ADDIS COLLEGE
CONSTRUCTION MANAGEMENT MASTER'S PROGRAM

Advanced Construction Quality, Cost and Time Management (COTM 6202)

1. Background to Construction Project Management Tools and Techniques

Organized by: Belachew Asteray (Ph.D.)

January 2020

1. Background to Construction Project Management Tools and Techniques

- Construction project managers are using a different kind of methods and techniques to accomplish project's objectives in pre-construction and post construction period.
- Project management tools assist for the effective planning and completion of tasks under the all work progress.
- Project manager handle varieties methods depend on the project type and nature of the works.
- Each manager comes with different ideas to manage and control the work in a large building or infrastructure projects.

1. Background to Construction Project Management Tools and Techniques…

- Today, project management is gaining ***prominence and recognition*** in countries all over the world, although the level of awareness and utilization of project management ***skills, tools and techniques*** have been seen to vary from countries to countries all over the world.
- The implementation of ***modern project management tools, methods and techniques*** is still ***not well established*** in public as well as in the private sectors, this results into failure of public institutions and their contractors in performing their duties concerning the budget, specifications and deadlines of the projects awarded.

1. Background to Construction Project Management Tools and Techniques…

- The best way to assess project management practices in various organizations is ***to assess the awareness and use of various project management tools and techniques***, and to also assess ***the success rate*** resultant from the use of those tools and techniques.
- Project Management planning tools/ techniques are tools/ techniques which generally ***helps to effectively plan towards the successful implementation of projects.***
- From the different institutions, every project manager should be familiar at least the following four key project management knowledge areas namely,
  - **Scope Management**
  - **Cost Management,**
  - **Project Time Management,**
  - **Risk Management and**
  - **Quality Management.**

•Tools and Techniques

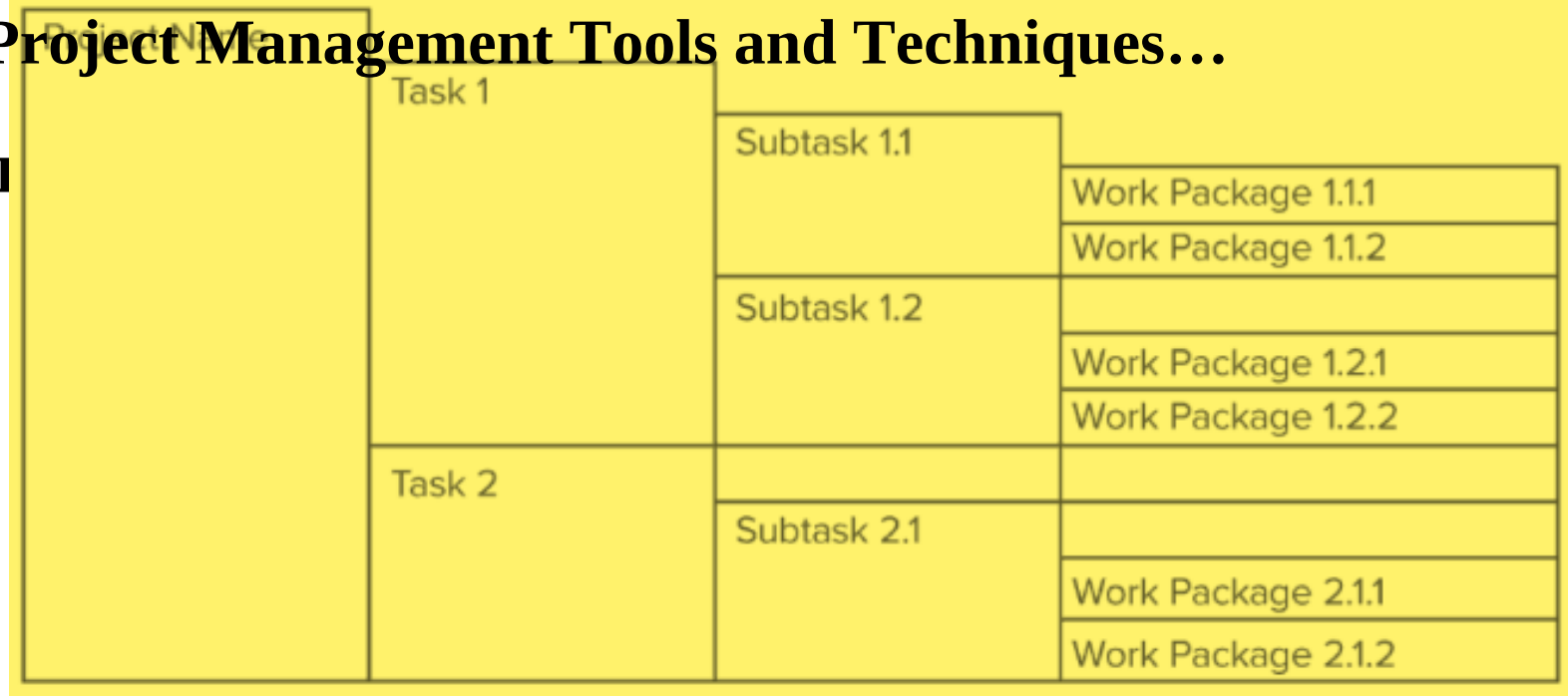
- **Work Breakdown Structure (WBS)**
- A work breakdown structure (WBS) is a ***visual tool for defining and tracking a project deliverable*** and all the small components needed to create it.
- As defined by the Project Management Body of Knowledge, the work breakdown structure is a "***hierarchical decomposition of the total scope of work*** to be carried out by the project team to ***accomplish the project objectives*** and ***create the required deliverables***."

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- **Work Breakdown Structure (WBS)**:
- According to Association for Project Management Body of Knowledge, (APMBOK, 2006), WBS is a way by which a project may be divided by level into discrete groups for programming, cost planning and control purposes.
- It deals with breaking down of the projects into manageable individual components in a **hierarchical structure**.
  - Such a structure defines ***tasks that can be completed independently of other tasks***, facilitating resource allocation, assignment of responsibilities and measurement and control of project (Olateju et al, 2011).

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- **Work Breakdown Structu**



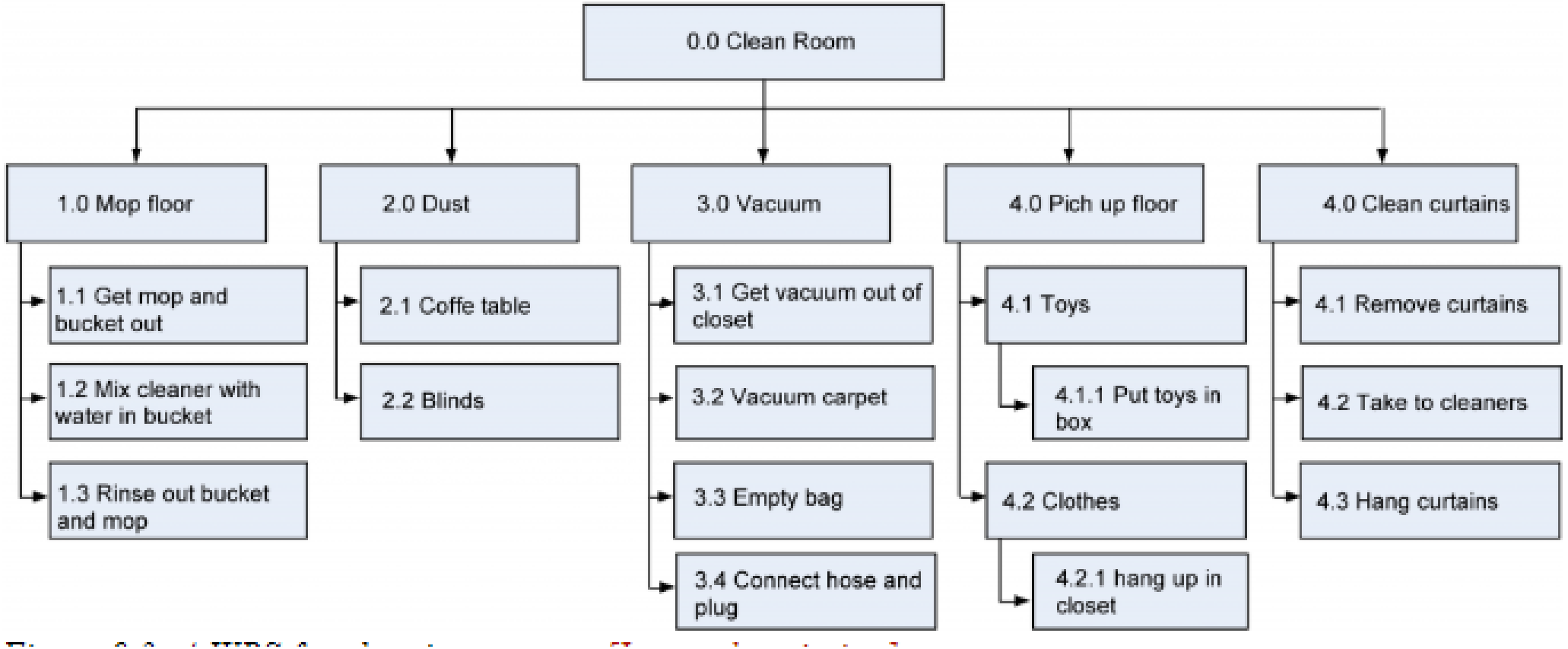
- The WBS defines the **scope of the project** and ***breaks the work down into components*** that can be scheduled, estimated, and easily monitored and controlled.
- The idea behind the WBS is simple: you ***subdivide a complicated task into smaller tasks***, until you reach a level that cannot be further subdivided.
- The deliverable can be a ***physical object, a service, or an activity***.

