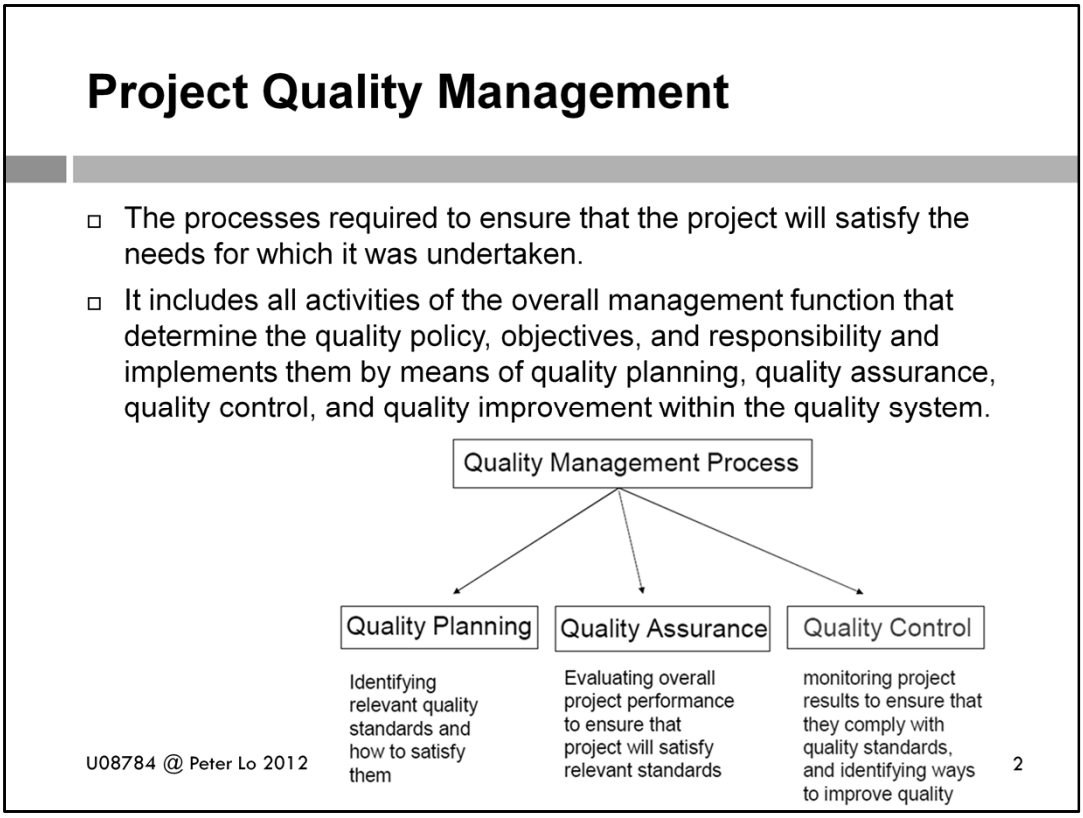
U08784
SOFTWARE PROJECT MANAGEMENT

Lecture 6: Project Quality Management

Peter Lo



<u>Project Quality Management</u>

Project Quality Management is the processes required to ensure that the project will satisfy the needs for which it was undertaken.

It includes all activities of the overall management function that determine the quality policy, objectives, and responsibility and implements them by means of quality planning, quality assurance, quality control, and quality improvement within the quality system.

- Focuses on project's products
  - Project's most important product is the system solution that the project team must deliver
- Focuses on project process
  - The activities, methods, materials, and measurements used to produce the product or service
  - Part of a quality chain where outputs of one process serve as inputs to other project management processes

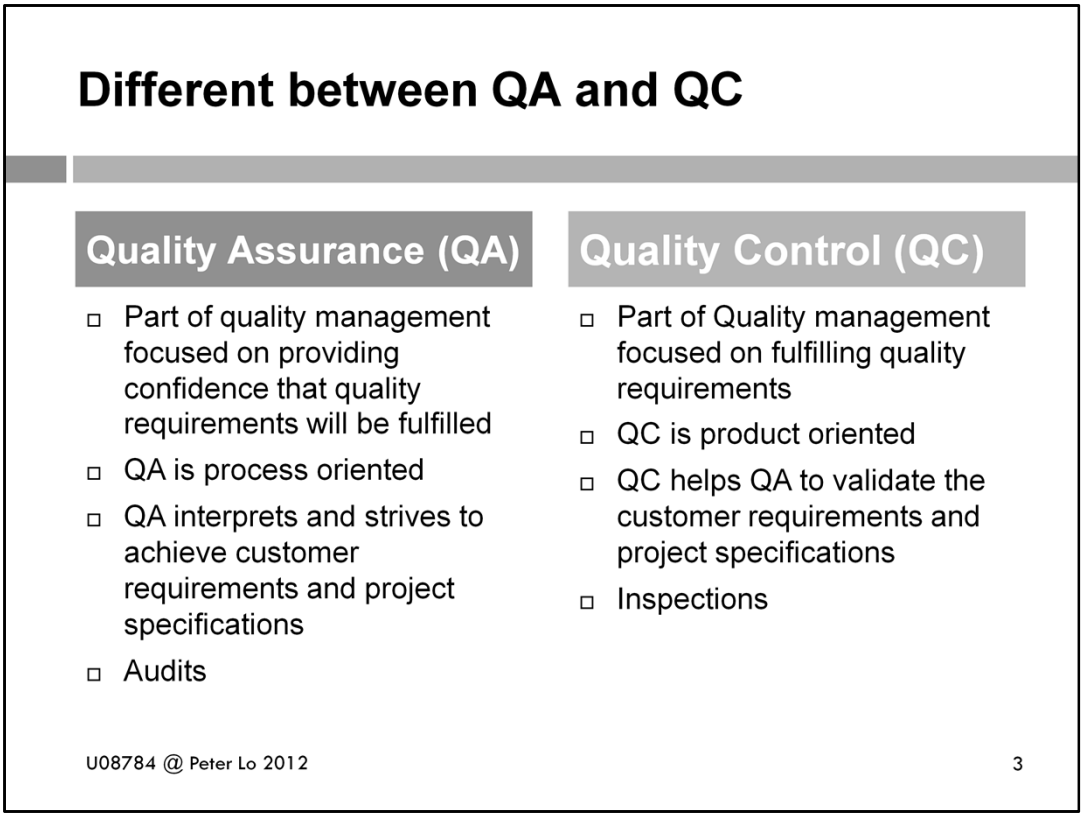
<u>Quality</u>

• An inherent or distinguishing characteristic; a property; having a high degree of excellence

• "Fitness for use" - Ensuring a product can be used as it was intended

• "Conformance to requirements" – Meeting written specifications

• Dependent on needs and expectations of customer



Many people and organizations are confused about the difference between quality assurance (QA), quality control (QC), and testing. They are closely related, but they are different concepts. Since all three are necessary to effectively manage the risks of developing and maintaining software, it is important for software managers to understand the differences. They are defined below:

- Quality Assurance: A set of activities designed to ensure that the development and/or maintenance process is adequate to ensure a system will meet its objectives.
- Quality Control: A set of activities designed to evaluate a developed work product.
- Testing: The process of executing a system with the intent of finding defects. (Note that the "process of executing a system" includes test planning prior to the execution of the test cases.)

QA activities ensure that the process is defined and appropriate. Methodology and standards development are examples of QA activities. A QA review would focus on the process elements of a project - e.g., are requirements being defined at the proper level of detail. In contrast, QC activities focus on finding defects in specific deliverables - e.g., are the defined requirements the right requirements. Testing is one example of a QC activity, but there are others such as inspections. Both QA and QC activities are generally required for successful software development.

Controversy can arise around who should be responsible for QA and QC activities -- i.e., whether a group external to the project management structure should have responsibility for either QA or QC. The correct answer will vary depending on the situation, but Mosaic's experience suggests that:

- While line management should have the primary responsibility for implementing the appropriate QA, QC and testing activities on a project, an external QA function can provide valuable expertise and perspective.
- The amount of external QA/QC should be a function of the project risk and the process maturity of an organization. As organizations mature, management and staff will implement the proper QA and QC approaches as a matter of habit. When this happens only minimal external guidance and review are needed.

