil Nadu to attract investments of Rs 10,000 Cr in each corridor by year 2024-25.
  - Launch of an indigenisation portal like SRIJAN to promote Make in India by Indian Industry together with MSMEs.
- While India is on the path of aatmanirbharta (self reliance), we have made quite a few achievements so far, to name a few :
  - INS Vikrant- India's first indigenous aircraft carrier.

- First indigenous Long-range artillery gun- Dhanush.
- INS Kalvari, INS Khanderi
- Supersonic cruise missile Brahmos developed by a joint venture with Russia.
- Arjun tank- the third-generation main battle tank developed by DRDO.
- Arihant- India's first indigenous nuclear submarine.

- With the help of greater funding by the government, increased R&D and greater private player participation India is bound to not only achieve self- reliance but also be a major defence exporter.

Stealth Technology

- Stealth technology works on the principle of eliminating radar reflections. This can be done by either Absorbing radio waves (RAM coatings) or Deflecting radio waves (Shaping of the surfaces).
- The radio waves are electromagnetic waves of varying frequencies. The methods of deflection and absorption of EM waves complement each other in order to create a stealth aircraft/ship.
- They aren't invisible, but extremely hard to detect and generally are detected at ranges of 10-20 km by ultra-modern radars compared to 150-300 km for non-stealth objects.
- This enables them to maintain the element of surprise which is extremely decisive in a conflict.

Advantages of Stealth Technology

- The benefits of stealth apply not only to platforms but to a lot of weapons as well. Anti-surface munitions like the JSOW, JASSM, Apache/SCALP/Storm Shadow, Taurus/KEPD and many others are specifically shaped and treated to minimize their radar and IR signatures.
- **This has two useful payoffs**: On the one hand, the weapon itself becomes less vulnerable to enemy defensive systems, which means that fewer of the weapons launched will be shot down before reaching their target(s). This in turn means that fewer weapons and their parent platforms need to be allocated to any given mission, and finally the end result is that a greater number of targets can be confidently engaged with a given force.
- The other benefit is the advantage of surprise and its effect in cases where shrinking the enemy and available reaction time is of the essence.

Disadvantages of Stealth Technology

- Stealth aircraft **cannot fly as fast or is not maneuverable** like conventional aircraft. The F-22 and the aircraft of its category proved this wrong up to an extent. Though the F-22 may be fast or maneuverable, it can't go beyond Mach 2 and cannot make turns like the Su-37.
- Another serious disadvantage with the stealth aircraft is the **reduced amount of payload** it can carry. As most of the payload is carried internally in a stealth aircraft to reduce the radar signature, weapons can only occupy a less amount of space internally.
- On the other hand a conventional aircraft can carry much more payload than any stealth aircraft of its class.
- Whatever may be the disadvantage a stealth aircraft can have, the biggest of all disadvantages that it faces is its sheer cost. Stealth aircraft literally costs its weight in gold.

Chemical Weapons

- A Chemical Weapon (CW) is a specialized munition that uses chemicals formulated to inflict death or harm on human beings. It releases toxic gas, liquid or solid that can poison people and the environment.

- Because they are relatively cheap and easy to produce, chemical weapons are referred to as the **"poor man's bomb".** Even though modern munitions, through precision of application and specialised use, can cause catastrophic damage, chemical weapons trigger unmatched horror and leave deep psychological scars.

How Chemical Weapons affect our body?

- People suffer from several diseases like breathing problem, choking, sensory irritation causes damage to the central nervous system, water from the eyes, such chemicals infuses with blood, excess of water comes from the nose, etc. and also causes death.
- The severe risk is when such chemicals migrate into the ground and affect the food chain.

Various types of Chemical Agents

- The toxic component of a chemical weapon is called its 'chemical agent'. Based on their mode of action (i.e. the route of penetration and their effect of on the human body), chemical agents are commonly divided into several categories: choking, blister, blood, nerve and riot control agents.

The most commonly used chemical agents include:

- **Soman:** With Sarin and another chemical weapon known as Lewisite — a blistering agent — the nerve agent Soman is said to have made up much of the former Soviet Union's chemical arsenal. It is considered a volatile substance effective mainly through inhalation.
- **Sarin:** It is a colourless, odourless nerve gas extremely potent - even trace amounts can kill humans- but its threat after being released in the atmosphere is short lived. The UN has confirmed the use of Sarin in the deaths of 87 people in Idlib province of Syria on April 4, 2017.
- **VX:** VX, or O-ethyl S-diisopropylaminomethyl methylphosphonothiolate, is brownish in liquid form, and its vapors are odorless. VX agents are among the most toxic substances known. Mere droplets can kill. It can remain on material, equipment and terrain for long periods. Uptake is mainly through the skin but also through inhalation of the substance as a gas or aerosol.
- **Mustard gas:** Possibly the world's most commonly used chemical weapon, it was widely used in World War I, and gets its name from its distinctive odour of rotten mustard. It is slow acting, and only about 5% to 10% of people exposed to it usually die.
- **Hydrogen Cyanide:** It is a commercially produced **"blood agent"** used in plastic and organic chemical products in many parts of the world. It is a colorless vapor at normal temperatures with a smell likened to bitter almonds. Hydrogen cyanide has high toxicity and in sufficient concentrations rapidly leads to death.
- **Tabun:** It is a colourless or brownish as a liquid and odourless as a vapour. Tabun, also an organophosphate like many pesticides, is considered among the easiest of nerve gases to manufacture, even in the non-industrialized world.
- **Phosgene Gas:** it is also one of the most dangerous weapons. When the person comes in contact with it, breathing problem, suffocation, water comes out from the nose and severe cough, etc.
- **Chlorine:** We all know that it is used for making pesticides, rubber, for cleaning purpose, etc. But if it is used in more quantity, it can be deadly. When it enters the body, it directly affects the lungs and in a very short span of time, he or she may die.

Chemical Weapons Conventions

- Considering the huge casualties faced during World War I and widespread public outrage, the Geneva Protocol was signed in 1925, which prohibited the use of chemical weapons in warfare.
- While a welcome step, the Protocol had a number of significant shortcomings, including the fact that it did not prohibit the development, production or stockpiling of chemical weapons. Also problematic

was the fact that many States that ratified the Protocol reserved the right to use prohibited weapons against States that were not party to the Protocol or as retaliation in kind if chemical weapons were used against them.