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- **Work Breakdown Structure (WBS)**…
- The WBS creation involves:
  - ***Listing all the project outputs*** (deliverables and other direct results)
  - ***Identifying all the activities required to deliver the outputs***
  - ***Subdividing these activities into sub activities and tasks***
  - ***Identifying the deliverable and milestone(s) of each task***
  - ***Identifying the time usage of all the resources (personnel and material) required to complete each task***
- The purpose of developing a WBS is to:
  - Allow ***easier management of each component***
  - Allow ***accurate estimation of time, cost, and resource requirements***
  - Allow ***easier assignment of human resources***
  - Allow ***easier assignment of responsibility for activities***

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- **Work Breakdown Structure (WBS)**…
- Example of a WBS



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- **Work Breakdown Structure (WBS)…**
- ***Benefits of creating a WBS:***
  - Provides ***a visual representation of all parts of the project***
  - Offers an ongoing view for stakeholders into how the project is progressing
  - Defines ***specific and measurable outcomes***
  - Breaks the ***work into manageable chunks***
  - Provides a way to make successful experiences repeatable
  - Sets a foundation for ***estimating costs and allocating team members and other resources***

- **Decomposition Technique**:
- According to PMBOK (2003), decomposition is the ***subdivision of project deliverables*** into smaller, more manageable components until the work and deliverables are defined to the work package level.
- Decomposition technique is used ***to create the WBS by subdividing the project deliverables*** into smaller manageable tasks or work components called work packages.
- It is also used in the ***activity definition process for subdividing the work packages*** into smaller, more manageable components called schedule activities.

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- ***Expert Judgment Technique***:
- This refers to ***judgment provided based upon expertise*** in an application area, knowledge area, discipline, industry etc as appropriate for the activity being performed.
- Such expertise may be provided by any group or person with ***specialized education, knowledge, skill, experience, or training***, and is available from many sources, including: other units within the performing organization; consultants; stakeholders, including customers; professional and technical associations and industry groups.
- For example, ***project team members*** or ***other experts*** who are experienced and skilled in ***developing detailed project scope statements, WBSs, and project schedules*** can provide expertise in defining activities.

- **Modular Approach/ *Bottom-up estimating***
- It is an estimating technique which is based on ***making estimates for every work package (or activity)*** in the work breakdown structure and summarizing them to provide ***a total estimate of cost or effort required*** (APMBOK, 2006).
- It is used ***when a schedule cannot be estimated with a reasonable degree of confidence***.
- The resource needs of each lower, more detailed piece of work are estimated, and these estimates are then aggregated into a total quantity for each schedule activity‘s resources.
- If there are dependencies between schedule activities, the pattern of resource usage is reflected in the estimated requirements of the schedule activity and is documented (PMBOK, 2003).

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- ***Benchmark Job Technique/ Comparative or analogous estimating***
- It is an estimating technique which uses ***historic data*** from similar project ***to determine the most appropriate cost and time*** (APMBOK, 2006).
- It uses the ***values of parameters*** such as ***scope, cost, budget, and duration, or measures of scale*** such as size, weight and complexity ***from a previous, similar activity*** as the basis for estimating the same parameter or measure for a future activity (PMBOK, 2003).

- ***Parametric Estimating Techniques***:
- It‘s an estimating technique that uses a ***statistical relationship between historical data and other variables*** (e.g. ***square meter in construction***) ***to calculate or estimate for activity parameters*** such as ***scope, cost, budget and duration***.
- This method of estimating is typically used in ***statistical modelling.***

- ***Gantt chart:***
- It‘s a ***particular type of bar chart*** used in project management showing **planned activity against time**.
- It is a ***time-phased graphic display*** of activity durations.
- Activities are listed with other tabular information on the left side with time intervals over the bars.
- Activity durations are shown in the form of horizontal bars.

- ***Linked Bar chart:***
- Linked bar chart is an ***improvement to the Gantt chart.***
- It‘s a bar chart that ***explicitly shows the dependency links between activities.***
- When the end of a preceding activity is connected to the start of a following activity by a link line, the ***traditional bar chart format is converted into a linked format.***

- ***Project Network Diagrams:***
  - It‘s a ***pictorial presentation of project data*** in which the project logic is the main determinant of the placements of the activities in the drawing.
  - Frequently called a flow chart, pert chart, logic drawing, and activity network or logic diagram (APMBOK, 2006).
- ***Critical Path Analysis***:
  - It refers to the procedure ***for calculating the critical path and floats*** in a network (APMBOK, 2006).

- ***Line of Balance***:
  - Is a management control procedure ***for collecting, measuring and presenting facts of time, cost and accomplishment***, ***against a specific target***.
  - It is a **graphic device** that enables a manager to visualize, at a single glance, which of the activities are in balance.
- ***Spreadsheets:***
  - Spreadsheets are a ***common computerized tools*** which can provide data needed for ***cost estimating, cost budgeting and cost control*** (Kathy, 2014).
  - It is also used ***to track costs and schedules***.

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- ***Other Simulation/ Statistical tools:***
- Simulation/ Statistical tools are ***computerized tools*** which are widely used to assist with cost estimating (PMBOK, 2000).
- They can also help ***to measure and forecast project outcomes*** with variable task times (Deborah et al, 2013).

- ***Cost Benefit Analysis***:
- It‘s an analysis of the ***relationship between the costs*** of undertaking an activity or project, ***initial and recurrent, and the benefits likely to arise from the changed situation***, initially and recurrently (APMBOK, 2006).
- It involves ***estimating tangible and intangible costs*** (outlays) and benefits (returns) of various project and product alternatives, and then using financial measures, such as return on investment or payback period, to assess the relative desirability of the identified alternatives (PMBOK, 2000).

- ***Benchmarking***:
- It involves ***comparing actual or planned project practices*** to those of other projects to generate ideas for improvement and to provide a standard by which to measure performance (PMBOK, 2000).
- For example, organizations who appear to be ***particularly successful*** in what they do and how they do it are taken to be examples to be emulated, i.e. ***used as benchmarks*** (APMBOK, 2006).

- ***Flow-charting:***
- A flow chart is any diagram that ***shows how various elements of a system relate***.
- ***Flowcharting techniques*** commonly used include:
  - a) ***Cause-and-effect diagrams***: It illustrates how various factors might be linked to potential problems or effects.
  - b) ***System or process flow charts***: It shows how various elements of a system interrelate.
- Flow charting can help the project team anticipate what and where ***quality problems*** might occur, and thus can help develop approaches for dealing with them (PMBOK, 2000).

- ***Cost of Quality***:
- It refers to ***the total cost of all efforts to achieve product/ service quality***, and includes all work ***to ensure conformance to requirements*** as well as all work resulting from ***nonconformance to requirements***.
- There are **three types of costs** that are incurred: ***prevention costs, appraisal costs, and failure costs***, where the latter is broken down into internal and external costs (PMBOK, 2000).

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2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques

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2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- A quality system is the ***method used to ensure*** that the quality level of ***a product or service*** is maintained.
- The system documentation can be viewed as as hierarchy containing four tiers



2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques

- ***What is a quality policy?***
- A quality policy is a ***brief statement*** that aligns with the organization's ***purpose and strategic direction***, provides a framework for quality objectives, and includes a ***commitment to meet applicable requirements*** (ISO 9001, customer, statutory or regulatory) as well as to continually improve.
- Often, the quality policy incorporates an ***organization's vision or mission statement and core values***.
- ***Quality Policy*** is a requirement defined in the ISO 9001:2015 Standard.
- Section 5.2 Quality Policy has two subclauses:
  - 5.2.1 Establishing the Quality Policy and
  - 5.2.2 Communicating the Quality Policy.

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- ***Who is responsible for the quality policy?***
- ***Top management*** is responsible for ***establishing, documenting, and communicating*** the quality policy as well as making it available to relevant interested parties.
- Many organizations will accomplish these requirements ***by documenting the quality policy*** within their quality manual, communicating to employees the quality policy during a training session, and posting printed copies of the quality policy throughout the building.



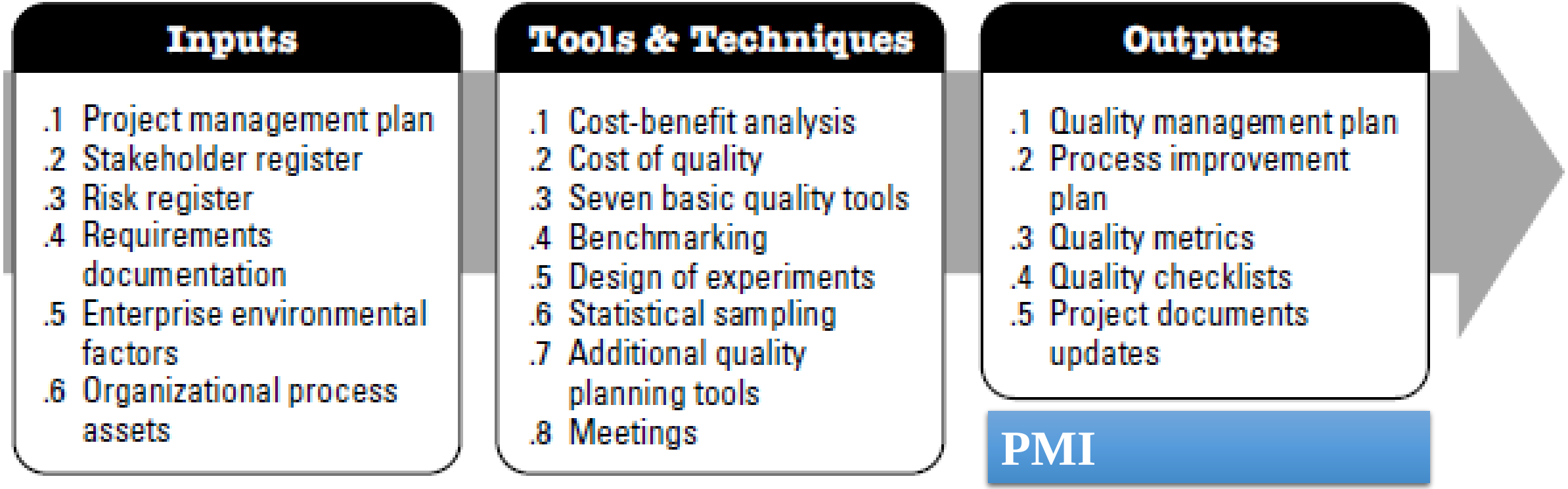
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- **Quality management** is vital to the success of an organization.
  - It enables ***to deliver products and services*** that ***meet both customers' requirements and regulations, protecting its reputation*** while reducing costs and driving improvement.
  - It also helps an organization ensure it is ***operating in the most sustainable way.***
- Quality management encompasses a number of different activities:
  - **Quality planning**: This ensures that ***quality requirements are addressed*** throughout the product and service lifecycle.
  - **Quality control**: This focuses **on process outputs** to ensure that standards are actually met.
  - **Quality assurance**: This gives confidence that **standards and requirements are being met.**
  - **Quality improvement**: This process is informed by all of the above activities and the requirements of the business.