Quality Management Concept

- Management Responsibility
  - The management has to provide the resource (people, finance, tools, training)
- Prevention over Inspection
  - Quality is planned in, not inspected in.
  - Cost of preventing mistakes is less than cost of correcting (inspection)
- Customer Satisfaction
  - Requirements requires the conformance to requirements fitness of use
- Continuously Improvement
  - One can follow the Plan-Do-Check-Act (PDCA) cycle

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Quality is different from grade. i.e. we can produce a low grade, high quality product

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Quality Management Concept

- Customer satisfaction
  - Conformance to requirement
  - Fitness for use: product/service produced must satisfy real needs
- Prevention over inspection
  - Cost of preventing mistakes < cost of correcting
- Continuous improvement (Kaizen)
  - Based on PDCA cycle
  - Using quality improvement initiatives e.g. TQM, 6 sigma
  - Using process improvement models e.g. OPM3, CMMI, Malcolm Baldrige
- Management responsibility
  - To provide the resource needed to succeed

Quality vs. Grade

- Quality: the degree to which a set of inherent characteristics fulfill requirements. Quality level that fails to meet quality requirements is always a PROBLEM
- Grade: A category assigned to product or service having the same functional use but different technical characteristics. Low grade may not be a problem

Benefit in Quality

- Deliver more value to customers
  - More business
- Increase profits
  - Cost of selling to existing customer is less
- Reduce wastage
  - Improve profit margin
- Improve competitiveness
  - Gaining market share means more revenue and eventually more profits
- Improve company image
  - Reduce staff turnover and reduce training cost
  - Improve sells brings more customers and higher value customers

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Risk of Low Quality

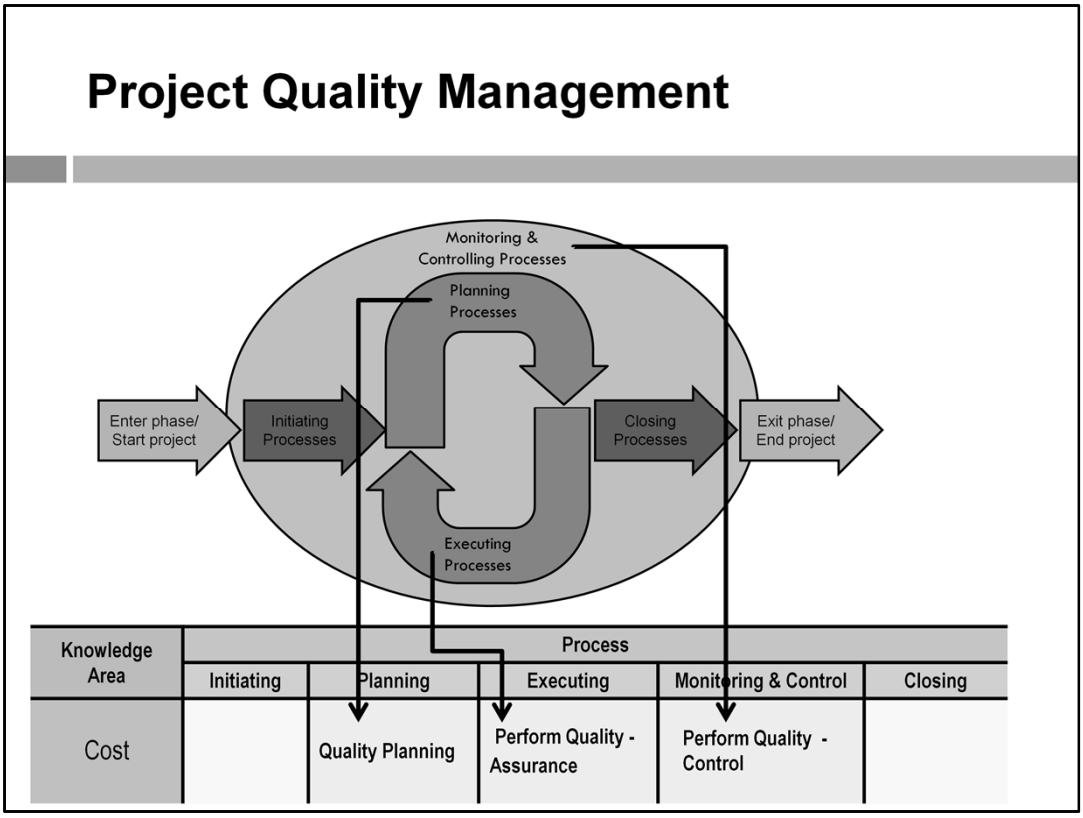
- Increased Cost
- Low morale
- Low customer satisfaction
- Increase risk
- Rework
- Schedule delays

Consequences of Poor Quality

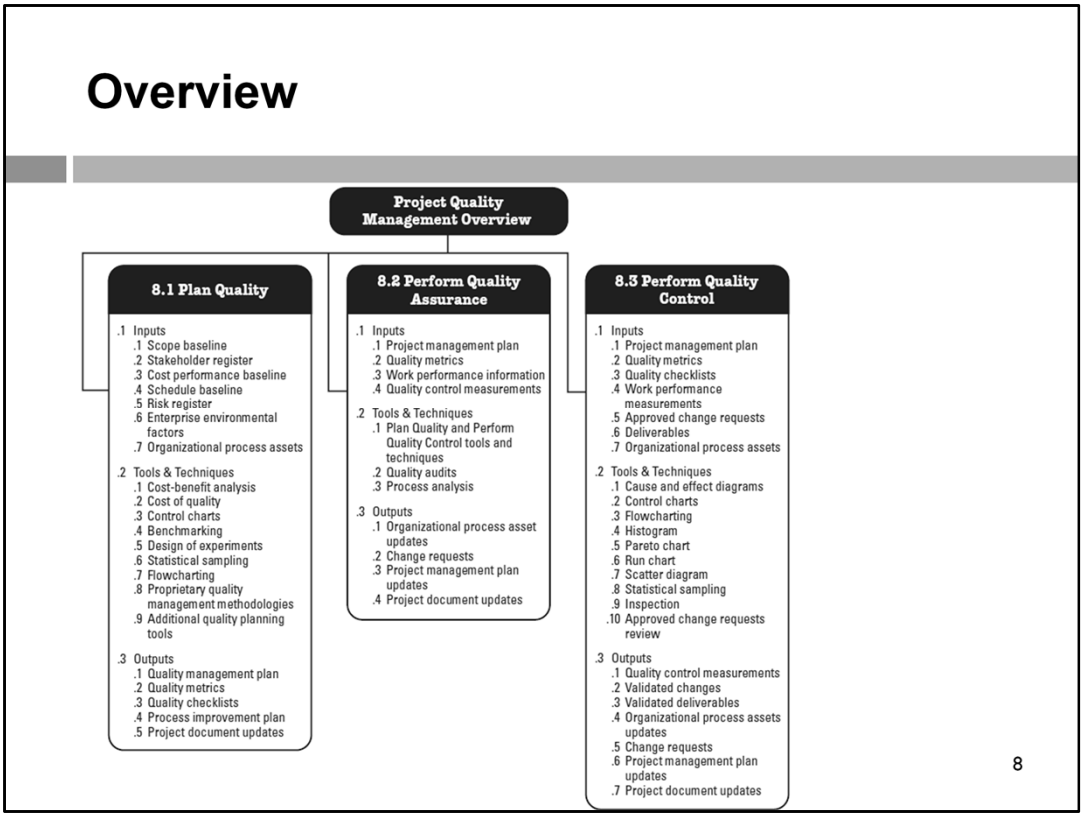
- Loss of business
- Liabilities & re-working
- Low productivity
- Increased inspections
- Cost overruns
- Disturbed cash flows
- Bad market reputation
- Disagreements over product acceptances

Common Quality Issue Handling Method

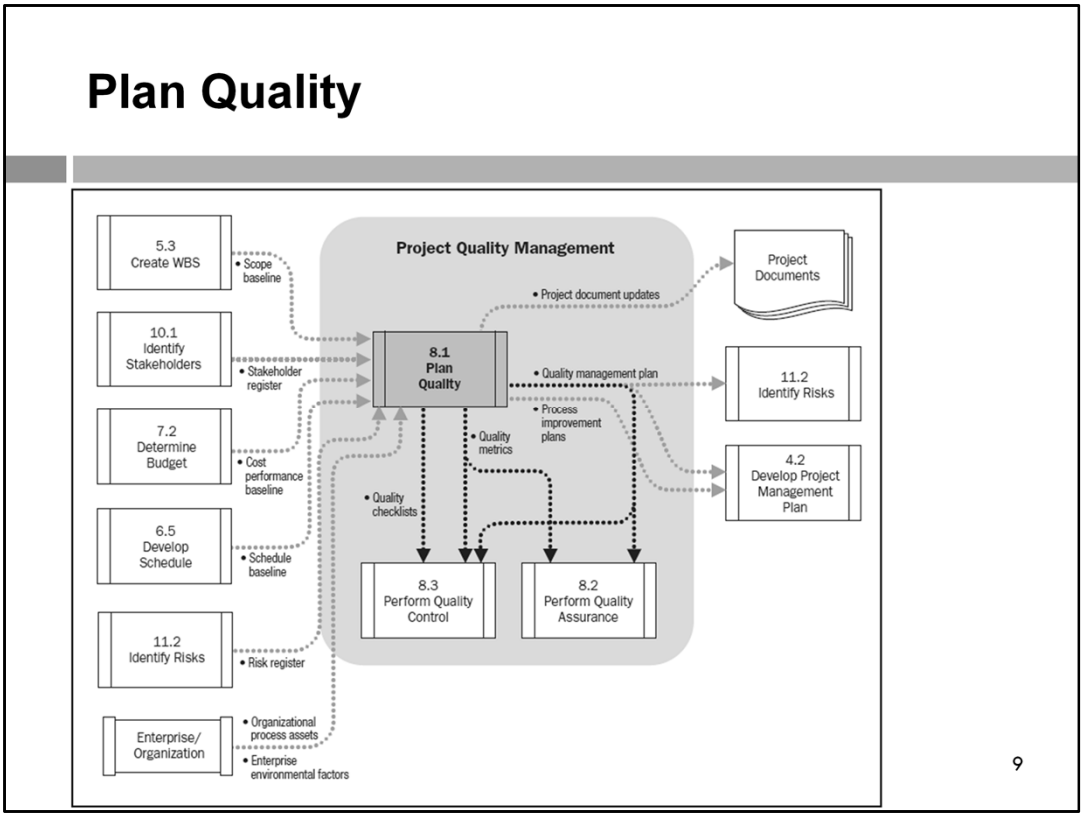
- **Gold Plating**: giving the customer extras
  - This practice is not recommended
- **Marginal Analysis**:
  - Looking for the point where benefits/revenue to be received from improving quality EQUALS the incremental cost to achieve that quality
- **Just in Time (JIT):** just when they are needed or just before they are needed.
  - It forces attention on quality practices.
- **Total Quality Management (TQM)**
  - Company & their employees focus on finding ways to continuous improve the quality of their business practices & products.