- The Cold War period saw significant development, manufacture and stockpiling of chemical weapons. By the 1970s and 80s, an estimated 25 States were developing chemical weapons capabilities. But since the end of World War II, chemical weapons have reportedly been used in only a few cases, notably by Iraq in the 1980s against the Islamic Republic of Iran.

Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction:

- Adopted during 1992 Conference on Disarmament, Geneva, after 12 years of negotiations, The Chemical Weapons Convention (CWC) is a universal non-discriminatory, multilateral, disarmament treaty that bans the development, production, acquisition, transfer, use, and stockpile or retains Chemical Weapons (CW). The treaty entered into force on April 29, 1997.
- In order to prepare for the entry-into-force of the CWC, a Preparatory Commission of the **Organisation for the Prohibition of Chemical Weapons (OPCW)** was established with the responsibility to prepare detailed operation procedures and to put into place the necessary infrastructure for the permanent implementing agency provided for in the Convention.
- Headquarters for this organization were established in The Hague, the Netherlands. The CWC entered into force on 29 April 1997, 180 days after deposit of the 65th instrument of ratification.
- The treaty puts all the States Parties on an equal footing. Countries having stockpiles of chemical weapons are required to declare and destroy them in a specified time frame and those, who produce and use chemicals that can be converted into chemical weapons have to be open and transparent about the use they put these chemicals to.
- The CWC also requires the complete and verifiable (inspectable) destruction of existing CW stockpiles. The CWC addresses one of the national programmes and indirectly addresses the threat of chemical terrorism.

Biological Weapons

Biological weapons are complex systems that disseminate disease-causing organisms or toxins to harm or kill humans, animals or plants. They generally consist of two parts – a weaponized agent and a delivery mechanism. In addition to strategic or tactical military applications, biological weapons can be used for political assassinations, the infection of livestock or agricultural produce to cause food shortages and economic loss, the creation of environmental catastrophes, and the introduction of widespread illness, fear and mistrust among the public.

Biological warfare agents

- Biological warfare agents differ greatly in the type of organism or toxin used in a weapons system, lethality, length of incubation, infectiousness, stability, and ability to be treated with current vaccines and medicines. There are five different categories of biological agents that could be weaponized and used in warfare or terrorism. These include:
  - Bacteria—single-cell organisms that cause diseases such as anthrax, brucellosis, tularemia, and plague.
  - Rickettsiae—microorganisms that resemble bacteria but differ in that they are intracellular parasites that reproduce inside cells. Typhus and Q fever are examples of diseases caused by rickettsia organisms.

- Viruses—intracellular parasites, about 1/100 the size of bacteria, that can be weaponized to cause diseases such as Venezuelan equine encephalitis.
- Fungi—pathogens that can be weaponized for use against crops to cause such diseases as rice blast, cereal rust, wheat smut, and potato blight.
- Toxins—poisons that can be weaponized after extraction from snakes, insects, spiders, marine organisms, plants, bacteria, fungi, and animals. An example of a toxin is ricin, which is derived from the seed of the castor bean.

How can biological weapons be defended against?

- Biological defense may be divided into the following categories: prevention, protection, detection, treatment, and decontamination.
- **Prevention** may take several forms. In the case of biological warfare, international disarmament and inspection regimes may deter production and dissemination of biological warfare agents. Intelligence assets may indicate potential threats and allow for preventative action to be undertaken.
- **Protection** against biological warfare agents is limited. Protective suits, clothing, gas masks and filters may provide limited protection for short periods of time. However, the persistence of biological agents such as anthrax makes such protections mainly useful for military personnel and first responders. Anthrax can remain active and potentially lethal for at least 40 years.
- **Detection** by improved and quicker detectors. Current detectors include: SMART (Sensitive Membrane Antigen Rapid Test) JBPDS (Joint Biological Point Detection System) BIDS (Biological Integrated Detection System) IBAD (Interim Biological Agent Detector)
- **Decontamination:** Unlike chemical weapons, which disperse over time, biological agents may grow and multiply over time. Anthrax can remain active in the soil for at least 40 years and is highly resistant to eradication.

The Biological and Toxin Weapons Convention

- The Biological and Toxin Weapons Convention (BTWC) entered into force in March 1975 after 22 governments had ratified, and was the first multilateral disarmament treaty banning an entire category of weapons of mass destruction. The Convention, about four pages long, **bans the development, production stockpiling, or acquisition of biological agents** or toxins of any type or quantity that do not have protective, medical, or other peaceful purposes, or any weapons or means of delivery for such agents or toxins. Under the treaty, all such materiel is to be destroyed within nine months of the treaty's entry into force. The BTWC currently has 163 states parties and 110 signatories.

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Chapter

5

NANOSCIENCE & NANOTECHNOLOGY

Nanotechnology is science, engineering, and technology conducted at the nano-scale, which is about 1 to 100 nanometers. Nano-science and nanotechnology are the study of application of extremely small things and can be used across all other science fields, such as chemistry, biology, physics, materials science and engineering.

What is Nanoscience & Nanotechnology?

- 'Nanoscience and nanotechnology' are closely related and linked in practice yet it is convenient to draw a distinction between them. Nanoscience is the study of structures and materials on the scale of nanometers. Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those a larger scale.
- Nanotechnologies, on the other hand, are the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale.
- Nanoscience and nanotechnology involve the ability to see and to control individual atoms and molecules.

Basics of Nanoscience

- The size range from 100 nm down to the atomic level (approximately 0.2 nm), because it is in this range (particularly at the lower end) that materials can have different or enhanced properties compared with the same materials at a larger size.
- The two main reasons for this change in behaviour are an increased relative surface area, and the dominance of quantum effects.
- A defining feature at the nanoscale is the very large surface-to-volume ratio of these structures. This means that no atom is very far from a surface or interface and the behaviour of atoms at these higher-energy sites have a significant influence on the properties of the material.
- For example, the reactivity of a metal catalyst particle generally increases appreciably as its size is reduced-matcroscopic gold is chemically inert, whereas at nanoscales gold becomes extremely reactive

and catalytic and even melts at a lower temperature. An increase in surface area (per unit mass) will result man increase in chemical reactivity, making some- nanomatenals useful as catalysts to improve the efficiency of fuel cells and batteries.