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- ***Quality management planning process***
- The ***quality management planning process*** determines the quality standards that are applicable to the project and devising a way to satisfy them.
- The goal is ***to create a quality management plan*** which documents the following:
  - the way the team will ***implement the quality policy***
  - the way the quality of both the project and the product will be ***assured during the project***
  - the resources ***required to ensure quality***
  - the additional ***activities necessary to carry out the quality plan***

- **Quality planning**
- **As per PMI, Quality Management planning is identifying quality requirements and/or standards** for the project and its deliverables.



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- ***Quality Planning Tools and Techniques***
- ***Cost-Benefit Analysis***
  - The cost-benefit analysis is similar to a cost-benefit ratio.
  - The ***costs and benefits are measured*** to analyze the ***trade-offs of providing quality.***
- **Cost of Quality**
- Cost of quality (COQ) includes ***all the costs that conform to the required quality of the project***, including the ***cost to ensure conformance*** to requirements as well as the ***cost of nonconformance***, and ***finding the right balance***.
- Modern quality management philosophy emphasizes ***preventing mistakes rather than detecting them*** later because the cost of nonconformance is very high.

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- ***Quality Planning Tools and Techniques…***
- ***Costs associated with quality:***
- **Prevention costs** are associated with ***keeping defective products away from the customer***.
  - Examples include ***quality training, quality planning, reliability engineering, test engineering, or data analysis***.
- **Appraisal costs** are associated with ***checking the product to make sure it is conforming***, such as
  - inspection,
  - testing,
  - calibration,
  - studies, or
  - surveys.

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- ***Quality Planning Tools and Techniques…***
- ***Failure costs*** can be categorized in a couple of ways:
  - **Internal**: Nonconformance that is found while the ***product is still within the performing organization*** is called ***internal failure costs***, and includes rework or scrap.
  - **External**: Nonconformance that is found when the product has been given to the customer is called ***external failure costs***, and includes repair or returns.
- The **cost of nonconformance** can also be classified as direct or indirect:
  - **Direct**: Direct failure costs include ***scrap, warranty costs, rework, engineering changes, liability insurance, or inventory costs***.
  - **Indirect**: Indirect failure costs include ***fewer sales, lost customers, increased costs to get customers back, decreased team morale, or decreased project efficiency.***

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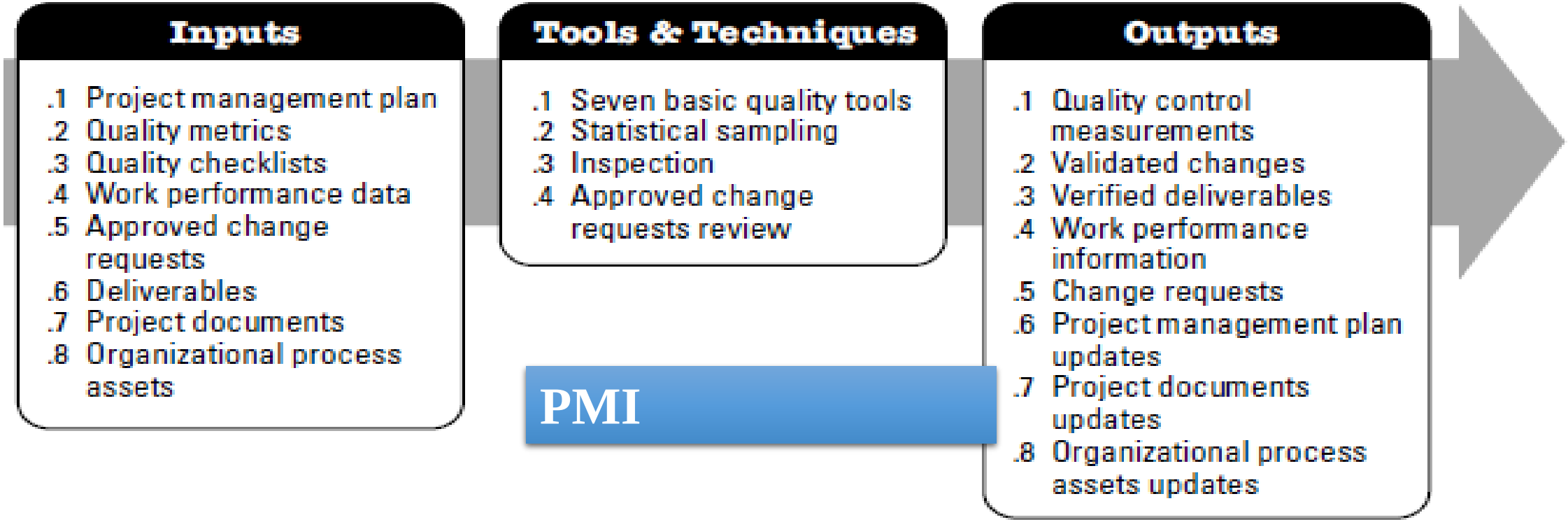
- ***Quality Planning Tools and Techniques…***
- ***Brainstorming*** is a technique for ***gathering information***, where multiple unfiltered inputs and ideas are solicited and captured for later analysis and decision making.
- ***Force field analysis (FFA)*** is a technique for analyzing ideas by ***grouping characteristics or factors*** that are for (pros) and against (cons) the idea.
- ***Nominal group technique (NGT)*** is an enhancement of brainstorming that ***adds mechanisms for ranking ideas***.
  - It is based on the assumption that a **nominal group** (one that has agreed to work as a team) ***will produce better results*** than a group engaging in traditional brainstorming.
  - NGT collects ***anonymous input from group members*** and ***encourages discussion of all input***.
  - Then, each member ***prioritizes the input items***.
  - The items are further ***prioritized based on their cumulative score***.

- **Quality Control**
- The goal of controlling quality is referenced in the PMBOK Guide by ***the control quality process.***
- According to the PMBOK Guide, the control quality process is defined as the "***process of monitoring and recording the results of executing the quality activities to assess performance and recommend necessary changes***."
- In other words, quality control focuses on ***project results ensuring that they comply with the quality standards*** defined for the project and eliminating any causes of unsatisfactory performance.
- This process measures ***the details of the product results***, such as ***deliverables or defects***, and also of ***the project management results***, such as schedule.

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- The PMBOK Guide acknowledges that often a specialized organizational unit with specific expertise in quality control performs quality control.
- Many of the techniques under the control quality process assume a working knowledge of statistical quality control, in particular the concepts of sampling and probability.
- The distinctions between ***attribute and variable sampling***, ***precision and accuracy***, and ***tolerance and control limits*** are fundamental components of a ***working knowledge of statistical quality control***:
  - ***Prevention aids*** in ***identifying and avoiding potential problems*** so that they never enter or impact the process.
  - **Inspection** helps ***to identify and eliminate or correct errors*** so that they are not delivered to the customer.
  - **Tolerance** is a range of ***acceptable performance or results***.

- **Quality Control**
- **the process of monitoring and recording results of executing the quality activities** to assess performance and recommend necessary changes.