- Quality is degree to which the project fulfills requirements
  Quality Management includes creating and following policies and procedures to ensure that a project meet the defined needs (from the customer's perspective).
- Completing project with no deviations from the project requirements.

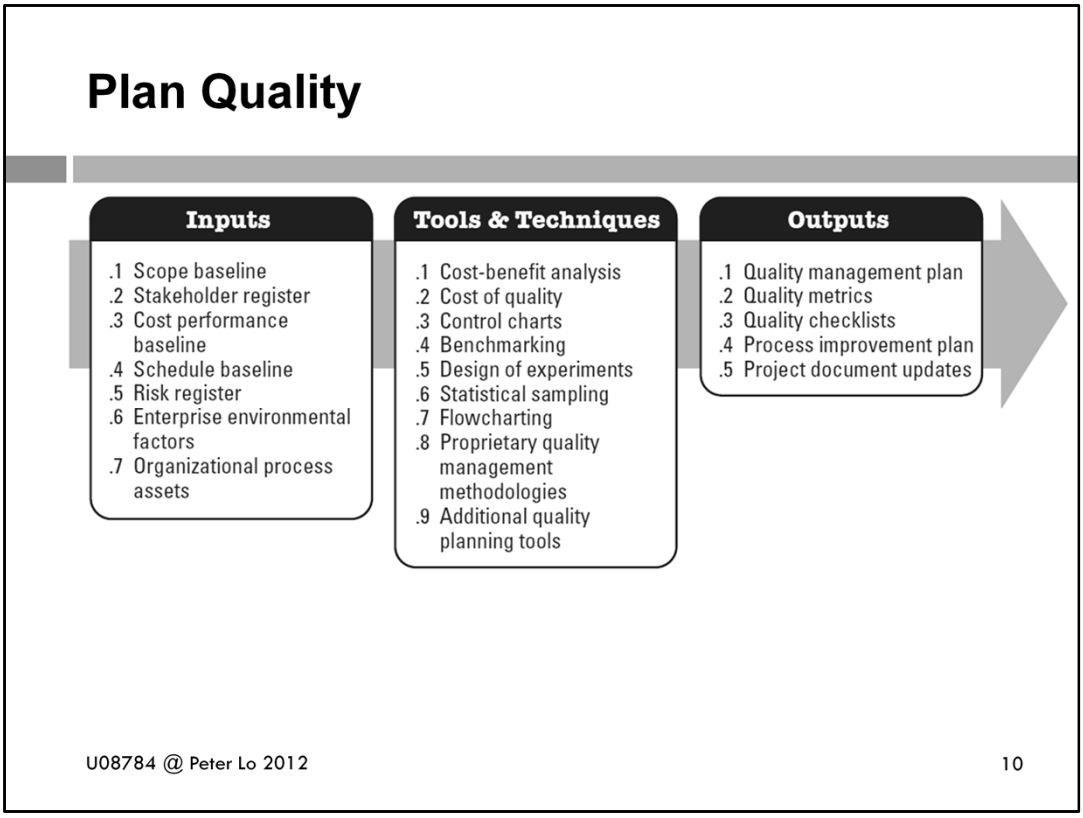


- Includes all the activities of the performing organization that determine quality policies, objectives and responsibilities, so that the project will satisfy the needs
- It implements the quality management system (QMS) through the policy, procedures, and processes.
- Continuous process improvement activities
- Meeting customer specifications and expectations
  - On time, on budget, no defect
  - Usable, easy to use, reliable
  - Flexible, add value to client business process, etc.
- Quality is “conformance to requirement or specifications” and fitness to use
- Customer satisfaction is the key to quality
- Meeting stakeholders‟ stated or implied expectations and needs



The process of identifying requirement and/or standards for the project and product and documenting how the project will demonstrate compliance. (What is quality? How will we ensure it?)

- Identifying the standards that are relevant to the project and determining how to satisfy them
- Create additional project specific standards
- Determine what work to do to meet standard
- Determine how to measure a work is meeting standard
- Balance the need of quality with scope, cost, time, risk and satisfaction
- Create a quality management plan and add to the project management plan
- Mostly done in project planning phase



Input
- Scope Baseline
- Stakeholder Register
- Cost Performance Baseline
- Schedule Baseline
- Risk Register
- Enterprise Environmental Factors
- Organizational Process Assets

Tools & Techniques
- Cost-Benefit Analysis
- Cost of Quality
- Control Chart
- Benchmarking
- Design of Experiments
- Statistical Sampling
- Flowcharting
- Proprietary Quality Management Methodologies
- Additional Quality Planning Tools

Output
- Quality Management Plan
- Quality Metrics
- Quality Checklists
- Process Improvement Plan
- Project Documents Updates

Plan Quality (Input)

- **Scope Baseline** includes scope statement (project description, major project deliverables and acceptance criterion), WBS & WBS dictionary.
- **Stakeholder Register** identifies stakeholders with a particular interest in, or impact on, quality
- **Cost Performance Baseline** documents the accepted time phase to measure cost performance.
- **Schedule Baseline** documents the accepted schedule performance including start and finish dates
- **Risk Register** contains threats and opportunities that can affect the project quality
- **Enterprise Environmental Factors** (Governmental regulations, working/ environmental conditions)
- **Organizational Process Assets** (Historical data and organizational policies and procedures)

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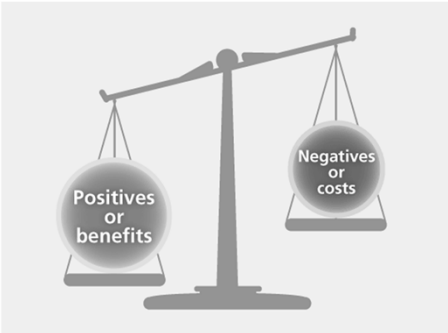
- Scope baseline
  - Scope statement: project description, deliverables, acceptance criteria
  - WBS: deliverables, work packages, control accounts
  - WBS dictionary: technical information for WBS
- Stakeholder register
- Cost performance baseline
- Schedule baseline
- Risk register
- Enterprise environmental factors
  - Governmental agency regulations
  - Rules, standards, and guidelines specific to the application area
  - Working/operating conditions of the project/product
- Organizational process assets
  - Organizational quality policies, procedures, and guidelines
  - Historical databases
  - Lessons learned
  - Quality policy, set by senior management
  - The United Nations Convention on Contracts for International Sale of Goods (CISG)
  - Govern international sale transactions
    - ISO 9000
    - Occupational Safety and Health Administration (OSHA)
      - United States standard for American workers

Plan Quality (Tools & Techniques)

- Cost-Benefit Analysis
  - Comparing cost of quality and the expected benefit
    - Weight the benefits versus the cost of meeting quality requirements
    - Less re-work, higher productivity, lower costs, increased stakeholder satisfaction



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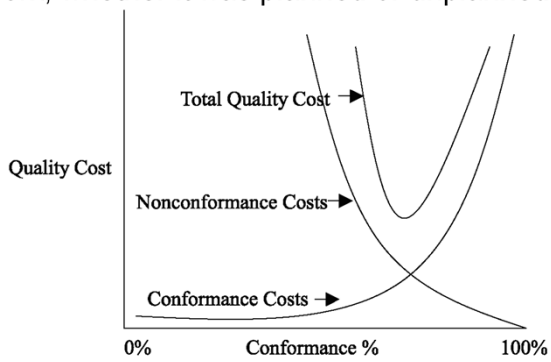
- Identifies the cost and benefits of performing quality management
- Same comparative analysis techniques as project initiation
  - Benefit Cost Ratio (BCR)
  - Present Value (PV) and Net Present Value (NPV)
  - Internal Rate of Return (IRR)
  - Payback Period
- The benefits should outweigh the cost
  - Identifies the cost of non compliance
  - Identifies the intangible cost and benefits of projects

Plan Quality (Tools & Techniques)

- Cost of Quality (COQ)
  - The total cost to produce the product or service of the project according to the quality standards.
    - Includes all costs incurred over the project life to prevent non-conformance to requirements.
    - Includes all work, whether it was planned or unplanned cost.