- As the size of matter is reduced to tens of nanometres or less, quantum mechanical effects can begin to play a role and lead to new physics and chemistry. These can significantly change a material's optical, magnetic or electrical properties.
- At the larger end of the size range, other effects such as surface tension or `stickiness' are important, which also affect physical and chemical properties. For liquid or gaseous environments Brownian motion, which describes the random movement of larger particles or molecules owing to their bombardment by smaller molecules and atoms, is also important. This effect makes control of individual atoms or molecules in these environments extremely difficult.
- Nanoscience is concerned with understanding these effects and their influence on the properties of material. 'Nanotechnologies aim to exploit these effects to create structures, devices and systems with novel properties and functions due to their size.
- Nanotechnologies can be regarded as genuinely interdisciplinary, and have prompted the collaboration between researchers in previously disparate areas to share knowledge, tools and Techniques.

Applications of Nanotechnology

Nano Medicine

- Nano medicine is the medical application of Nano technology. Nano medicine ranges from medical application of Nano materials and biological devices to nano electronic bio sensors and future biological machines.
- **Advantage of nano in biological application:** The size of nano materials is similar to that of most biological molecules and structures; therefore, nano-materials can be useful for both in vivo(inside the body) and in vitro(outside body) biomedical research and applications. Thus far, the integration of nano materials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.
  - **Drug Delivery:** Nanotechnology has provided the possibility of delivering drugs to specific cells using nanoparticles (increases effectiveness, less side effects)
  - **Tissue Engineering:** Tissue engineering is the new emerging field of science which makes use of nanotechnology to repair the damaged tissues. The cells can be artificially reproduced by using suitable nanomaterials scaffolds and other growth factors.
  - **Diagnostic:** The use of nanomaterials to diagnose different diseases is the most important achievement of medical field. Nanoparticles are attached to the antibody or they can be attached to the molecules to label or to see the structures of proteins in any organism.
  - **Sensing:** Lab-on-chip technology, where magnetic nano particles bound to a suitable antibody, are used to label specific molecules, structures or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample.

Food

- Nanotechnology offers some exciting potential benefits for the quality and safety of our foods.
  - **Contamination Sensor:** Flash a light to reveal the presence of E. coli bacteria.
  - **Antimicrobial Packaging:** Edible food films made with cinnamon or oregano oil, or nano particles of zinc, calcium other materials that kill bacteria.

- **Improved Food Storage:** Nano-enhanced barrier keeps oxygen-sensitive foods fresher.
- **Enhanced Nutrient Delivery:** Nano-encapsulating improves solubility of vitamins, antioxidants, healthy omega oils and other 'nutraceuticals'.
- **Green Packaging:** Nano-fibers made from lobster shells or organic corn are both antimicrobial and biodegradable.
- **Pesticide Reduction:** A cloth saturated with nano fibers slowly releases pesticides, eliminating need for additional spraying and reducing chemical leakage into the water supply.
- **Tracking, Tracing and Brand Protection:** Nanobarcodes can be created to tag individual products and trace outbreaks.
- **Texture:** Food spreadability and stability improve with nano-sized crystals and lipids for better low-fat foods.
- **Flavor:** Trick the tongue with bitter blockers or sweet and salty enhancers.
- **Bacteria Identification and Elimination:** Nano carbohydrate particles bind with bacteria so they can be detected and eliminated.

Semiconductors and Computing

- The computer industry is already working on a nanoscale.
- Trend is emerging of the convergence between IT, nanotechnology, biotechnology and cognitive sciences.
- **Nanotechnology improve the capabilities of electronic components as given below:**
  - By reducing the size of transistors used in integrated circuits.
  - Researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch and this increases the density of memory chips.
  - By improving display screens on electronics devices and this reduces power consumption and also the weight and thickness of the screens.
  - By traditional scaling limits in standard CMOS technology. This development of nano electronic components are called as 'Beyond CMOS' domain of development.
- **Energy Production:**
  - The devices using Nano electronics technology also includes solar cells that are highly efficient and cheaper than the conventional ones. If such efficient solar energy can be created it would be a revolution to the global energy needs.
  - Using the technology, researchers are developing a generator for energy production in vivo called bio-nano generators. Basically, the generator is an electrochemical device which is designed in nanoscale size. It works like a fuel cell which generates the power by absorbing the blood glucose in a living body. The glucose will be separated from the body with the help of an enzyme. This enzyme separates the glucose from the electrons and makes them useful for generating power.
- **Nano Fabrication:**
  - Single electron transistors, nano electromechanical systems, ultra dense parallel line of nano wires
- **Textiles**
  - The textile industry could be affected quite significantly by nanotechnology, with some estimates talking of a market impact of hundreds of billions of dollars over the next decade. Nanoscience has already produced stain- and wrinkle-resistant clothing, and future developments will focus on upgrading existing functions and performances of textile materials; and developing "smart" textiles with unprecedented functions.

- Carbon Nanofibers and Carbon Nanoparticles
- Clay Nanoparticles

Sustainable Energy

- Prototype solar panels incorporating nanotechnology are more efficient than standard designs in converting sunlight to electricity, promising inexpensive solar power in the future. Nanostructured solar cells already are cheaper to manufacture and easier to install, since they can use print-like manufacturing processes and can be made in flexible rolls rather than discrete panels. Newer research suggests that future solar converters might even be "paintable."
- Nanotechnology is improving the efficiency of fuel production from normal and low-grade raw petroleum materials through better catalysis, as well as fuel consumption efficiency in vehicles and power plants through higher-efficiency combustion and decreased friction.
- Nano-bioengineering of enzymes is aiming to enable conversion of cellulose into ethanol for fuel, from wood chips, corn stalks (not just the kernels, as today), unfertilized perennial grasses, etc.
- Nanotechnology is already being used in numerous new kinds of batteries that are less flammable, quicker-charging, more efficient, lighter weight, and that have a higher power density and hold electrical charge longer. One new lithium-ion battery type uses a common, nontoxic virus in an environmentally benign production process.
- Nanostructured materials are being pursued to greatly improve hydrogen membrane and storage materials and the catalysts needed to realize fuel cells for alternative transportation technologies at reduced cost. Researchers are also working to develop a safe, lightweight hydrogen fuel tank.
- Energy efficiency products are increasing in number and kinds of application. In addition to those noted above, they include more efficient lighting systems for vastly reduced energy consumption for illumination; lighter and stronger vehicle chassis materials for the transportation sector; lower energy consumption in advanced electronics; low-friction nano-engineered lubricants for all kinds of higher-efficiency machine gears, pumps, and fans; light-responsive smart coatings for glass to complement alternative heating/cooling schemes; and high-light-intensity, fast-recharging lanterns for emergency crews.