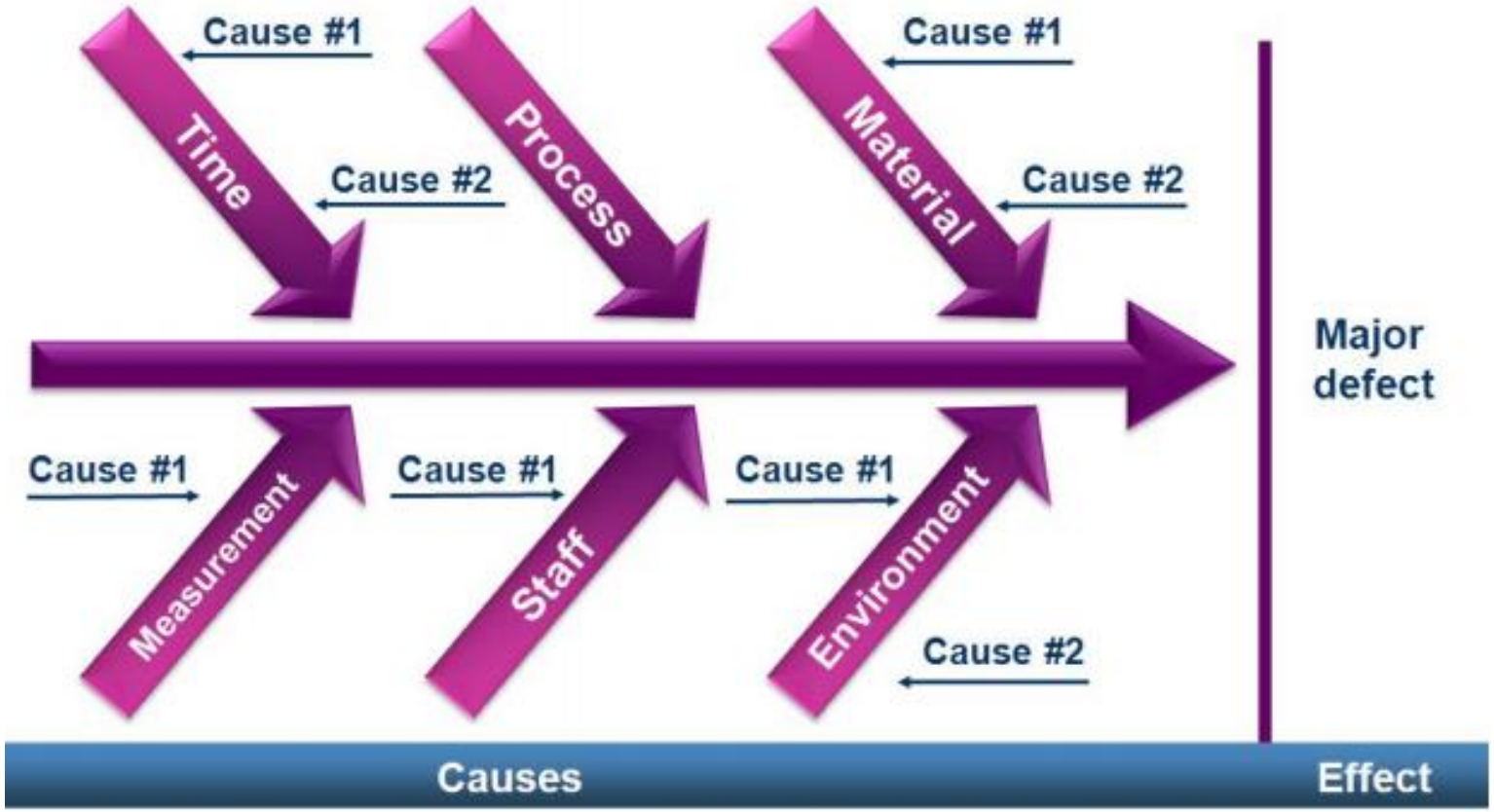
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- ***Tools Useful in both Quality Planning and Control Quality***
- There are ***seven basic quality tools*** identified as appropriate for use in both the ***quality management plan and control quality processes***.
- They are known as ***Ishikawa's seven basic tools of quality (7QC tools)***:
  - cause-and-effect diagrams,
  - flowcharting,
  - check sheets,
  - Pareto diagrams,
  - control charts,
  - histograms and
  - scatter diagrams

- **Cause and Effect Diagrams**
- were developed ***to illustrate and help determine how various factors relate to potential problems.***
- Cause-and-effect diagrams are also called ***fishbone diagrams*** because ***they resemble the skeleton of a fish***.

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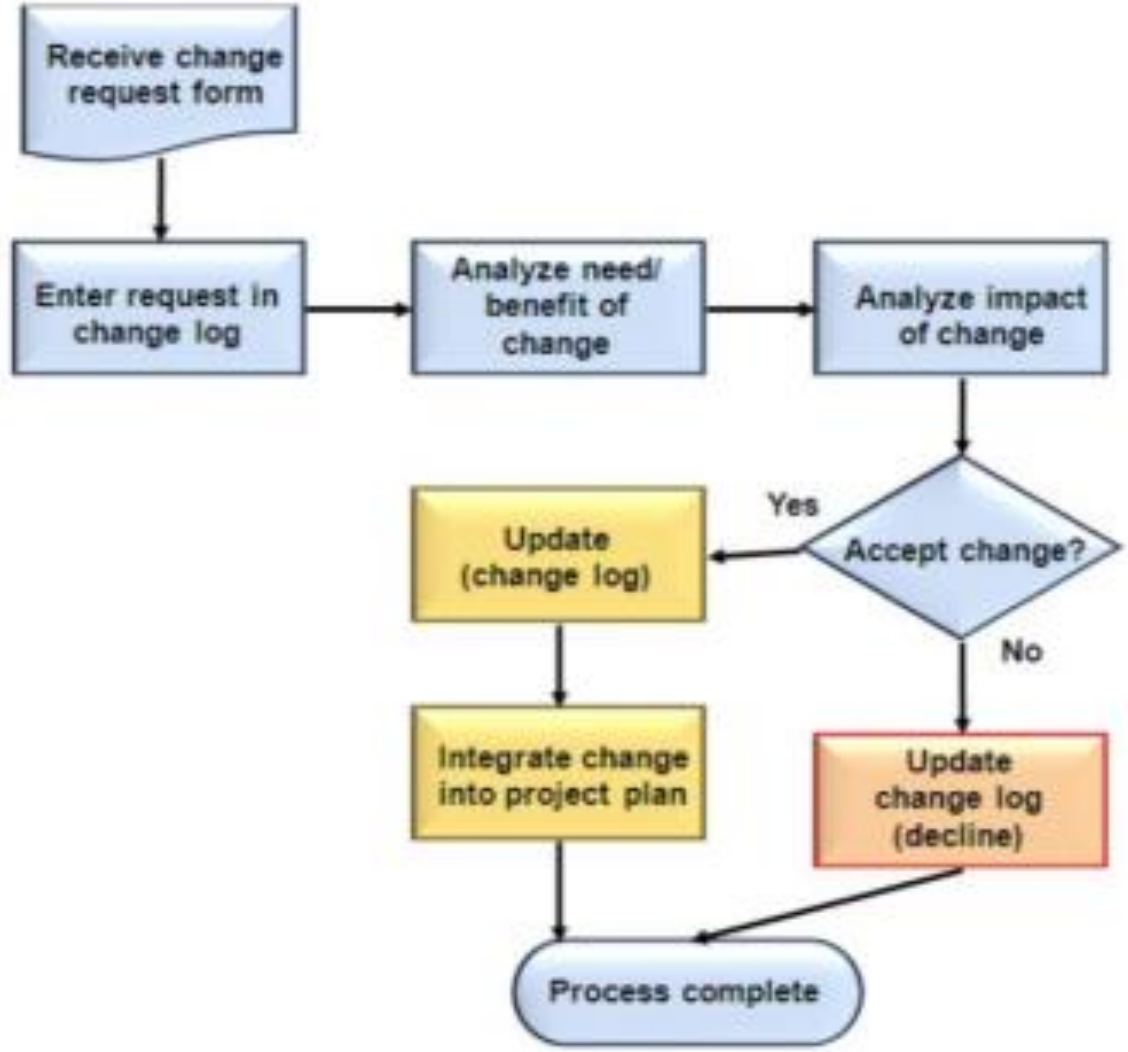
- The **head of the fish** is the **effect** and ***each bone of the fish is a cause that leads to that effect***.
- The ***bones can branch off into smaller bones*** as you determine the lower level cause-effect relationships.
- When ***all the bones are filled in***, the diagram lets you look at all the possible causes (individual or combinations) of the effect (or problem) so that you can develop a solution to mitigate that effect.



- The diagram allows ***organized thought and encourages orderly consideration of the factors*** that result in a certain outcome.

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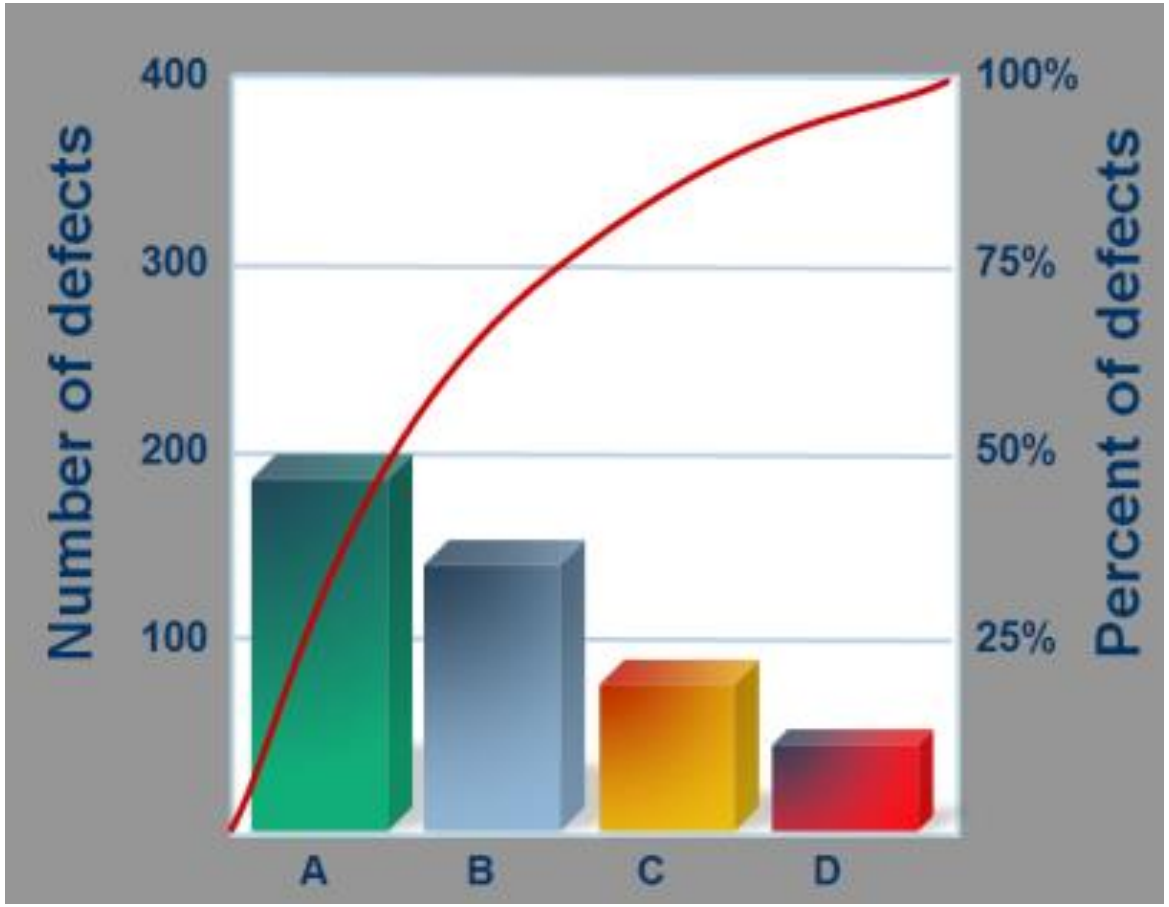
- ***Flowcharts***
- Flowcharts ***show the logical steps in a process*** and ***how various elements within a system are related***.
- They can be used ***to determine and analyze potential problems*** in quality planning and quality control.
- The ***system, or process, flowchart*** is probably the one that people are most familiar with.
- This type of flowchart ***outlines the logical steps to complete a process***.
- By documenting these logical steps, the team can ***identify where quality problems*** might occur and then ***develop approaches*** to proactively manage them.
- Flowcharting also helps ***to create a process that is repeatable***.