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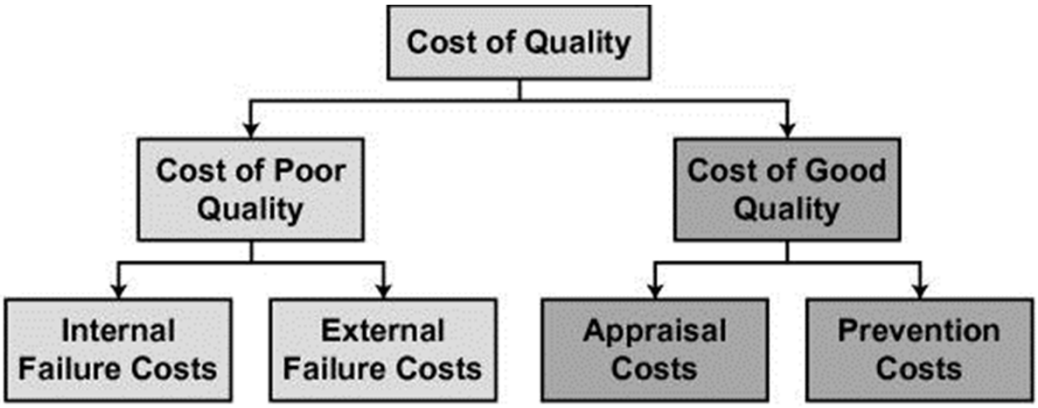
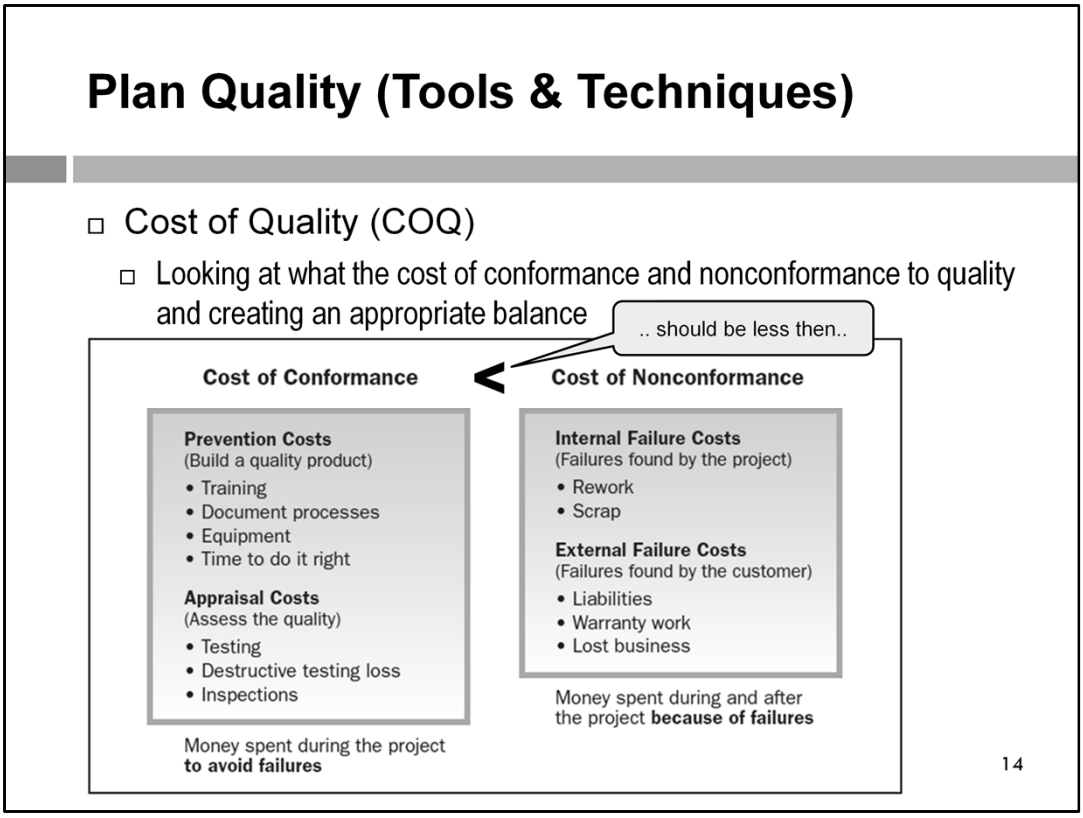
Theories on the COQ

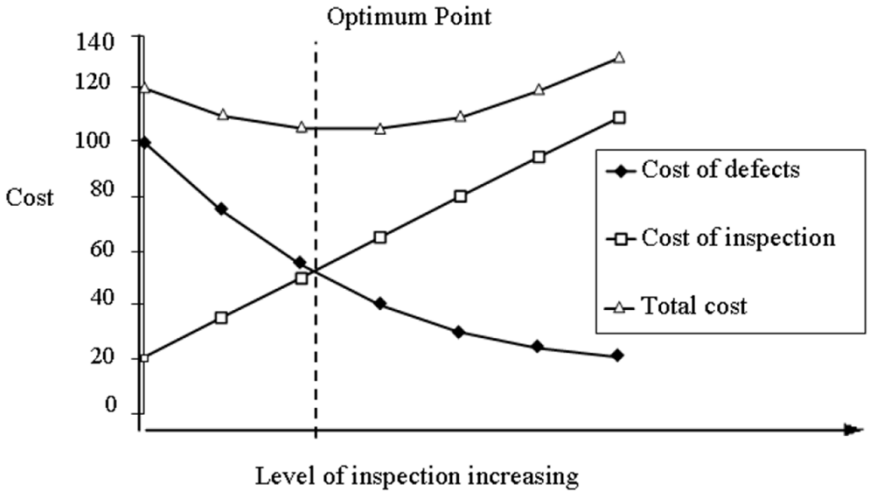
- ***Crosby*** = Zero defects and preventions or reworks results.
- ***Juran*** = Fitness for use, conformance. Quality by design
- ***Deming*** = Quality is a management problem.
- ***Feigenbaum*** = Founder of TQM
- ***Shewhart*** = Plan-Do-Chek-Act cycle
- ***TQM*** = Quality must be managed in and must be a continuous process
- ***Six Sigma*** = measurement based strategy; no more than 3.4 defects per million opportunities.
- ***Kaizen*** = Continuous improvement; improve quality of people first.
- ***Continuous improvement*** = Watch continuously for ways to improve quality





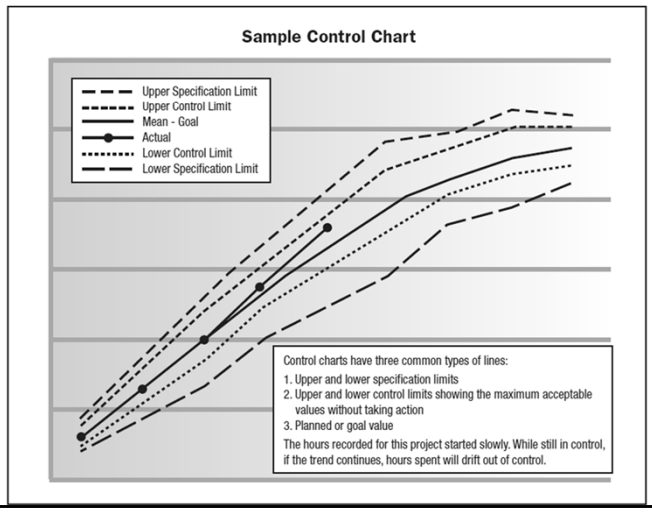
Looking at what the cost of conformance and nonconformance to quality and creating an appropriate balance

- Failure Costs: Costs incurred by defective parts/products or faulty services from poor quality.
  - Internal Failure Costs: Costs incurred to fix problems that are detected before the product/ service is delivered to the customer.
  - External Failure Costs: All costs incurred to fix problems that are detected after the product/service is delivered to the customer.
- Appraisal Costs – Cost expended to examine the product or process and make certain the requirements are being met, costs of activities designed to ensure quality or uncover defects.
- Prevention Costs – Cost associated with satisfying customer requirements by producing a product without defects. All training, planning, customer assessment, process control, and quality improvement costs to prevent defects from occurring.



Plan Quality (Tools & Techniques)

- Control Chart
  - Used to determine process stability and predictable performance.



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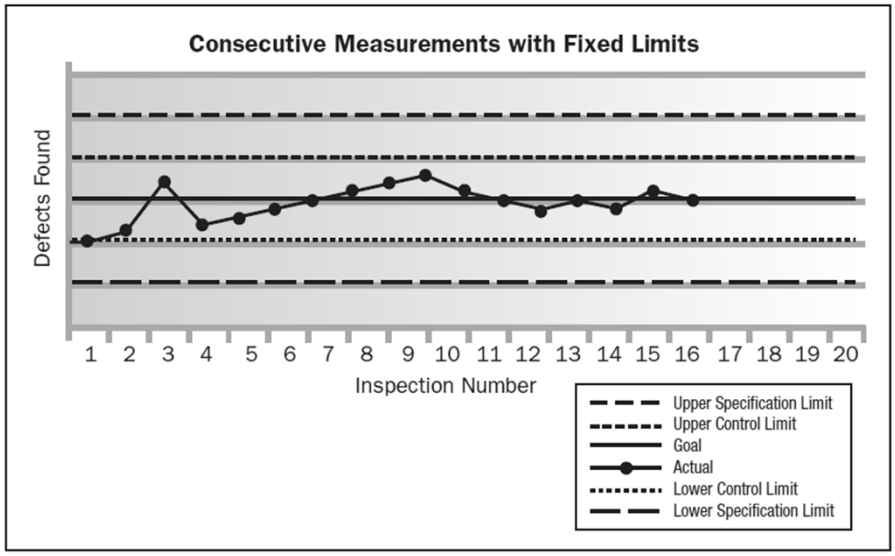
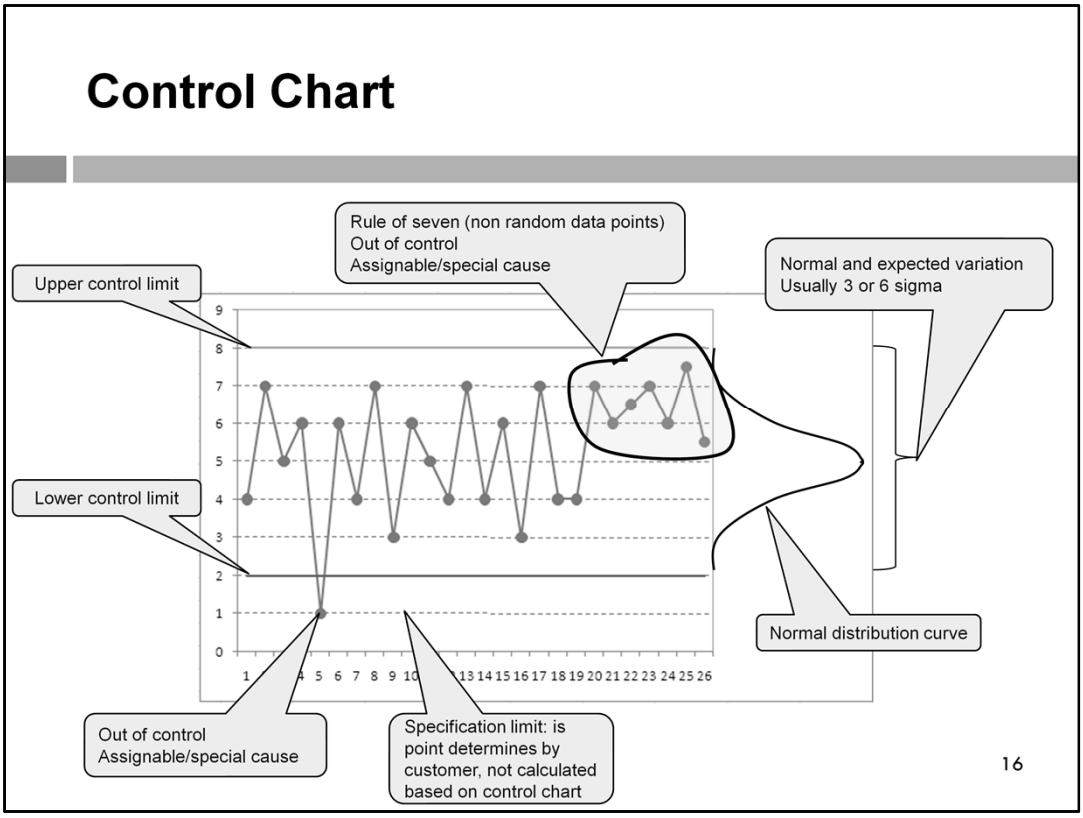
Control Charts are used to determine process stability and predictable performance.