Environment

- Besides lighter cars and machinery that requires less fuel, and alternative fuel and energy sources, there are many eco-friendly applications for nanotechnology, such as materials that provide clean water from polluted water sources in both large-scale and portable applications, and ones that detect and clean up environmental contaminants.
- Nanotechnology could help meet the need for affordable, clean drinking water through rapid, low-cost detection of impurities in and filtration and purification of water.
- Nanoparticles can be used to clean industrial water pollutants in ground water through chemical reactions that render them harmless, at much lower cost than methods that require pumping the water out of the ground for treatment.
- Researchers have developed a nanofabric "paper towel," woven from tiny wires of potassium manganese oxide, that can absorb 20 times its weight in oil for cleanup applications.
- Many Airplane cabin and other types of air filters are nanotechnology-based filters that allow "mechanical filtration," in which the fiber material creates nanoscale pores that trap particles larger than the size of the pores. They also may contain charcoal layers that remove odors.
- New nanotechnology-enabled sensors and solutions can be able to detect, identify, and filter out, and/or neutralize harmful chemical or biological agents in the air and soil with much higher sensitivity than is possible today.

Transport

- In addition to contributing to building and maintaining lighter, smarter, more efficient, and "greener" vehicles, aircraft, and ships, nanotechnology offers various means to improve the transportation infrastructure:
- Nano-engineering of steel, concrete, asphalt, and other cementitious materials, and their recycled forms, offers great promise in terms of improving the performance, resiliency, and longevity of highway and transportation infrastructure components while reducing their cost. New systems may incorporate innovative capabilities into traditional infrastructure materials, such as the ability to generate or transmit energy.
- Nanoscale sensors and devices may provide cost-effective continuous structural monitoring of the condition and performance of bridges, tunnels, rails, parking structures, and pavements over time. Nanoscale sensors and devices may also support an enhanced transportation infrastructure that can communicate with vehicle-based systems to help drivers maintain lane position, avoid collisions, adjust travel routes to circumnavigate congestion, and other such activities.

Space

- Employing materials made from carbon nanotubes to reduce the weight of spaceships like the one shown below while retaining or even increasing the structural strength.
- Using carbon nanotubes to make the cable needed for the space elevator, a system which could significantly reduce the cost of sending material into orbit.
- Including layers of bio-nano robots in spacesuits.
- Producing thrusters for spacecraft that use MEMS devices to accelerate nanoparticles.
- Using carbon nanotubes to build lightweight solar sails that use the pressure of light from the sun reflecting on the mirror-like solar cell to propel a spacecraft. This solves the problem of having to lift enough fuel into orbit to power spacecraft during interplanetary missions.
- Working with nanosensors to monitor the levels of trace chemicals in spacecraft to monitor the performance of life support systems.

Agriculture

- **Nanotechnology for Crop Biotechnology**
  - Nanoparticles can serve as 'magic bullets', containing herbicides, chemicals, or genes, which target particular plant parts to release their content. Nanocapsules can enable effective penetration of herbicides through cuticles and tissues, allowing slow and constant release of the active substances.
- **Nanotech Delivery Systems for Pests, Nutrients, and Plant Hormones**
  - Nano-sensors and nano-based smart delivery systems could help in the efficient use of agricultural natural resources like water, nutrients and chemicals through precision farming. Through the use of nanomaterials and global positioning systems with satellite imaging of fields, farm managers could remotely detect crop pests or evidence of stress such as drought. Once pest or drought is detected, there would be automatic adjustment of pesticide applications or irrigation levels.
  - Nano-sensors dispersed in the field can also detect the presence of plant viruses and the level of soil nutrients. Nano-encapsulated slow release fertilizers have also become a trend to save fertilizer consumption and to minimize environmental pollution.
  - Nano-barcodes and nano-processing could also be used to monitor the quality of agricultural produce. Scientists at Cornell University used the concept of grocery barcodes for cheap, efficient, rapid and easy decoding and detection of diseases.

- They produced microscopic probes or nano-barcodes that could tag multiple pathogens in a farm which can easily be detected using any fluorescent-based equipment. This on-going project generally aims to develop a portable on-site detector which can be used by non-trained individuals.
- Through nanotechnology, scientists are able to study plant's regulation of hormones such as auxin, which is responsible for root growth and seedling establishment.

Guidelines for Evaluation of Nano-based Agri-input and food products in India

- Guidelines for Evaluation of Nano-based Agri-input and food products in India' was jointly released by Dr. Harsh Vardhan, Minister for Science & Technology, Health & Family Welfare and Earth Sciences and Narendra Singh Tomar, Minister of Agriculture & Farmers Welfare and Rural Development & Panchayati Raj in Delhi on July 7, 2020.
- The guidelines have been prepared by the Department of Biotechnology (DBT) in conjunction with Ministry of Science and Technology, Ministry of Agriculture and Farmers' Welfare and Food Safety and Standards Authority of India (FSSAI) and Ministry of Health and Family Welfare.
- The guidelines are meant to assist in policy decision making by providing relevant information on the existing regulations for nano-based products in agriculture and food and also to ensure quality, safety and benefits of the intended products. Compared to the amount of chemical inputs in crops, use of nano-nutrients can reduce nutrient run-off into ground and surface water and can thus help to reduce environmental pollution.
- The guidelines can also help policy makers and regulators to frame effective provisions for future novel nano-based products in the agri-input and food sectors. The guidelines will also provide significant benefits for the government's mission on doubling farming income by 2022.