- **Check Sheets**
- Check sheets are used ***to organize information in order to facilitate data gathering.***
- Check sheets are particularly effective ***for doing inspections, enabling focus on the particular attributes*** that may be contributing to potential or identified quality problems.
- ***Histograms***
- A histogram is a ***vertical bar graph*** that represents the frequency of each measured category (known as bins) of variable.
- In other words, the graph represents a ***rough frequency distribution of the data***.
- The histogram is particularly useful ***for identifying common causes***.
- The histogram can be ***ordered***, similar to a Pareto chart, ***or unordered***.

- **Pareto Diagrams**
- A Pareto chart or diagram, is a ***specific type of histogram*** that is based on ***Pareto's principle***, which states that ***a large number of defects or problems are caused by a small number of causes***.
- Pareto's principle, frequently referred to as ***the 80/20 rule or 80/20 principle***.
  - Which means that ***eighty percent of the cost of defects*** are caused by ***twenty percent of the problems***.

- **Pareto Diagrams…**
- A Pareto diagram is an ***ordered bar graph*** showing the ***number of defects and their causes*** ranked by frequency.
- **The bars** on the diagram graphically show ***the number and percentage of causes*** individually and the ***line shows the cumulative value.***
- Pareto charts help ***focus attention on the most critical issues*** to get the most benefit.



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- ***Control Charts***
- Control charts are used ***to determine if processes are in or out of statistical control***.
- Most processes experience a degree of normal variation (or common cause variation); that is to say, most processes do not achieve target performance all the time.
- Control charts ***provide a mechanism for establishing a statistically objective range of acceptable variation around the target performance***, thereby enabling attention to be focused on special cause variations (those that fall outside of the established performance limits).
- Control chart limits are established on ***the basis of standard deviations from the mean (target) performance.***
- The upper control limit (UCL) and lower control limit (LCL) are established so that ***99.73 percent (three standard deviations above and below the mean)*** of the measured data points fall within the range.
- Sometimes upper and lower warning limits are also established, usually ***at two standard deviations from the mean***.
- The PMBOK Guide also refers to ***upper and lower specification limits***, which are defined based on requirements in an agreement.

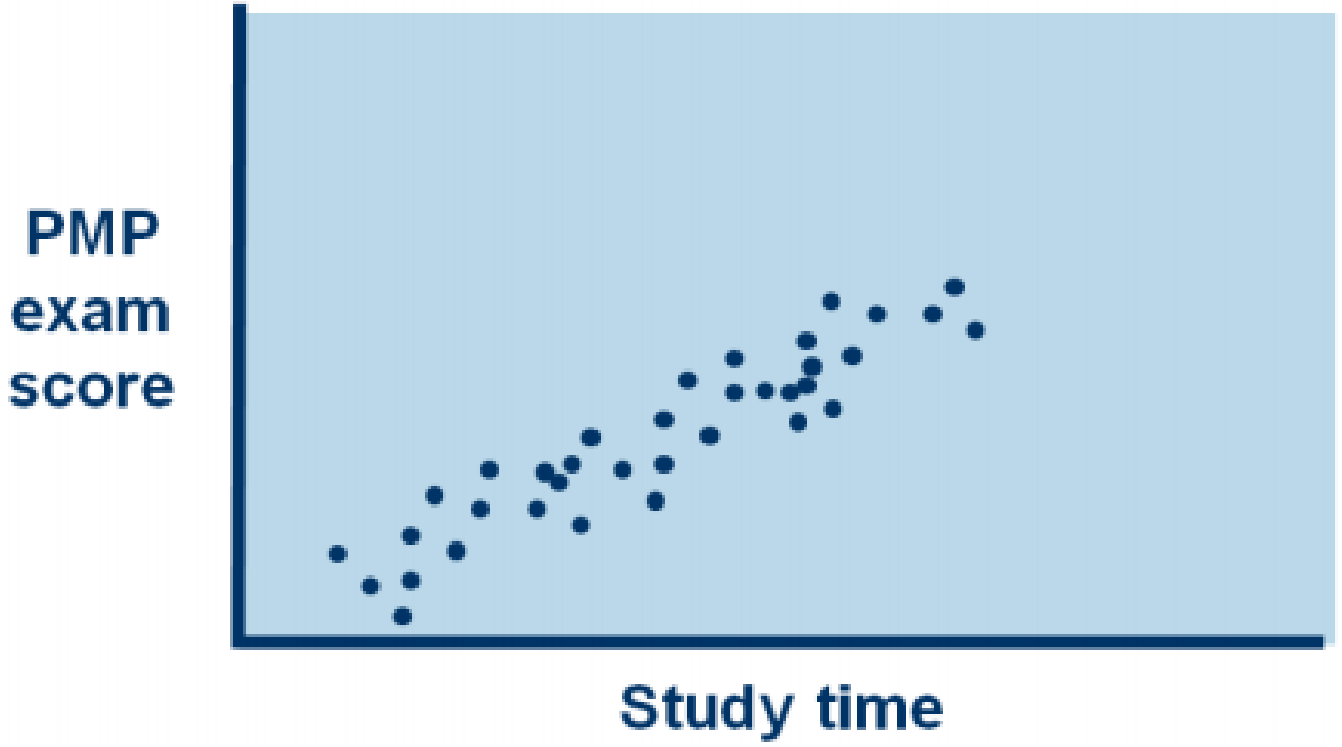
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- ***Control Charts…***
- ***Measures of the quality characteristics*** are then taken over time and the emerging data pattern is evaluated ***to determine whether the variations in performance are due to common causes or special causes***.
- The normal average run length (ARL) is 370 data points, based on work by American physicist, engineer, and statistician Walter A. Shewhart, who showed that there is a 0.27 percent chance of a measure falling outside of the control limits even when a process is in control.
- There are many rules ***for identifying special cause variations***, but the following ones are more common:
  - **Rule of Seven**, or Seven Run Rule: Seven data points in a row are above or below the mean.
  - **Trend of Seven Rule**: Seven data points in a row follow a trend up or down.
  - **Rule of One**: Any single data point is outside of the control limits (upper or lower).

- **Scatter Diagrams**
- Scatter diagrams plot two variables, ***the independent variable and the dependent variable***, ***to graphically show the relationship between them***.
- The X-axis in the diagram represents **one characteristic** (usually the ***independent variable***), and the Y-axis measures the other.

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- **Scatter Diagrams…**
- To interpret the diagram, look at two characteristics of the clustering:
  - ***Tightness***: The closer the cluster is to a diagonal line drawn through the graph, the more the two variables are likely to be linearly correlated. ***High correlation between the characteristics means that a change in one characteristic will be accompanied by a change in the other***.
  - **Direction**: If the correlation is positive, then as one variable increases so does the other, and the line will have a positive slope (from lower left to upper right). On the other hand, if the correlation is negative, it implies that as one characteristic increases, the other decreases, and the line will have a negative slope (from lower right to upper left).



- **Benchmarking**
- Benchmarking involves ***comparing the current project or activity to similar projects or activities***.
- This process ***generates ideas for improvement and provides a standard to measure quality performance***.
- Benchmarks can be ***created from a variety of standards***, including
  - experience on ***other projects within the company***,
  - experience by ***vendors outside the company***, or
  - ***published industry standards***.