- Graphical display of results, over time, of a process
- Also utilize statistical probability
- Used to determine if a process is "in control"
- Focus on preventing defects, not on detection or elimination
- Used to verify the impact on a process when changes are made
- Are used to check if a process is stable and has predictable performance
- Upper and lower specification limits based on contract
- Penalty might be associated with exceeding limits
- Three sigma for repetitive processes
- Can be used with various types of outputs such as cost and schedule variances, volume and frequency of scope changes

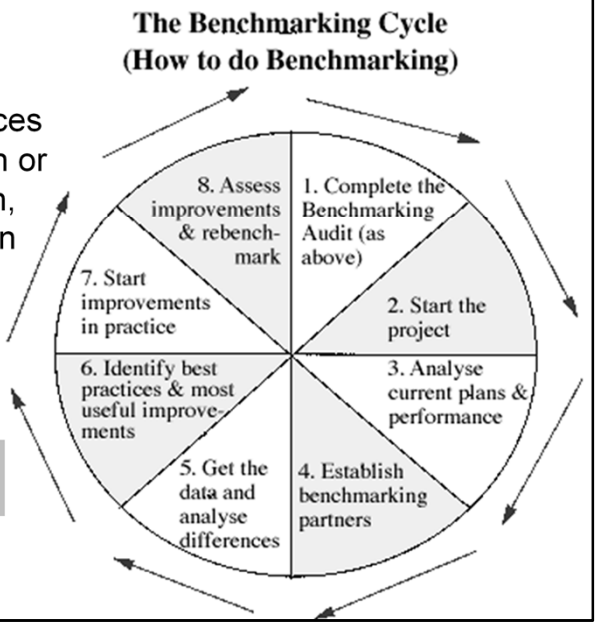




- Upper and Lower Limits
  - Acceptable range of variation of a process often show as two dash lines on a control chart
  - The acceptable range between upper limit and lower limit is determined by organization standard (3 or 6 sigma)
    - 3 sigma (SD) = 99.73%
    - 6 sigma (SD) = 99.99985%
- Mean
  - A line in middle of the control chart shows the middle of the acceptable variation range. Also called X bar
- R
  - The different between the highest and lowest value of a certain measurement period is call R
- Specification Limit
  - Represent the customer expectation or contractual requirement
- Out of control
  - A data point fall outside of the upper or lower control limit
  - Non random data points that within upper or lower limits, such as rule of seven
- Rule of seven
  - Non random data points grouped together in a series of total seven on one side of the mean
  - Process is not random and maybe out of control

Plan Quality (Tools & Techniques)

- Benchmarking
  - Comparing actual or planned project practices to best practices within or outside of organization, within same application area or another one



Comparing your planned practices to those of comparable projects.

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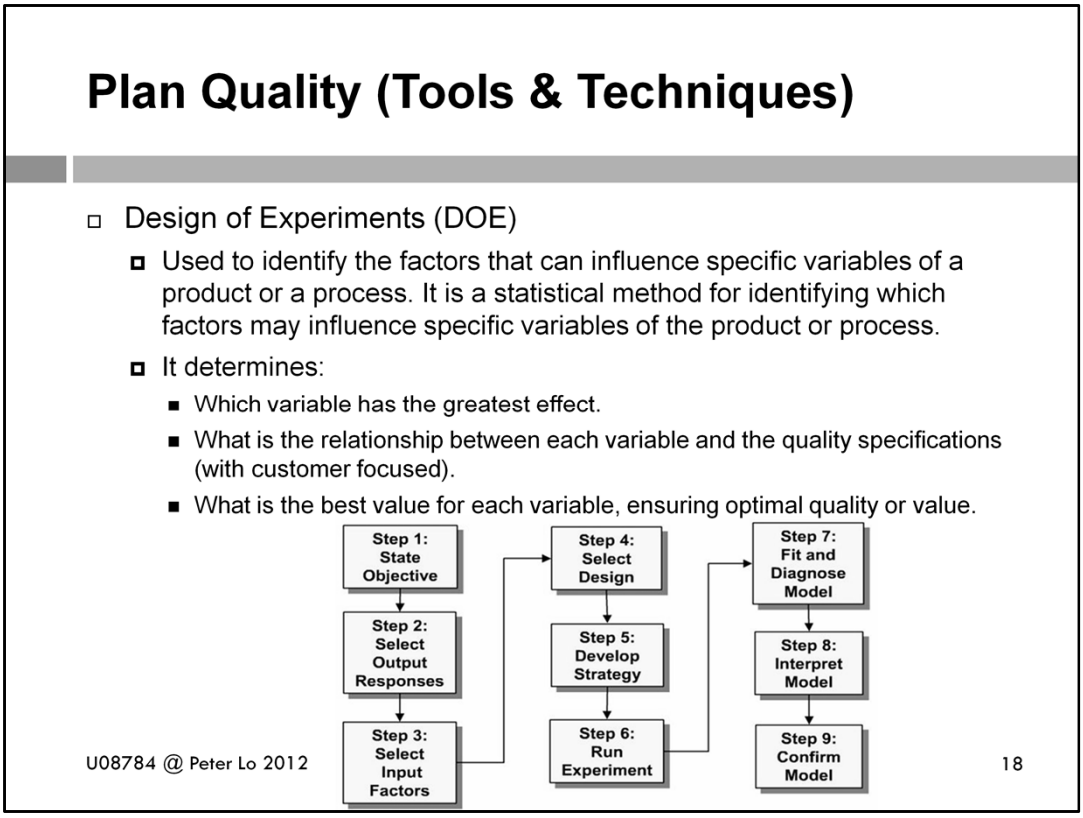
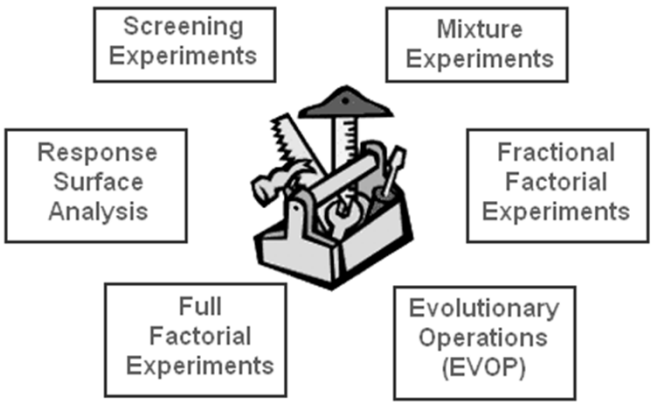
Comparing the actual or planned project practices to reference projects to generate ideas of improvements and to provide a standard for performance measurement
Used for process and product improvement
The reference data can be within the organization or with other organizations which have similar processes
Alternatively, one can also benchmark against a reference quality model. E.g. appraised by external authorized appraiser to attend the CMMI Maturity Level



DOE is a technique to systematically identify varying levels of independent variables.