Health & Environmental Impacts of Nanotechnology

- Many nanotechnologies pose no new risks to health and almost all the concerns relate to the potential impacts of deliberately manufactured nanopartilces and nanotubes that are free rather than fixed to or within a material. Only a few chemicals are being manufactured in nanoparticulate form on an industrial scale and exposure to free manufactured nanoparticles and nanotubes is currently limited to some workplaces (including research laboratories) and a small number of cosmetic uses.
- At least some manufactured nanoparticles will be more toxic per unit of mass than larger particles of the same chemical. This toxicity is related to the surface area of nanoparticles and the chemical reactivity of the surface (which could be increased or decreased by the use of surface coatings). It also seems likely that nanoparticles will penetrate cells more readily than larger particles.
- It is very unlikely that new manufactured nanoparticles could be introduced into humans in doses sufficient to cause the health effects that have been associated with the nanoparticles in polluted air. However, some may be inhaled in certain workplaces in significant amounts and steps should be taken to minimize exposure.
- The physical characteristics of carbon and other nanotubes mean that they may have toxic properties similar to those of asbestos fibres, although preliminary studies suggest that they may not readily escape into the air as individual fibres. If nanoparticles penetrate the skin they might facilitate the production of reactive molecules that could lead to cell damage.
- So far, there is no information available about the effect of nanoparticles on species other than humans or about how they behave in the air, water or soil, or about their ability to accumulate in food chains. Until more is known about their environmental impact scientists think that the release of nanoparticles and nanotubes to the environment should be avoided as far as possible.

Social & Ethical Impacts

- The perceived opportunities and threats of nanotechnologies often stem from the same characteristics. For example, the convergence of nanotechnologies with information technology, linking complex networks of remote sensing devices with significant computational power, could be used to achieve greater personal safety, security and individualized healthcare and to allow businesses to track and monitor their products.
- It could equally be used for covert surveillance, or for the collection and distribution of information without adequate consent.
- As new forms of surveillance and sensing are developed, further research, and expert legal analysis might be necessary to establish whether current regulatory frameworks and institutions provide appropriate safeguards to individuals and groups in society.
- In the military context, too, nanotechnologies hold potential for both defence and offence and will therefore raise a number of-social and ethical issues. There is also speculation that a possible future convergence of nanotechnologies with biotechnology information and cognitive sciences could be used for reengineering human beings also If these possibilities were ever realised they would raise profound ethical questions.

Nano-Science & Nanotechnology in India

- In April 2004, President A P J Kalam organised a meeting of nanoscience experts to devise a national mission plan. Its recommendations included spending US$22 million each year for the next five years on five new national facilities specializing in complimentary areas of nanotechnology and ten 'mini centres' across the country. These centres would each serve US$5 million, and would focus on one or two areas of nanoscience and technology. Overall, the experts recommended that US$200 million be spent on nanotechnology over a five-year period.
- The President also called for a "dynamic task force" to identify important national projects and set deadlines for achieving results in areas such as nanotube based solar power cells, diagnostic kits and drug delivery systems for cancer and HIV/AIDS, and fluorescent nanopowders for use in display technologies.

'Nano Mission'

- It is in this background that the Government of India has in 2007 approved the launch of a Mission on Nano Science and Technology (Nano Mission) with an allocation of Rs. 1000 crore for 5 years. The Department of Science and Technology will be the nodal agency for implementing the Nano Mission.
- According to the mission statement Nano Technology being knowledge intensive and "enabling technology" is expected to influence a wide range of products and processes with far-reaching implications for national economy and development.

Significance of the Mission

- Capacity-building in this upcoming area of research will be of utmost importance for the Nano Mission so that India emerges as a global knowledge-hub in this field also.
- For this, research on fundamental aspects of Nano Science and training of large number of manpower will receive prime attention. Equally importantly, the Nano Mission will strive for development of products and processes for, national development, especially in areas of national relevance like safe drinking water, materials development, sensors-development, drug delivery, etc.

- For this, it will forge linkages between educational and research institutions and industry and promote Public Private Partnerships.
- The Nano Mission has been structured in a fashion so as to achieve synergy between the national research efforts of various agencies In Nano Science and technology and launch new programmes in a concerted fashion. International collaborative research efforts will also be made wherever required.
- The Indian government is also actively promoting links between research institutes and industry, and the Department of Science and Technology has cleared three collaborations between-public research institutions and the private sector.
- The New Millennium Indian Technology Leadership Initiative programme of the Council of Scientific and Industrial Research is also promoting two public private collaborative ventures for developing nanotechnologies that target drugs to exactly where they are needed in the-human body.
- Besides launching the Nano Science and Technology Initiative, India has also entered into bilateral nanotechnology programmes with the European Union, Germany, Italy, Taiwan and the United States. A national centre for nonmaterial's has been set up at the International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) in Hyderabad, in collaboration with Germany, Japan, Russia, Ukraine and the United States.
- When fully operational the centre will include pilot-scale facilities for producing and manipulating carbon nanotubes, ceramic and polymer composites rein-forced with such nanotubes and nanopowders for water and air purification technologies.

Current Nanosciene Scenario in India

- Some nano-products from ARCI have already been transferred to industry, including a water filter system for rural areas that uses silver nanoparticles and has shown good results. The centre has also developed technology for coating materials with nanopowders.
- Scientists at Banaras Hindu University have devised a simple-method to produce carbon nanotube filters that efficiently remove micro-to nano-scale contaminants from water and heavy hydrocarbons from petroleum. Made entirely of carbon nanotubes, the filters are easily manufactured using a novel-method for controlling the cylindrical geometry of the structure. They are produced by spraying benzene into a tube-shaped quartz mould and heating the mould to 900°C. **The nanotube composition makes the filters strong, reusable, and heat resistant, and they can be cleaned easily for reuse.**
- A research group headed by Professor A. N. Maitra of the University of Delhi has developed 11 patentable technologies for improved drug delivery systems using nanoparticles. Four of these processes have been granted U.S. patents.
- Another technology transferred to industry deals with nanoparticle drug delivery for eye diseases. Traditionally, steroids have been used extensively in the treatment of ocular inflammatory disease and allergies. However, prolonged use of steroids has many side effects. A Delhi University group has developed a process using nanoparticles to encapsulate non-steroidal drugs. This process aims to improve the bioavailability of the drug on the surface of the cornea. The technology has been transferred to Chandigarh-based Panacea Biotech Ltd.
- Typhoid Detection Kit has been developed by Defence Research and Development Establishment, Gwalior using the nano sensor developed by Indian Institute of Science, Bangalore. In India for routine diagnosis for typhoid disease widal test is performed with single serum sample which does not provide the correct diagnosis of infection. Therefore a Latex agglutination based test has been developed at the DRDE using recombinant DNA technology and immunological technique for rapid diagnosis of typhoid infection.
- There has been a significant increase in the number of nanoscience publications by Indian scientists in recent years though the number is small compared to China. According to one estimate, Indian researchers have so far only published about 100 nanoscience papers in major journals, while Chinese researchers produce more than twice that number each year.