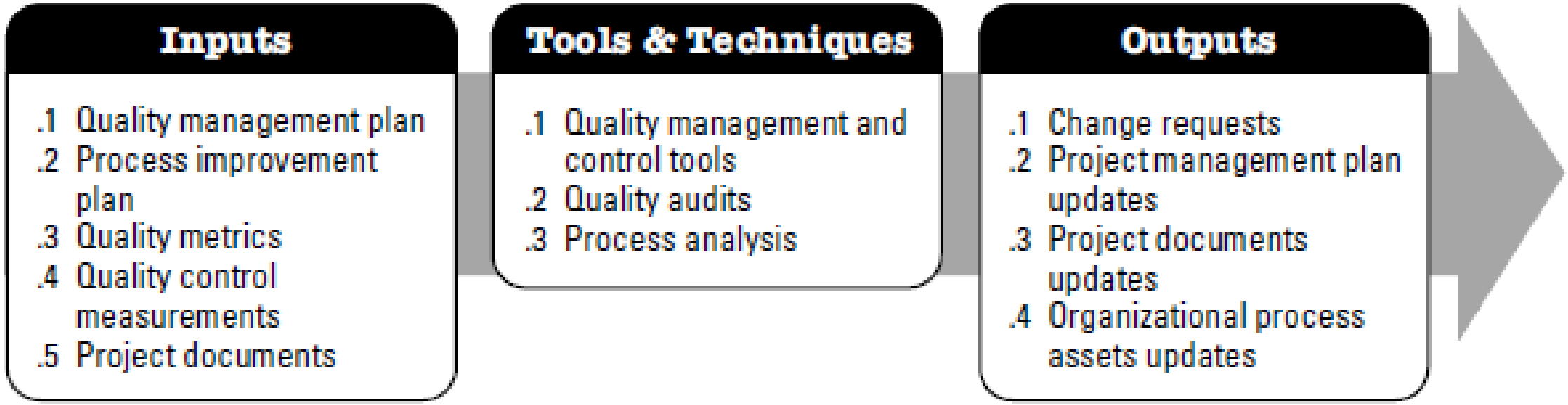
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- ***Design of Experiments***
- Design of experiments is the ***process of going through what-if scenarios with a limited number of samples*** to determine the optimal solution ***to improve quality.***
- It is a ***statistical method that identifies the variables that will have the greatest effect on the quality of the project.***
- Typically, this method is used on ***the product of the project***, but it also can be applied to ***the project management process***.
- For example, ***a senior network analyst is more expensive***, but he or she can install and troubleshoot hardware in a shorter amount of time than ***a junior network analyst.***
- In this case, the experiment can yield an ***appropriate mix of junior and senior analysts*** to provide an optimum mix of analysts for the installation phase of the project.
- The benefit of this technique is that ***all major or important factors can be changed at one time, rather than one at a time***.

- ***Statistical Sampling***
- Statistical sampling is ***an approach to selecting a few representative items for inspection*** and then ***extrapolating the results to the whole***.
- The ***type of sampling and the frequency or size of the sample*** should be established in the quality management plan.
- There are ***two types of sampling***:
  - ***Attribute sampling*** is the ***determination of whether a sample conforms*** (for example, true/false, right/wrong, pass/fail, and so forth).
  - ***Variable sampling*** is the ***determination of the degree of conformity*** (for example, number of calls per hour, weight of chickens, and so forth).

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- **Quality Assurance**
- **process of auditing the quality requirements** and the results from quality control measurements to ensure that appropriate quality standards and operational definitions are used.



- ***Tools and Techniques of the Perform Quality Assurance Process***
- ***Affinity Diagrams***
- Affinity diagrams are ***used to organize large numbers of ideas for review and analysis***.
- It is an excellent tool ***for organizing large amounts of ideas and data into meaningful groups*** by finding relationships between the ideas.
- It makes data easier ***to review and analyze***.
- The affinity diagram was ***developed by a Japanese anthropologist Jiro Kawakita*** and is therefore also known as "the KJ method" (The Japanese put their family name first).

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

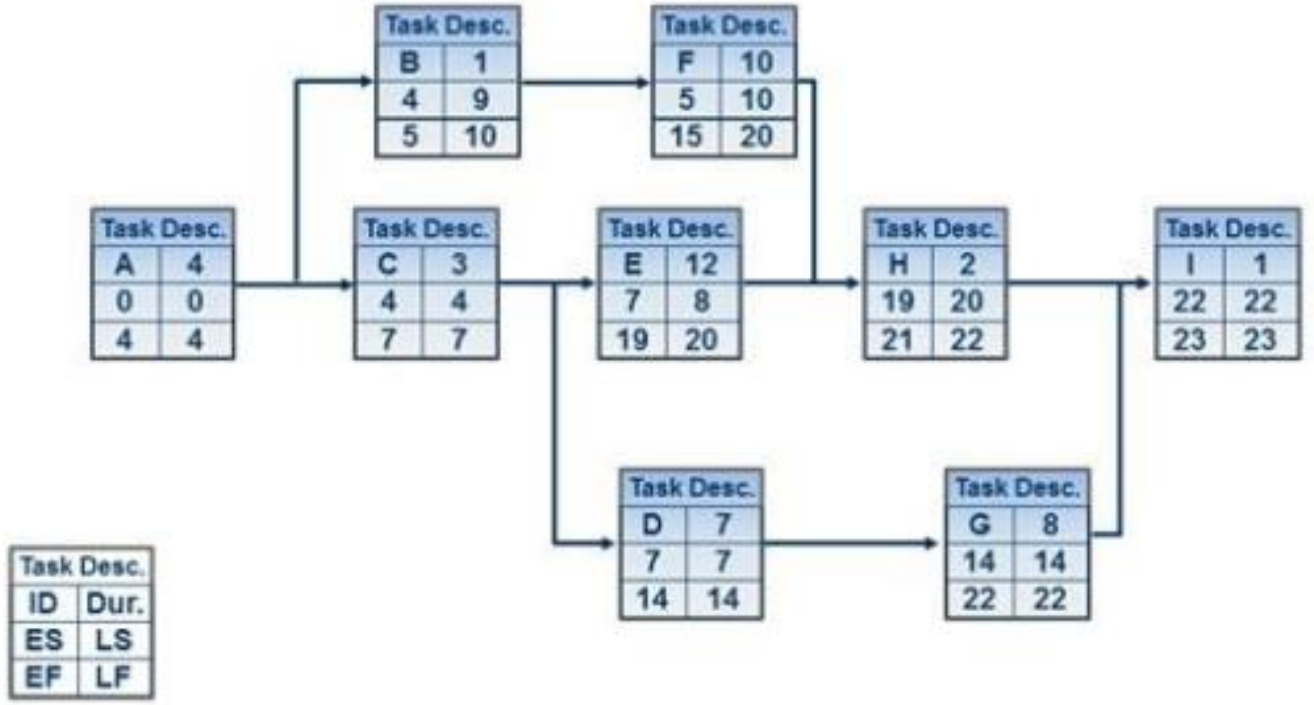
- ***Process Decision Program Charts (PDPC)***
- This technique helps to identify the steps necessary to reach a goal. It also enables analysis of the incremental steps required, thereby facilitating identification of potential problems or pitfalls before they are encountered.
- **Interrelationship Diagraphs**
- An interrelationship diagraph is a visual display of the cause-and-effect relationships between multiple variables, complex problems, or desired outcomes.
- **Tree Diagrams**
- Tree diagrams, also known as systematic diagrams, are used to break down broad categories into finer and finer levels of detail, which helps move from generalities to specifics.
- **Prioritization Matrices**
- Prioritization matrices provide a mechanism for ranking the relative importance of ideas or issues.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- ***Activity Network Diagrams***
- A network diagram is a generic term that can refer ***to the output of any one of several techniques***, such as
  - ***program evaluation and review technique (PERT),***
  - ***critical path method (CPM),***
  - ***arrow diagramming method (ADM), or***
  - ***precedence diagramming method (PDM).***
- The network diagram is a ***schematic display of the logical relationships, or interdependencies, of all the project activities***.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- We can create it ***manually or with a project management software tool***.
- ***The network diagram*** is a good tool to show the workflow of the project and it can help effectively plan and organize the project.
- We create a network diagram ***by putting tasks, or work packages, in order of completion.***
- Then, ***use arrows to connect the tasks***, thereby graphically displaying the workflow of the project, interdependencies of tasks, bottlenecks, risks, etc.



- Because the diagram shows network logic, dependencies, and sequencing, it is an effective tool to help plan the project.
- However, although ***network diagrams show task durations***, they do not graphically portray start or end dates for the tasks, nor for the project.
- After we complete a network diagram, if we have task and resource estimates, we can ***calculate an estimate of project duration***.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- ***Matrix Diagrams***
- Matrix diagrams are used ***to illustrate the relationship among various factors***.
- Matrix-based charts can be in the form of a ***responsibility assignment matrix*** (RAM) that documents the roles of the project team members.
- One such type of RAM is called a ***responsible, accountable, consult, and inform (RACI) chart*** that lists the work to be done on the left as activities.
- The ***resources assigned*** to work on these activities are ***listed across the top of the chart*** and can be shown as individuals or groups, depending on the ***level of detail that the chart shows***.

Key:
R: Responsible
A: Accountable
C: Consult
I: Inform

	Person A	Person B	Person C	Person D
Task A	A	I		R
Task B		R	A	
Task C	C	A		R
Task D		C	R	A
Task E	I	R	A	

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- ***Quality Audit***
- One of the most important sub processes performed ***during the quality assurance process*** is the ***quality audit***.
- According to the PMBOK Guide, the quality audit is an ***independent review conducted by internal or external auditors***.
- The quality audit can be ***performed on a regularly scheduled basis or an ad hoc basis.***
- The audit is a ***structured review of quality management activities*** to identify good or best practices and lessons learned for use on current or future projects.
- The ***periodic review of the quality management activities and measurements*** assures stakeholders that the measures taken are appropriate and that quality processes are followed.
- If the measurements result in variances ***beyond the defined tolerance***, ***corrective actions can be identified***.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- ***Quality Audit…***
- Audits ensure that ***the product is fit for use*** and that applicable laws are followed or safety standards met.
- The information learned as ***a result of the quality audit*** should ***lead to improvements in the quality processes***, which is the result of quality assurance.
- The PMBOK Guide lists the following as ***objectives of a quality audit***:
  - Identify ***good or best practices***.
  - Identify ***gaps and shortcomings***.
  - ***Share good practices*** within the organization or industry.
  - Proactively ***improve processes to raise team productivity***.
  - ***Highlight contributions*** identified through the audit in the lessons learned repository.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

- ***Process Analysis***
- ***Process analysis*** involves ***applying the procedures that are defined in the process improvement plan*** ***to identify necessary areas of improvement***.
- A key tool of process analysis is ***root cause analysis***.
- A root cause analysis focuses on
  - ***determining what happened***,
  - ***why it happened***, and
  - ***how to reduce the possibility*** of having it happen again.