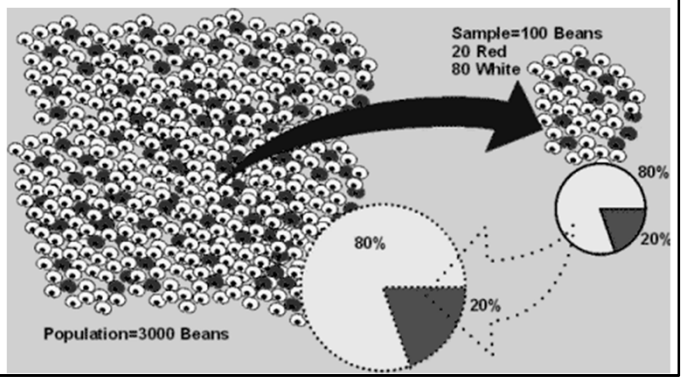
- Statistical method for identifying the factors which influence specific variables in a project (e.g. how to provide safer ride at a reasonable cost?)
- Change the variables in order to assess different outcomes, which helps to determine an optimal solution
- This technique frequently applied to products of a project
- Useful in assessing impacts of one or more variable on cost, schedule, or other targets of improvement
- Conduct several experiments in order to determine the optimal combination
- Use experimentation to statistically determine what variable will improve quality
- Systematically changing all of the important factors, rather than changing the factors one at a time
- Should be used during the Plan Quality Process to determine the number and type of tests and their impacts on COQ
- Plays role in optimization of products and processes
- Can be used to reduce the sensitivity of products to variables



Plan Quality (Tools & Techniques)

- Statistical Sampling
  - Involves choosing part of a population of interest for inspection
  - Sample frequency and sizes should be determined during the plan quality process

We need it since studying entire population would take too long, too much cost, be too destructive



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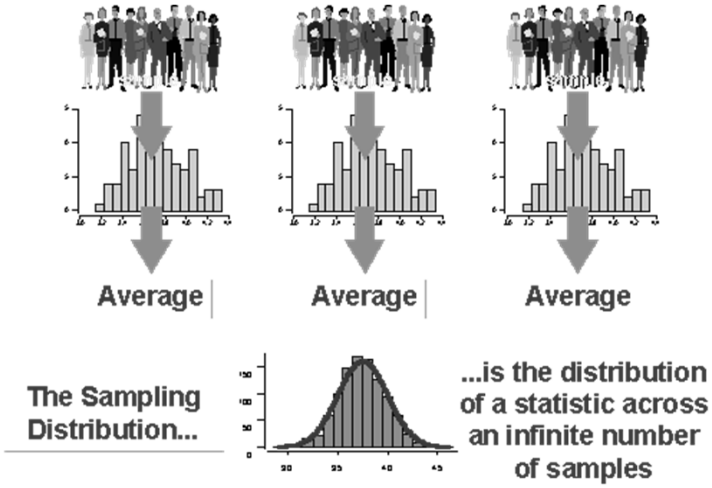
Statistical sampling refers to the study of populations by gathering information about and analyzing it. Statistical sampling is the base for a great deal of information, ranging from estimates of average height in a nation to studies on the impact of marketing to children. Numerous professions use statistical sampling, including psychology, demography, and anthropology. Like any study method, however, statistical sampling is prone to errors, and it is important to analyze the methods used to conduct a study before accepting the results.

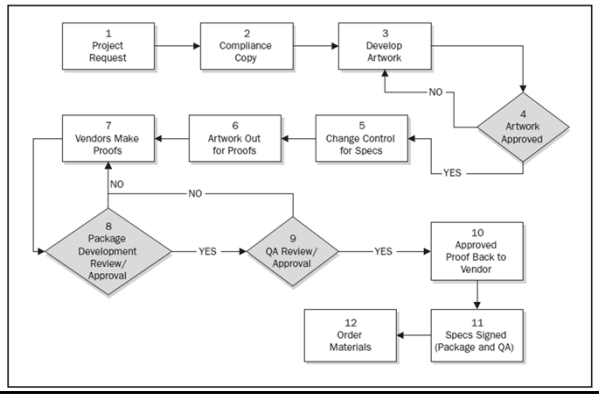
This process begins with a definition of the population the scientist wants to study, and the variable which he or she wants to measure. For example, someone might want to know the average weight of elementary school children. Next, the scientist decides how to collect the desired data. In the previous example, the scientist might travel to schools with a scale, send questionnaires out to doctors or parents, or try to access school health records. Many researchers try to measure directly, rather than relying on self-responses, because this way the results are consistent.

Once the population, variable being measured, and method have been defined, the scientist decides how to accurately sample the population so that the collected data is representative of a larger group. In other words, statistical sampling does not involve measuring the desired variable in every individual of the population being studied; a selection of individuals is used to generalize results. Generally, the larger the sample size, the better the results.



Plan Quality (Tools & Techniques)

- Flowcharting
  - Use to see a process or system flows and find potential quality problem
    - Showing the relationships among process steps
    - Shows activities, decision points, and the order of processing



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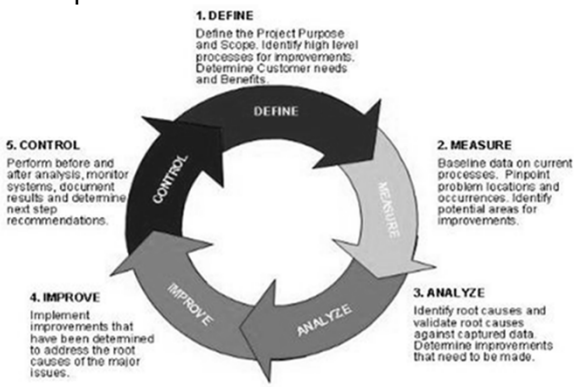
Flowcharting is graphical relationship of processes in an activity.
A flowchart is a type of diagram that represents an algorithm or process, showing the steps as boxes of various kinds, and their order by connecting these with arrows. This diagrammatic representation can give a step-by-step solution to a given problem. Process operations are represented in these boxes, and arrows connecting them represent flow of control. Data flows are not typically represented in a flowchart, in contrast with data flow diagrams; rather, they are implied by the sequencing of operations. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.

Plan Quality (Tools & Techniques)

- Proprietary Quality Management Methodologies
  - Include renowned tools like
    - Six Sigma
    - Lean Six Sigma
    - Quality Function Deployment
    - CMMI

Six Sigma

- Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes.
- It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization who are experts in these methods.



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Sigma is another name of standard deviation
It is a rigorous and disciplined methodology that uses data and statistical analysis to measure and improve company performance by identifying and eliminating defects in manufacturing and service related processes
Commonly defined as x defects per y opportunities
Six Sigma DMAIC process (define, measure, analyze, improve, control) is an improvement system for existing processes falling below specification and looking for incremental improvement
Six Sigma DMADV process (define, measure, analyze, design, verify) is an improvement system used to develop new processes or products at Six Sigma quality levels. It can also be employed if a current process requires more than just incremental improvement

ISO 9000 series

- The ISO 9000 family of standards is related to quality management systems and designed to help organizations ensure that they meet the needs of customers and other stakeholders while meeting statutory and regulatory requirements related to the product.

Standard	*Objectives/Tasks*
ISO 9000	This provides guidelines on selection and use of quality management and quality assurance standards.
ISO 9001	It has 20 elements covering design, development, production, installation and servicing.
ISO 9002	It has 18 elements covering production and installation. It is same as ISO 9001 without the first two tasks, *viz*., design and development. This is applicable for the units excluding R & D functions.
ISO 9003	It has 12 elements covering final inspection and testing for laboratories and warehouses etc.
ISO 9004	This provides guidelines to interpret the quality management and quality assurance. This also has suggestions which are not mandatory.

- ISO 9000 series
  - 9000: Guidelines for selection and use
  - 9001: QA in Design / Development (9001:2000 Quality Management standard)
  - 9002: QA in production and installation (obsolete)
  - 9003: QA in final inspection and test (obsolete)
  - 9004-4 1993: QA & Quality system elements
  - 10006 1997: Guidelines to quality in project management
  - 14000/14001: Environmental Management System (EMS)
- ISO essence
  - Establish your QMS (Have a process)
  - Document your QMS (Document the process)
  - Implement your QMS (Follow the process)
  - Improve your QMS (Continuous improvement)
  - Maintain your record (Show evidence that you follow the process)
  - Pass Certification (ISO 9001 2000 Certification)

Plan Quality (Tools & Techniques)

- Additional Quality Planning Tools

Tool	Description
Brainstorming	Used to generate ideas within a large group. A brainstorming session can also utilize and review information obtained using the nominal group technique.
Affinity diagrams	Used to group and organize thoughts and facts and can be used in conjunction with brainstorming.
Force field analysis	A method of examining the drive and resistance of change.
Nominal group techniques	Brainstorming sessions consisting of small groups. The ideas of these sessions are later reviewed by a larger group.
Matrix diagrams	Used as a decision-making tool, particularly when several options or alternatives are available.
Prioritization matrices	Used to prioritize complex issues that have numerous criteria for decision making.

Additional Quality Planning Tools include brainstorming, matrix diagrams and affinity diagrams etc.