Prospects for Nanotechnology in India

- The next decade will see nanotechnology playing a dominant role in the global-business environment and is likely to become a trillion dollar industry.
- In this scenario, with the core competence of IITs and Indian R&D institutions in collaboration with international institutions and industries create vertical missions under a joint venture organisation for many nano technology products in Water, Energy, Agriculture, Healthcare, Space and Defence and ICT sectors these identified vertical missions, R&D institutions, Universities, private and public Industries from India and other partnering countries should work together for faster design, development and production of products for world market.
- Nano technology holds great potential for India and a multi pronged approach will ensure that this is fully leveraged. Funding should be increased and long term funding which can accommodate coherent research programs with high-impact outcome is needed. Various research centers throughout India must work together so that the collective efforts can lead to better results. A highly equipped central facility should plan and initiate research activities.
- The administrative aspects of new projects should be streamlined. Most importantly, remuneration for people trained in the field should increase, to attract high caliber work force to join these research facilities.

Way Forward

- Other commercial applications related to nano-science and nanotechnology are expected in the near future; still more predicted for more distant horizons. Many of these commercial applications are predicted to stem from the interaction of several different disciplines and technologies at the nano-scale. It has been said that "this kind of disruptive technology' may create whole new industries and products we can't begin to imagine". In recent times there have been reports on exciting potential applications for the future, from the precise delivery of drugs to parts of the body to cables from earth to space capable of carrying small vehicles and producing energy.
- Hopes have been expressed for the development and use of mechanical nano-machines which would be capable of producing materials (and themselves) atom-by-atom. Alongside such hopes for self-replicating machines, fears have been raised about the potential for these machines to go out of control, produce unlimited copies of them, and consume all available material on the planet in the process.

Nano-Technology Medicines

- Nano-technology is a group of emerging technologies in which the structure of matter is controlled at the nanometer scale, the scale of small numbers of atoms, to produce novel materials and devices that have useful and unique properties.
- Nano medicine is the medical application of Nano technology. Nano medicine ranges from medical application of Nano materials and biological devices to nano electronic bio sensors and future biological machines.

Advantage of Nano-Technology in Biological Application

- The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nano-materials can be useful for both in vivo (inside the body) and in vitro (outside body) biomedical research and applications. Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

- Drug Delivery: Nano-technology has provided the possibility of delivering drugs to specific cells using nanoparticles (increases effectiveness, fewer side effects).

Positive Impact

- Amount of drug required for treatment is reduced
- Less side effects.
- Effective treatment (more bioavailability). More than $65 billion are wasted each year due to poor bioavailability.
- Cost of treatment is reduced
- Smaller devices: A benefit of using nanoscale for medical technologies is that smaller devices are less invasive and can possibly be implanted inside the body, plus biochemical reaction times are much shorter
- Nanoparticles can be used in combination therapy for decreasing antibiotic resistance and multidrug resistance

Negative Impact

- Biodistribution of these nanoparticles is still imperfect due to the complex host's reactions.
- Difficulty in targeting specific organs in the body.
  - **Visualization:** Using Nano-particle contrast agents, high contrast images (e.g MRI, CT)
  - **Sensing:** Lab-on-chip technology, where magnetic nanoparticles bound to a suitable antibody, are used to label specific molecules, structures or micro-organisms.
- Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample.
- Nanopore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.
- Nanotechnology-based arthroscopes, which are pencil-sized devices that are used in surgeries with lights and cameras so surgeons can do the surgeries with smaller incisions.

Tissue Engineering:

- Nanotechnology may be used as part of tissue engineering to help reproduce or repair damaged tissue using suitable nanomaterial-based scaffolds and growth factors.
- Tissue engineering if successful may replace conventional treatments like organ transplants or artificial implants.
- Nanoparticles such as graphene, carbon nanotubes and tungsten disulfide are being used as reinforcing agents to fabricate mechanically strong biodegradable polymeric nanocomposites for bone tissue engineering applications.

The popularity of nano-medicine is escalating to attain safe and effective therapy, offering numerous benefits including:

- Personalized health care
- Improved bioavailability
- Sustained and controlled release
- Site-specific targeting
- Lack of occlusion of blood capillaries
- Easier transport across most physiological bio-barriers

- Protection of fragile drugs/proteins from the harsh biological environment
- Faster, safer and more precise disease diagnosis
- Better accuracy and less invasiveness

Challenges and Issues

- In India, nanomedicines are slowly appearing in the market, for example, Ranbaxy's Volini nanogel; therefore, regulatory guidelines are required to mitigate the hazardous outcome of any nanotechnology-based drug. The total number of nanomedicines under clinical trial is 21.
- The guideline preparation for nanomedicines is certainly not an easy task due to the lack of extensive and deep scientific knowledge as well as tools and techniques.
- There are few scientific and analytical concerns in the context of regulatory guideline for nanomedicines are discussed here:
- Firstly, the definition of nanoproducts is not universally accepted and as a result, there is no homogenization of the acceptable limit, for example, the US National Nanotechnology Initiative (NNI) launched in 2000 considers the dimension from 1-100nm. The U.K. Royal Society and Royal Academy of Engineering, 2004 proposed a range of 0.2-100nm. The Friends of the Earth Australia recommend defining nanoparticles up to 300nm in size.
- Secondly, occupational hazards and associated health risks are not clear.
- Thirdly, the aspects related to the clinical usage of nanomedicines as they are supposed to deliver the drugs locally in high doses at a particular cellular site. The localized high drug dose may lead to toxicity of a particular cell/organ type (lethal particularly in patients like diabetes and chronic kidney disease) or the emergence of antibiotic-resistant superbugs in case of antibiotics.
- Therefore, the regulatory bodies need to assess whether the nanomedicines are allowed to market under strict medical supervision or simply labeled as Nano.

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Chapter

6

ROBOTICS

What is Robotics?