Total Quality Management (TQM)

- Total quality management is an organization-wide effort ***to create a constant thrust towards improvement***.
- ***Improvement*** can be defined as an ***employee's ability to provide on-demand products and services*** that are of value to their customers, even as their needs change.
  - That's the "***quality***" in ***total quality management***.
  - The "total" indicates that the effort is one that ***touches every inch of every employee of an organization***.
- Total quality management ***has no widely agreed upon approach***.
  - It does, though, ***draw from other tools and techniques***, such as ***project quality control, quality assurance and testing,*** and others.

2. Quality Policy, Planning, Assurance, Controlling and Auditing Tools and Techniques…

Total Quality Management (TQM)…

- ***History of TQM***
- The roots of total quality management can be traced back to ***the economic instability*** of the late 1970s and into the early 1980s.
- It was at this time that the dominance of ***North America and Western Europe*** was challenged by competition from the East, specifically ***Japan's skill*** at making ***high-quality inexpensive products***.

The gradual evolution and metamorphosis of quality improvement in construction

Duration	Quality Systems
Pre – 1900	Quality as in integral element of craftsmanship
1900 – 1920	Quality Control by Foremen
1920 – 1940	Inspection-based Quality Control
1940 – 1960	Statistical Control
1960 – 1980	Quality Assurance and Total Quality Control
1980 – 1990	Total Quality Management (TQM)
1990 – 2000	TQM and Culture of continuous improvement
2000 – Present	Organisation-wide Quality Management

Total Quality Management (TQM)…

- Total Quality Management (TQM) is a methodology derived ***from Japanese industry.***
- Like other quality control methodologies, ***TQM is customer-based***. In other words, the methodology looks to customers to define quality.
- TQM depends upon a hierarchy; those in the ***top managerial positions of a company must implement*** and ***model TQM principles for employees***.
- Total Quality Management ***contains its own system of productivity tools***.
- The first three ***principles of TQM*** are as follows:
  - It ***requires everyone in the company*** to be completely involved and ***it covers all company activities***.
  - It ***requires that the standards are set by customers***, and that ***all practices conform to those requirements***.
  - It requires that ***quality is monitored and controlled for optimum results***.

Total Quality Management (TQM)…

- ***Mechanisms of Total Quality Management***
  - ***Customer Focused***: The definition of quality lies with the customer, and all efforts to achieve success in the organization lead to customer satisfaction.
  - **Total Employee Involvement**: The effort is not isolated to one department of an organization. To be successful in its objective of customer satisfaction, there must be a common goal for all aspects of business and for each employee.
  - **Process Oriented**: Process thinking is fundamental to total quality management; the internal steps a company takes directly result in the external output delivered to the customers.
  - **Integrated System**: Basically, regardless of the size or complexity of the organization, all its distinct parts must work together.
  - **Strategic and Systemic Approach**: Using strategic planning to create a strategic plan that integrates quality as a core component of the company is a way to structure total quality management into an organization's mission.

Total Quality Management (TQM)…

- ***Mechanisms of Total Quality Management…***
  - ***Continual Improvement***: The mantra for total quality improvement is customer satisfaction, but that is not a one-shot goal: the act of improving quality for the customer is a process without an end.
  - ***Fact-Based Decision Making***: In order to know if an organization is meeting its objectives, there must be data on performance, and those metrics must be collected and analyzed with accuracy and without prejudice.
  - ***Communications***: It's impossible to maintain a successful TQM approach without an effective communication plan. Communication plans make sure that every department is aware of what they and others are responsible for, so they can coordinate operations to achieve their common goal.

Total Quality Management (TQM)…

- As per U.S. Navy, the key concepts of total quality management developed include:
  - Quality is defined by what ***the customers' requirements*** are
  - Top-tier management is ***directly responsible for the improvement in quality***
  - It is by ***systemic analysis***, and using that data to improve work processes, that an increase in quality occurs
  - The improvement of quality is ***a continuous effort*** and is conducted throughout the entire organization



Total Quality Management (TQM)…

- ***Fundamentals in Total Quality Management***

1. ***New strategic thinking*** must be pursued. A great way to do this is to use brainstorming tools to come up with solutions to perceived problems.
2. ***Know your customers*** – you must research their needs. Create a survey, gather the data, and determine who your customers are.
3. ***Quality requirements*** will be set by your customers' requirements for quality.
4. ***Prevention is key*** – correction costs too much money. By preventing quality problems in the future, the quality improvement process is more streamlined and less costly.
5. ***Reduce waste and sources of waste*** – this step is held in common with principles from Lean Six Sigma. Waste is anything that does not contribute to the immediate needs of the project.
6. ***The improvement strategy*** that your company pursues should be continuous. It would not make sense to start a quality improvement project only to quit after small successes.
7. ***Improve processes*** through use of a structured methodology. By following a structure, you can minimize time figuring out how to improve processes or when to improve processes.
8. ***Reduce any variation*** in your products or services.
9. ***Balance your approach*** – make sure that one sector isn't receiving more attention than others.
10. ***Apply the quality improvement process*** to all functions.

Total Quality Management (TQM)…

- ***Tools in Total Quality Management***
  - **Check sheet** used to collect data in real time
  - **Control chart** to determine if a process is in a state of control
  - ***Stratification (or flow or run) chart*** to sample a group
  - **Pareto chart**, which is both a bar and line graph that assess the most frequently occurring defects by category
  - ***Histogram*** to roughly assess the probability distribution of a given variable by depicting the frequencies of observations occurring in certain ranges of value
  - ***Cause-and-effect diagram***
  - ***Scatter diagram*** to display the value for two in a set of data

Total Quality Managem

- **Elements of TQM**



Total Quality Management (TQM)…

- ***Elements***
- ***Management commitment and Leadership***
- The Business Roundtable construction industry cost effectiveness study concluded that the primary causes for the decline of construction productivity directly or indirectly involved poor management practices (Burati, Michael and Satyanarayana 1992).
- Since quality is part of productivity, the first step for management is to recognize that there is a problem.
- The success of a **TQM program first of all depends on management practices**.
- TQM is a culture and philosophy that must permeate an organization as the method of management.
- It can thrive only under a senior management that establishes TQM as a top priority.
- This commitment must be coupled with a thorough understanding of TQM.
- The ***level of management commitment*** to continuous quality improvement was rated as one of the most important factors that affect the quality of the constructed facility

Total Quality Management (TQM)…

- ***Elements…***
- ***Employee Training on Quality***
- Under TQM, ***quality becomes everyone's responsibility*** and the training must be targeted for every level of the company.
- There are ***many aspects, such as training and awareness*** that are similar between the safety consciousness of construction firms and the implementation of TQM concepts.
- The training effort may include
  - ***instruction in the basics of TQM***,
  - ***cause-and-effect analysis***,
  - ***team problem solving***,
  - ***interpersonal communication and interaction***,
  - ***rudimentary statistical methods*** and
  - ***cost of quality measurement***.

Total Quality Management (TQM)…

- ***Elements…***
- ***Teamwork Among Professionals***
- **Quality teams** provide companies with the structured environment necessary ***for successfully implementing and continuously applying the TQM process.***
- **Quality training** is conducted and the ***continuous improvement process*** executed through a well-planned team structure.
- The ***ultimate goal of the team approach*** is to get everyone, including contractors, designers, vendors, subcontractors, and owners involved with the ***TQM process***.
- At ***the industry level***, ***extending the TQM concept to the parties*** mentioned above in the form of joint teams achieves ***higher customer satisfaction***.
- These joint teams are responsible for establishing joint goals, plans, and controls.

Total Quality Management (TQM)…

- ***Elements…***
- **Statistical Methods**
- Statistical methods ***provide problem-solving tools*** to the TQM process.
- According to Perisco (1989) they provide teams with the tools
  - to ***identify the causes of quality problems***,
  - to ***communicate in a precise language*** that can be understood by all team members,
  - to ***verify, repeat, and reproduce measurements*** based on data,
  - to ***determine the past, present***, and to a lesser degree, the future status of a work process, and
  - to ***make decisions on facts*** that are based on data rather than the opinions and preferences of individuals or groups.

Total Quality Management (TQM)…

- ***Elements…***
- ***Cost of Quality***
- The cost of quality is considered by scholars to be the ***primary tool for measuring quality.***
- In their approach, it is ***used to track the effectiveness of the TQM process***, ***select quality improvement projects***, and ***provide cost justification to doubters***.
- By bringing together these easily assembled costs of review, inspection, testing, scrap, and rework, one can convince management and others of the need for quality improvement.
- It is effective in its intended purpose of raising awareness about quality and communicating to management the benefits of TQM in terms of money.
- Quality costs consist of the cost of prevention, the cost of appraisal, and the cost of deviation.
  - Prevention costs are those resulting from activities used to avoid deviations or errors, while appraisal costs consist of costs incurred from activities used to determine whether a product, process, or service conforms to established requirements.

Total Quality Management (TQM)…

- ***Elements…***
- ***Supplier Involvement***
- The ability to produce a ***quality product*** largely depends ***on the relationship among the parties involved in the process***; ***the supplier, the processor, and the customer.***
- The quality of any stage in a process is contingent upon the quality of the previous stages.
- The quality of the project built by the constructor is directly related to
  - the quality of the ***plans and the specifications*** prepared by the designer,
  - the quality of the ***equipment and materials*** supplied by the vendors, and
  - the quality of ***work performed by the subcontractors***.

Total Quality Management (TQM)…

- ***Elements…***
- ***Customer Service***
- TQM is a process that ***requires universal involvement to be successful***. This includes ***customer involvement***.
- As more and more companies become involved ***in the TQM process and demands for improved quality increase***, this concept becomes increasingly important.
- Customers may be either ***internal or external.***
- Satisfying the needs of these customers is ***an essential part of the process of supplying*** the final external customer with a quality product.
- Juran (1998) claims that the parties in a process (supplier, processor, and customer) have a "triple role".