- Brainstorming
- Affinity diagrams (identifying logical groupings based on natural relationships)
- Force field analysis (diagrams of the forces for and against change)
- Nominal group techniques (brainstorming in small groups and reviewed by a larger group)
- Matrix diagrams (include 2,3, or 4 groups of information and show relationships between factors, causes, and objectives)
- Prioritization matrices (ranking diverse set of problems)

Plan Quality (Output)

- Quality Management Plan
  - Sometimes refers to as quality assurance plan or quality plan. It is a subsidiary of project management plan
  - Describe how quality policy will be implemented
  - The plan should contains
    - Quality policy, standards and objectives
    - Organizational structure responsible to quality processes
    - Processes and procedures (review, inspection, testing, etc.)
    - Resources needed to implement
    - Acceptance criteria
    - Testing plan
    - Review plan

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- Describes how the project team would ensure project and product quality.
- Includes quality control, quality assurance, and continuous process improvement approaches for the project
- May be formal/informal, highly detailed or broadly framed
- Contains:
  - Project management method
  - Role and responsibility in managing quality
  - Deliverable measurement
  - Standard for monitoring & control purpose
  - Process review
  - Major check points
  - Inspection & acceptance criteria
- Describe
  - What are the standards that apply on the project
  - Who would be involved in managing quality, when and what duties
  - Review of earlier decisions to ensure that they are correct
  - Quality meetings to be held and when
  - Reports that will address quality
  - What metrics would be used to measure quality
  - What parts of the project or deliverables would be measured and when

Plan Quality (Output)

- Quality Metric
  - Is used to translate customer needs into performance measurement.
  - An **operational** that describes **how** quality control process will measure it.
  - What are things that important to measure and decide what measurement is acceptable
    What should be measured, how, its value and allowed variation
    - Examples: on-time performance, budget control, defect frequency, failure rate, availability, reliability, and test coverage

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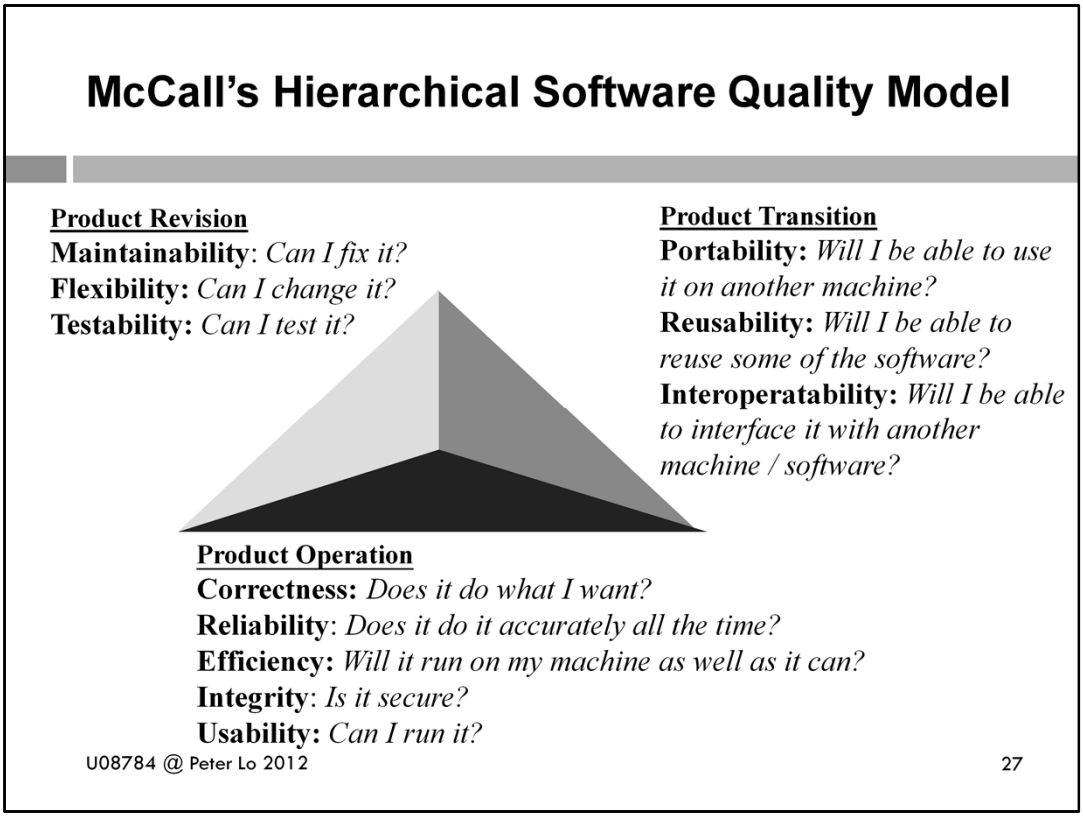
- The following maybe measure as a quality index
  - On time for every deliverable
  - Number of trouble calls per week
  - Number of features completed per month
- Specify performance characteristics
- Transfer conceptual quality to concrete measurements
- From measurement to interpretation of results



McCall's quality factors were proposed in the early 1970s. They are as valid today as they were in that time. It's likely that software built to conform to these factors will exhibit high quality well into the 21st century, even if there are dramatic changes in technology.

Product Operations – Operation Characteristics

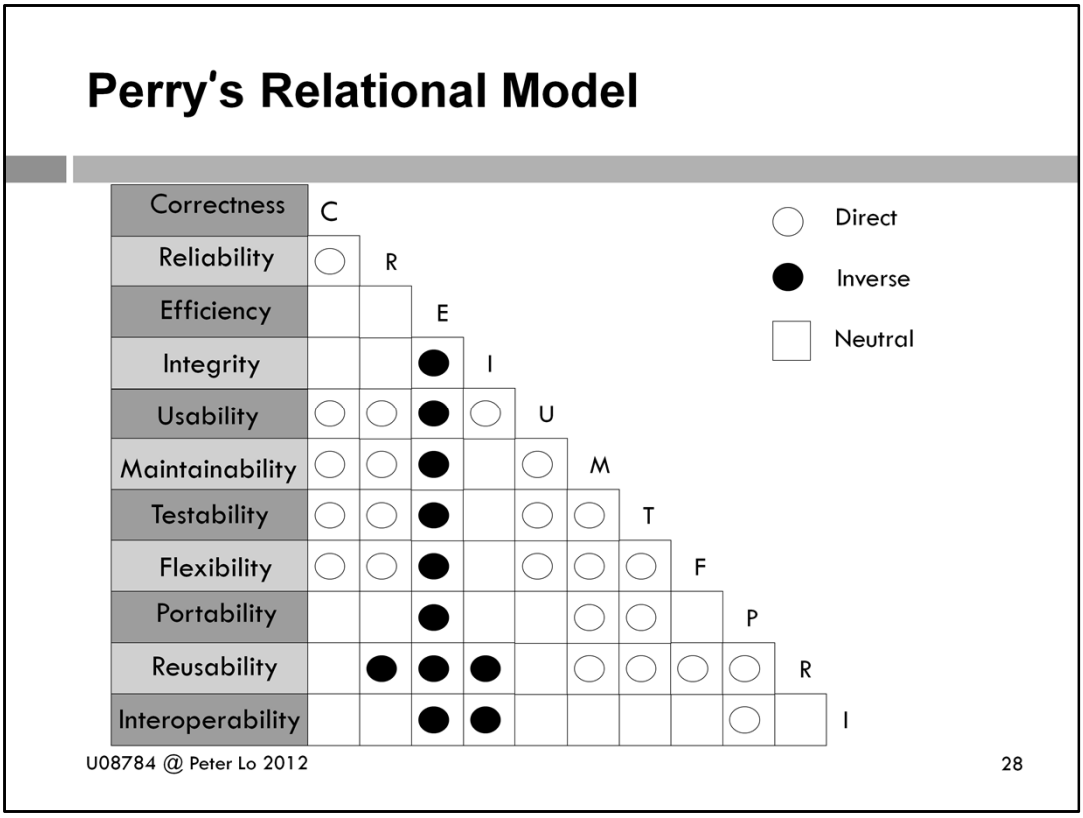
- ***Correctness***: The extent to which a program satisfies its specification and fulfills the customer's mission objectives.
- ***Reliability***: The extent to which a program can be expected to perform its intended function with required precision.
- ***Efficiency***: The amount of computing resources and code required by a program to perform its function.
- ***Integrity***: The extent to which access to software or data by unauthorized persons can be controlled.
- ***Usability***: The effort required to learn, operate, prepare input, and interpret output of a program.

Product Revision – Ability to Undergo Change

- ***Maintainability***: The effort required to locate and fix an error in a program.
- ***Flexibility***: The effort required to modify an operational program.
- ***Testability***: The effort required to test a program to ensure that it performs its intended function.

Product Transition – Adaptability to New Environments

- ***Portability*:** The effort required to transfer the program from one hardware and / or software system environment to another.
- ***Reusability*:** The extent to which a program (or parts of a program) can be reused in other applications - related to the packaging and scope of the functions that the program performs.
- ***Interoperability*:** The effort required to couple one system to another.