- Robotics is the field of S & T dealing with the design, manufacture & application & using computer for their manipulation & processing.
- Robots can be autonomous or semi-autonomous and range from humanoids such as Honda's **Advanced Step in Innovative Mobility (ASIMO)** and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, medical operating robots, patent assist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots. By mimicking a lifelike appearance a robot may convey a sense of intelligence or thought of its own

Advantages of Robots

- **Cost:** The most obvious advantage of robots is their cost. Robots are cheaper than most human counterparts, and their costs are still decreasing.
- **Abilities:** Robotic abilities, what robots can do are now extremely vast and growing.
- **Productivity:** Robots do not tire and can work very long hours without service or maintenance. As a result, robots can be significantly more productive than people.
- **Precision:** Robots can be much more precise than people. For instance, robots should not tremble or shake as human hands do.
- **Strength:** Without a doubt, robots can be significantly stronger than people.
- **Speed:** Additionally, robots can be significantly faster than people too.
- **Size:** Robots can come in any size. Whatever size needed for any task can be created.
- **Environment:** Robots can be designed to work in extremely harsh environments, such as in space, without air, underwater, fire, etc.
- **Dangerous and Unwanted Work:** Finally, robots can do jobs that people are unwilling to do. For instance, many robotic probes have been sent throughout the solar system to never return back to Earth.
- **Warfare:** Using robots in warfare eliminates putting more people at risk and has proven to be very successful.

Disadvantages of Robots

- **Jobs:** The biggest issue with using robots is the huge loss of jobs for people. Basically, robots have eradicated a wide range of middle class jobs in several industries, such as car manufacturing.
- **Limited Functionality:** Robots are very good at doing perfectly defined jobs, however robots typically do not handle the unexpected as well as people do.
- **Lack of Intelligence:** Since robots are not intelligent or sentient, robots can never improve the results of their jobs outside of their predefined programming.
- **Dangerous:** Robots can be extremely dangerous. Whether robots are malfunctioning or designed for warfare, robots can be very hazardous to people.

Applications of Robotics

- **Industrial Sector:** Industrial robots are electronically controlled, both programmable and reprogrammable to carry out certain tasks with high precision and accuracy.
- **Aerospace:** Another application of robots is in aerospace for outer space exploration. Aerospace robots or unmanned robotic spacecraft play a key role in outer space probe\
- **Healthcare Delivery:** A highly possible advancement in healthcare is using robots in robotic surgery. Due to technological advancement, this is possible even if the patient is located in remote areas. This possibility defies distance.
- **Outer Space:** Robotic arms that are under the control of a human being are employed to unload the docking cove of outer-space shuttles to launch satellites or to build a space station.
- **The Intelligent Home:** Robotic systems can nowadays scrutinize home safety, ecological circumstances and energy consumption.
- **Exploration:** Robots can enter the environments that are injurious to human beings. An illustration is observing the atmosphere within a volcano or investigating our deep marine life.
- **Military Robots:** Flying robot drones are brought into play for close watch in present time's modern armed force.
- **Disaster Areas:** Observation robots built-in with superior sensing and imaging gears. This robot can work in dangerous environments like urban site spoiled by earthquakes by inspecting floors, walls and roofs for structural reality.
- **Entertainment:** Interactive robots that shows behaviors and education capability. One such robot is owned by SONY which moves around freely, responds to all your commands, carries your luggage and even responds to your oral instructions.
- **Agriculture:** Programmed robots are used by harvesters to cut and collect crops. Robotic milk farms are existing permitting workers to nourish and milk their cattle distantly.
- **Service robot:** A service robot is a robot which operates semi or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations.
- **Education:** Robots are used as educational assistants to teachers. There are robot kits like Lego Mindstorms, BIOLOID, OLLO from ROBOTIS, or BotBrain Educational Robots can help children to learn about mathematics, physics, programming and electronics.

Military Robots (Robotic soldier)

- Military robots are autonomous robots or remote-controlled mobile robots designed for military applications, from transport to search & rescue and attack.
- There are also moves being made to develop cyborg soldiers - Humans and animals augmented by technology.

Some examples are:

- **Terminator-Style Humanoids:** One such robot is Atlas, a 6'2, machine that walks on 2 legs and is designed, at least for the time being, for disaster relief.
- **Four-legged Carrier Mules:** AlphaDog is a 4-legged horse/mule robot designed for military purposes to carry heavy loads of equipment. The sturdy machine can run across uneven and rocky terrain and it can also right itself very easily if it is pushed over or falls
- **Bomb-disposal Bots:** Bomb disposal is a highly-skilled and risky profession, so it makes complete sense to let a robot get up close and personal with the explosives, while the human commander can watch and give commands from afar.
- **Stealthy Spybots:** The US Navy has been working on a swarm of robot boats that work together autonomously to overwhelm a target. The boats are designed to follow a bigger boat like a pack of guard dogs and then attack on command using weapons if necessary.
- **Sleepless Sentries:** Along border between North and South Korea are dotted weaponised robot sentries that are alert 24 hours per day. It can detect intruders using machine vision and fire at targets 3 miles away. The system requires no human presence
- **Drone Aircraft Carriers:** The sky-based aircraft carrier would be useful for releasing surveillance and killing missions without putting pilots at risk
- **Cyborg Super Soldiers:** Instead of replacing humans with robots, why not augment humans with wearable computers, helmet visors with a heads-up display and night vision as well as robotic exoskeletons for super-human strength.

Medical Robots (Robotic Medicine)

- A medical robot is a robot that allows surgeons greater access to areas under operation using more precise and less invasive methods.
- In the field of medical robotics, the word robot is just as fuzzily defined, with many different applications. These range from simplistic laboratory robots, to highly complex surgical robots that can either aid a human surgeon or execute operations by themselves.
- Applications The use of robots is not confined to the operating theatre. Other application areas where medical robots prove useful include:
  - **Laboratory Robots:** Laboratory robots carry out hundreds of tests (e.g. blood testing for HIV) in parallel, saving time and freeing manpower for other purposes.
  - **Hospital Robots:** As hospital staff is in short supply, mobile robots in hospitals can help by fetching or distributing medicine, while patient handling robots may assist in the lifting and positioning of patients that are difficult to manage.
  - **Rehabilitation Robots:** Rehabilitation robots are robots that help permanently or temporarily disabled people with the matters that they cannot deal with themselves.
  - **Robotic Surgery:** Robotic surgery is the process whereby a robot actually carries out a surgical procedure under the control of nothing other than its computer program. Although a surgeon almost certainly will be involved in the planning of the procedure to be performed and will also observe the implementation of that plan, the execution of the plan will not be accomplished by them - but by the robot.

Robotics and Issues of Unemployment

- World is witnessing the beginning of fourth industrial revolution that is fundamentally changing the way we live, work and relate to one another.