Six Pack Approach

- The Six Sigma theory was originally developed by ***the American company Motorola in 1986.***
- Today, this quality management method is used ***in many business and industrial sectors.***
- It seeks ***to identify and remove the causes of errors as a result of which the quality of business processes can be improved***.
- Six Sigma ***consists of a collection of methods*** that improve the quality of processes.
- It is important to find employees within an organization with specific specializations and expertise in this field.
- It ***reduces product and business variations with the objective*** to match products and/or services with customer expectations.
- The Six Sigma theory projects have quantifiable financial objectives such as ***cost reduction and/or profit improvement***.

Six Pack Approach…

- ***What is Six Sigma?***
- The term "Six Sigma" refers to ***a process in which the production is 99.99966% defect free*** and it originated from terminology that is associated ***with the manufacturing industry***.
- Here, specific terms are associated with ***statistic modelling and manufacturing processes***.
- A "sigma rating" indicates ***the yield or percentage of defect-free products.***
- Motorola set a goal of ***six sigma for all of its manufacturing processes*** and this became ***the nickname for all the management and technical activities*** used to achieve this.

Six Pack Approach…

- ***Six Sigma as quality framework***
- As soon as ***high demands are made on quality***, Six Sigma comes into play.
- But also when there is a relatively high loss in production or when there are problems and errors are reported.
- It is proven ***quality management tool set*** and in particular for industry processes and the high tech sector.
- However, it is ***also used as a general management method*** so that processes can be optimized.

Six Pack Approach…

- ***Six Sigma tools***
- **Six Sigma tools** are defined as the ***problem-solving tools used to support Six Sigma*** and ***other process improvement efforts***.
- The Six Sigma expert uses ***qualitative and quantitative techniques*** to drive process improvement.
- ***DMAIC***:
  - The ***define, measure, analyze, improve, and control*** process is a data-driven quality strategy used ***to improve processes***.
  - It is an ***integral part of a Six Sigma initiative***, but can also be implemented as a ***standalone quality improvement procedure*** or as part of other process improvement initiatives such as ***lean***.

Six Pack Approach…

- ***Six Sigma tools…***
- **Five S's of lean** :
  - The Five S's of lean is a ***methodology that results in a workplace*** that is ***clean, uncluttered, safe, and well organized to help reduce waste and optimize productivity.***
  - It's designed ***to help build a quality work environment***, both physically and mentally.
  - The ***5S philosophy*** applies ***in any work area suited for visual control and lean production***.

Six Pack Approach…

- ***Six Sigma tools…***
- ***Seven wastes:***
- ***A core principle of lean***—reducing and eliminating waste—the seven wastes are
  - **overproduction ahead of demand**;
  - ***waiting for the next process, worker, material, or equipment***;
  - ***unnecessary transport of materials***;
  - ***over-processing of parts due to poor tool and product design***;
  - ***inventories more than the absolute minimum;***
  - ***unnecessary movement by employees during the course of their work; and***
  - ***production of defective parts.***

Six Pack Approach…

- ***Six Sigma tools…***
- ***Value stream mapping***:
  - Value stream mapping (VSM) is ***a pencil and paper tool used in two stages***.
  - First, ***follow a product's production path from beginning to end*** and ***draw a visual representation of every process*** in the material and information flows.
  - Second, ***draw a future state map of how value should flow***.
  - The ***most important map*** is the future state map.
- **Flow**: Flow is the ***progressive achievement of tasks along the value stream*** so a product proceeds from design to launch, order to delivery, and raw to finished materials in the hands of the customer with no stoppages, scrap, or backflows.
- ***Visual workplace***: A visual workplace is defined ***by devices designed to visually share information about organizational operations*** in order ***to make human and machine performance safer, more exact, more repeatable, and more reliable***.

Six Pack Approach…

- ***Six Sigma tools…***
- ***Voice of the customer***:
  - Quality function deployment (QFD) begins with an ***exploration and discovery of customer needs***.
  - The first step is ***to capture the voice of the customer*** (VOC) and then ***create a voice of the customer table*** (VOCT).
  - Common sources can include ***sales and technical trip reports, warranty claims, user support forums or help lines, and social media***.

- Six Sigma team leaders also use project management tools, such as ***Gantt charts***, and ***team engagement tools***, such as ***brainstorming and nominal group technique.***

KAIZEN

- ***What Is Kaizen?***
- Kaizen is a Japanese word meaning **continuous improvement**.
- It's made up of two characters in Japanese: ***kai, which means 'change***,' and ***zen, which means 'good.'***
- It's ***used to describe a company culture*** where everyone, from the ***CEO to the front desk clerk***, regularly evaluates his or her work and thinks of ways to improve it.
- The concept is that small steps on a regular basis will lead to large improvements over time.
- Kaizen is ***a slow but ongoing process of improvement***, not a 'blitz' or quickly implemented set of changes.
- The improvements are suggested by the person doing the work, not an outside evaluation team.
- If a worker has a problem to address or is considering whether a change will make sense, he should pull in several team members for a quick discussion and brainstorming session and then decide what to do from there.

KAIZEN…

- ***How Do You Implement Kaizen?***
- It's important to note that ***kaizen is a way of thinking***, not a project to complete.
- To implement it, all employees should receive training on the concept of kaizen and should have some guidelines in terms of what they need to do before implementing a change.
- For example, it may be fine for an office worker to change his or her handling of paperwork without any discussion.
- A change in the production process, though, may impact multiple teams and should be discussed with all impacted parties before implementation.
- In addition, most production steps will be subject to safety regulations and will have detailed documentation on accurate performance, and these need to be in place before a change is made.
- It's also important that **management is trained and be behind the effort**.
- Kaizen will result in many more suggestions for improvements and changes and will take away from a rigid focus on moving items quickly through the existing production process.
- Management must be ready to accept some time away from current work to focus on changes with longer-range impact.

KAIZEN…

- Essentially, Kaizen is the ***principle of continuous improvement***, within a paradigm of some ***key guiding principles***, including:
  - **Good processes bring good results**
  - **Take action to contain and correct root causes of problems**
  - **Go see for yourself to grasp the current situation - or, 'Going to Gemba'**
  - **Speaking with data, managing with facts**
  - **Working as a team**

KAIZEN…

- ***How can Kaizen Work with Lean?***
- Kaizen works by reducing waste, or 'muda' and eliminating work processes that are too complex or difficult - 'muri'.
- As a lean business tool, Kaizen puts emphasis on success occurring only when all employees look for areas to improve and providing suggestions, based on their own observations and experience.
- For this to work, a culture must be created within the organization that all suggestions are welcome, and that there will be no negative consequences for participating.
- Instead, employees are encouraged for suggesting changes that improve the workplace.
- Workers become more confident and invested in improving the company.
- In turn, they become leaders that continually look for areas that can be improved.

EFQM Excellence Model

- The EFQM model is a ***framework for management systems***, developed by the ***European Foundation for Quality Management***.
- It aims to
  - **assess performance;**
  - **integrate and align existing tools, procedures and processes;**
  - **introduce a way of thinking that encourages reflection and stimulates continuous improvement; and**
  - **identify the key actions that are driving results.**

EFQM Excellence Model…

- A key feature of the model is a ***diagnostic framework*** that allows organizations to grade themselves ***against nine key criteria***.
- **These focus** on the cause and effect relationship between how an organization carries out its actions (enablers), and what these achieve (results).

Enablers	Results
Leadership Strategy People Partnerships and resources Processes, products and services	Customer results People results Society results Business results

Business process re-engineering (BPR)

- Business process re-engineering (BPR) was ***popularized as a formal concept*** by the writings of ***Hammer (1990)***, ***Davenport and Short (1990)*** and ***Hammer and Champy (1993).***
  - But perhaps ***James Harrington (1987)***, with his emphasis on process improvement in action, was the real originator.
- The earlier work of Hammer and the later expanded version of Hammer and Champy tended to focus on ***corporate transformation***, while the other influential text of Davenport and Short has a focus on ***business process redesign***, linking the concept specifically ***to developments in technology and industrial engineering***.
- Many of the first cases of BPR had a ***heavy focus on information technology***, ***to enable redesign implementation***.

Business process re-engineering (BPR)…

- In recent times, BPR has emerged as the concept which enables ***an organization to take a radical and revolutionary look at the way*** in which it operates and the way work is done, and references to it abound in management and technical publications with such words as ***'radical', 'dramatic', 'rethinking', 'optimize', 'redesign'.***
- It has become ***popular in a short period of time***, promising amazing results very quickly in relation to ***corporate and technological change, transformation and competitive pressures***.

Business process re-engineering (BPR)…

- **How Business Process Reengineering works:**
- BPR is a dramatic change initiative that contains ***five major steps that managers*** should take:
  - ***Refocus company values on customer needs***
  - ***Redesign core processes, often using information technology to enable improvements***
  - ***Reorganize a business into cross-functional teams with end-to-end responsibility for a process***
  - ***Rethink basic organizational and people issues***
  - ***Improve business processes across the organization***

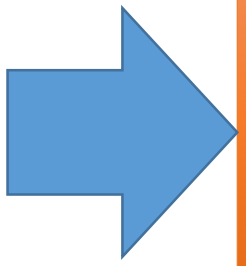
Business process re-engineering (BPR)…

- BPR is advantageous for companies to :
- **Reduce costs and cycle times**.
  - BPR reduces costs and cycle times by ***eliminating unproductive activities and the employees who perform them***.
  - **Reorganization by teams**
    - ***decreases the need for management layers*****,**
    - **accelerates information flows and**
    - **eliminates the errors and rework caused by multiple handoffs.**
- **Improve quality**.
  - BPR improves quality ***by reducing the fragmentation of work and establishing clear ownership of processes***.
  - ***Workers gain responsibility for their output*** and can ***measure their performance based on prompt feedback***.

Thank you!

- **Questions??? Comments**

Next Class



Part Two