- Previous industrial revolutions liberated humankind from animal power, made mass production possible and brought digital capabilities to billions of people. This Fourth Industrial Revolution/ second Machine Age is, however, fundamentally different. It is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human.
- The Second Machine Age involves the automation of a lot of cognitive tasks that make humans and software-driven machines substitutes, rather than complements to Human effort. It contrasts with the "First Machine Age", or First Industrial Revolution, which helped make labor and machines complementary.
- Initially it was assumed that computers could make human tasks easier but they could not do away with the human altogether. But after 50 years of the computer age that barrier has finally cracked. Robots nowadays are increasingly doing complex things as the mental and physical dexterity gap has been narrowed down. For Example - Google's driverless car is around the corner, Amazon's robots pack delivery boxes in warehouses so empty of people that there is no need for light or a controlled temperature. Amazon's Kiva Robots lift shelves that weigh around 1,360kg, 24x7, without a toilet break, lunch hour, health insurance or pension plan. They don't get stuck in traffic or snow and they don't have attitude.
- The resulting shifts mean that we live in a time of great promise and great peril.

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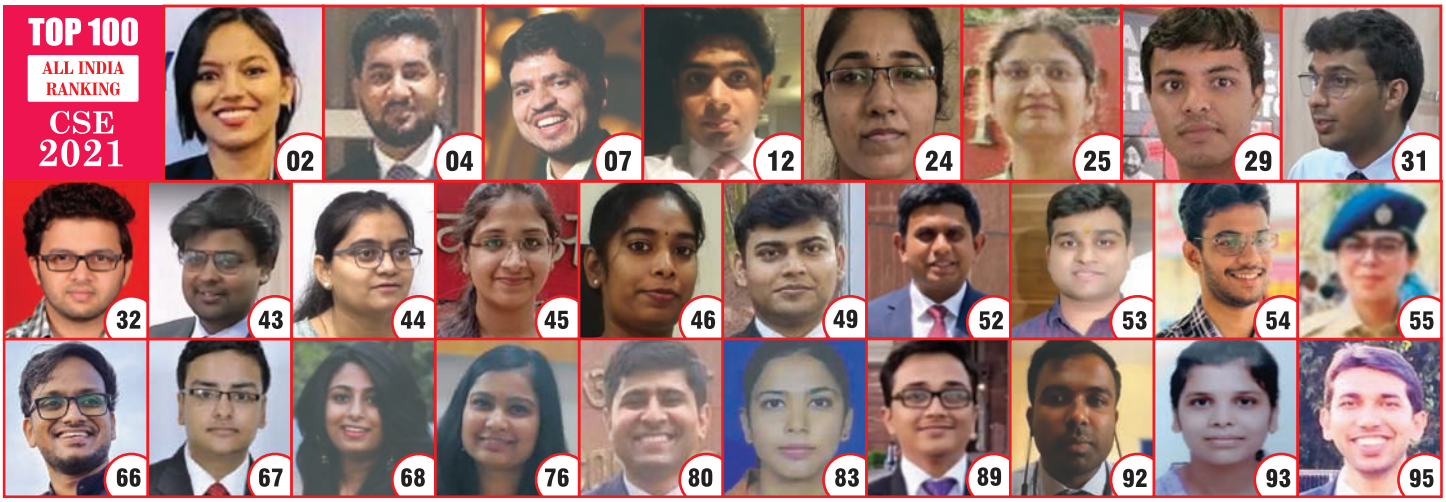
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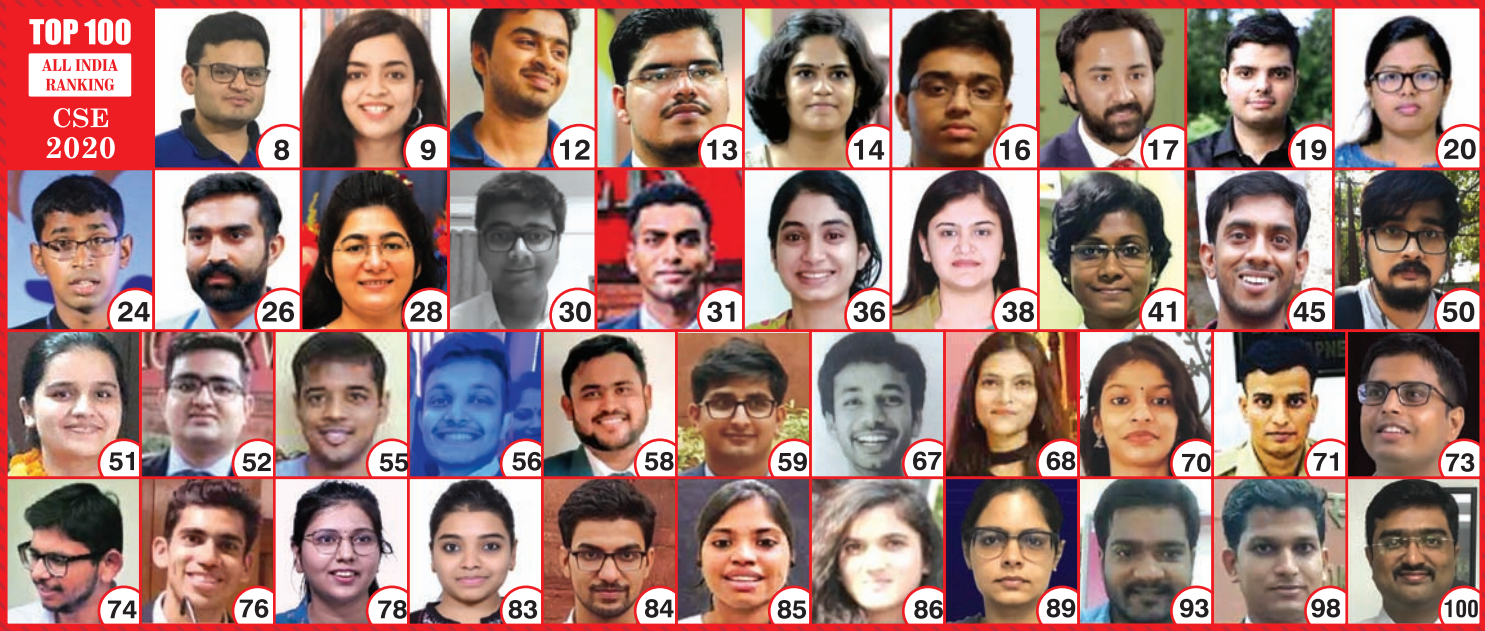
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