Notes on Software Quality Attributes

- Not all attributes are of equal importance
- An attribute may have different importance in different software systems
- The value of an attribute for a given software may change as time passes
- Relationships between attributes are very complicated; some are positive; some are negative
- Different people may have different view on quality

[Alan Gillies, Software Quality: Theory and Management, Second Edition, International Thomson Computer Press, 1997]

Plan Quality (Output)

- Quality Checklist
  - Is a tool to verify that a set of required steps have been performed.
  - A list of items to inspect, step to be performed and note if any defects found

Quality metrics is input for
- Quality Assurance AND
- Quality Control

Quality checklist is input for
- Quality Control ONLY

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Processing Quality Checklist

↑ Increase
↓ Decrease

	RAPID RESPONSE							SLOWER RESPONSE				
	Back Pressure	Boost Pressure	Injection Rate	Mold Open Speed	Packing Pressure	Screw Decompression	Screw Forward Time	Cycle Time	Melt Temperature	Mold Temperature	Nozzle Temperature	Possible Causes and/or Solutions
Bubbles/Voids		↑			↑	↓	↑		↓	↑		Improve venting, Inc. gate size, Min. thick section
Burn Marks		↓	↓				↓		↓			Improve venting, Relocate gate
Discoloration	↓		↓					↓	↓		↓	Purge barrel/Clean screw/Barrel/Nozzle
Distortion Upon Ejection				↓	↓							Check mold surface for smooth release
Erratic Screw Retraction	↑								↑			Check for screw wear
Flash	↓	↓	↓		↓				↓	↓		Mold needs adjustment/Clamp tonnage too low
Flow Lines			↓						↑	↑		Increase gate size, Check venting
KO Pin Penetration				↓	↓			↑				Poor mold cooling
Lamination		↑	↑		↑				↑	↑		Contaminated material, Increase gate size
Nozzle Drool	↓					↑			↓		↓	Use reverse taper nozzle
Part Sticking in Mold		↓	↓		↓		↓	↑	↓	↓	↑	Check for damaged mold surfaces
Poor Weld Lines		↑	↕		↑				↑	↑		Improve venting, Relocate gate, Clean vents
Short Shots		↑	↑		↑		↑		↑	↑		Increase gate size, Increase shot size
Shot to Shot Variation			↑		↑		↑					Non-return valve leakage
Sink Marks		↑			↑		↑		↕			Increase gate size
Splay Marks			↓		↑	↓			↓	↑	↓	Wet material
Sprue Sticking					↓		↓				↑	Damaged sprue bushing, Increase taper
Surface Blemish		↑	↑		↑				↑	↑		Wet material
Unmelted Pellets	↑							↑	↑			Check heater bands
Warpage			↕		↑		↓	↑	↕	↓		Check cooling line location
White Spots	↓	↑	↓			↓				↑		Wet material

- A simple tracking device to count and accumulate data
- Establish a common reference for quality management execution
- Especially effective when developed and improved over several projects or iterations
- Maybe in the form of a table with pass/fail check

Plan Quality (Output)

- Process Improvement Plan
  - Steps for analyzing process and taking actions to improve the process
  - E.g. PLAN – DO – CHECK – ACT (Deming cycle), start with pilots, check results, modify and deploy in the organization
  - A typical content:
    - Process description and boundary: Purpose and objectives, scope, entry criteria, inputs, activities, exit criteria, output, measurement, and verification (ETVX – entry criteria, task, verification, exit criteria)
    - Measurements e.g. process metrics and targets

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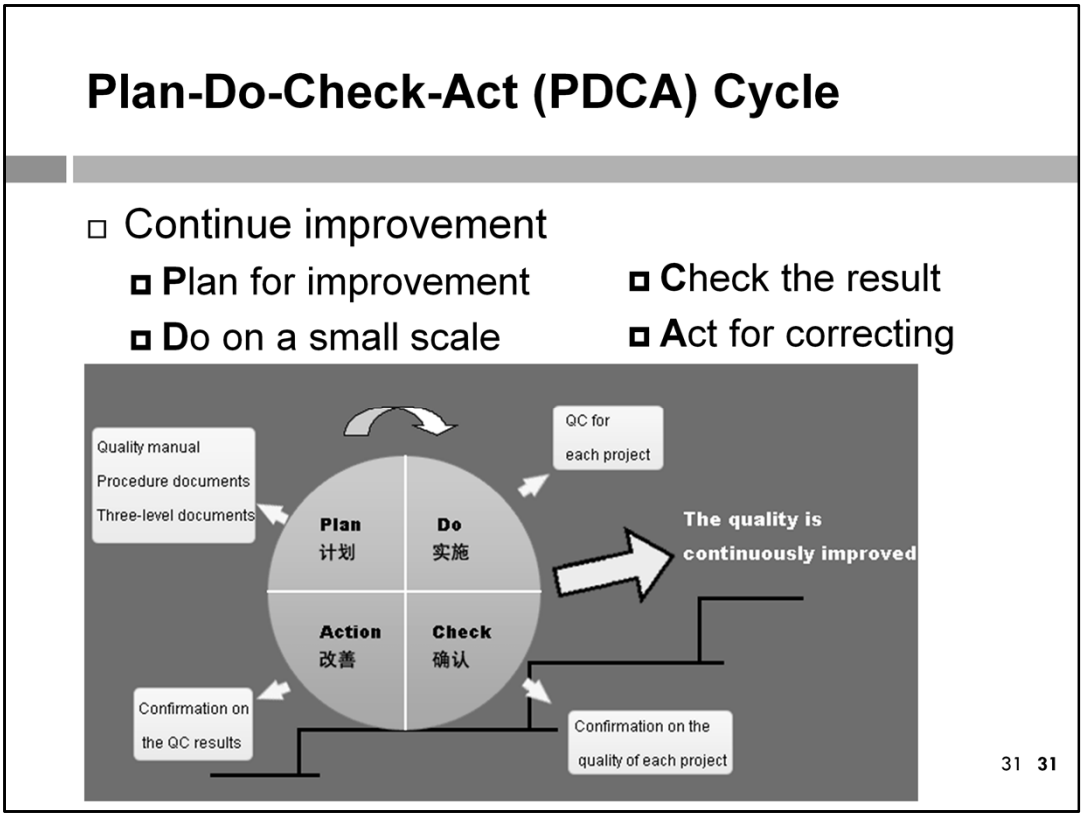
Details the steps for analyzing processes to identify activities than enhance their value. It is subsidiary plan of the PMP.

- A subsidiary of the project management plan
- It details the steps for analyzing processes to identify activities which enhance their value
- Area to consider include:
  - Process boundaries: purpose, start, end, inputs, outputs, data, owner and the stakeholders of processes
  - Process configuration: graphic description of processes, with interfaces identified and used to facilitate analysis
  - Process metrics
  - Targets for improved performance: guides the process improvement activities
  - Project document updates
- Stakeholder register
- Responsibility assignment matrix



PDCA (Plan–Do–Check–Act) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. The steps in each successive PDCA cycle are:

PLAN

- Establish the objectives and processes necessary to deliver results in accordance with the expected output (the target or goals). By establishing output expectations, the completeness and accuracy of the specification is also a part of the targeted improvement. When possible start on a small scale to test possible effects.

DO

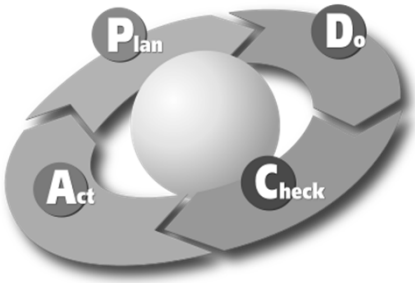
- Implement the plan, execute the process, make the product. Collect data for charting and analysis in the following "CHECK" and "ACT" steps.

CHECK

- Study the actual results (measured and collected in "DO" above) and compare against the expected results (targets or goals from the "PLAN") to ascertain any differences. Look for deviation in implementation from the plan and also look for the appropriateness/completeness of the plan to enable the execution i.e., "Do". Charting data can make this much easier to see trends over several PDCA cycles and in order to convert the collected data into information. Information is what you need for the next step "ACT".

ACT

- Request corrective actions on significant differences between actual and planned results. Analyze the differences to determine their root causes. Determine where to apply changes that will include improvement of the process or product. When a pass through these four steps does not result in the need to improve, the scope to which PDCA is applied may be refined to plan and improve with more detail in the next iteration of the cycle, or attention needs to be placed in a different stage of the process.



Plan Quality (Output)

- Project Document Updates
  - Include stakeholder register and Responsibility Assignment Matrix (RAM)

Stakeholder Register

Project Name:	Testiing 101	Date:	12/12/2010
Project Phase:	Execution		

Name of Stakeholder	Designation	Department	Role In Project	Type of Stakeholder	Type of Communication	Expectati	Influence on
John Abraham	Director PM	Information Systems	Client PM	External	Weekly Video Conference	On-time, budget d	
Mandy Ali	Business Lead	Vendor Management	Business Analyst	External	Weekly Video Conference	Measure business on-time	
Ashita Sharma	Director Tech.	Internal	Tech. Architect	Internal	Daily Meetings; Weekly Checkpoint	Clear requirem time sign skilled re	

WBS Element	Project Team Members					Other Stakeholders		
	I.B.You	M. Jones	R. Smith	H. Baker	F. Drake	Sponsor	CInt Mgt	Func Mgt
I.0.1.1 **Activity A**	N				R			
I.0.1.2 **Activity B**		R	C					
I.0.1.3 **Activity C**	R		S			A		G
I.0.2 **Activity D**			R		S			A
I.0.3.1 **Activity E**			R			N		
I.0.3.2 **Activity F**				R				
I.0.3.3 **Activity G**	R			S		A	A	
I.0.4 **Activity H**		R			C	N		

Key: R = Responsible, S = Support Required, C = Must Be Consulted, N = Must Be Notified, A = Approval Required, G = Gate Reviewer

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Project Management Plan (Updates)

- Additional activities: Time management
- Additional cost: Cost management
- Additional deliverables: Scope management
- Additional types of scope: Scope management, e.g. performance requirement
- Reduction of risk: Risk management
- Others

Responsibility Assignment Matrixes

- **Responsibility Assignment Matrix** (RAM) is a matrix that maps the work of the project to the people responsible for performing the work

WBS activities →

OBS units ↓

	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8
Systems Engineering	R	R P					R	
Software Development			R P					
Hardware Development				R P				
Test Engineering	P							
Quality Assurance					R P			
Configuration Management						R P		
Integrated Logistics Support							P	
Training								R P

R = Responsible organizational unit
P = Performing organizational unit

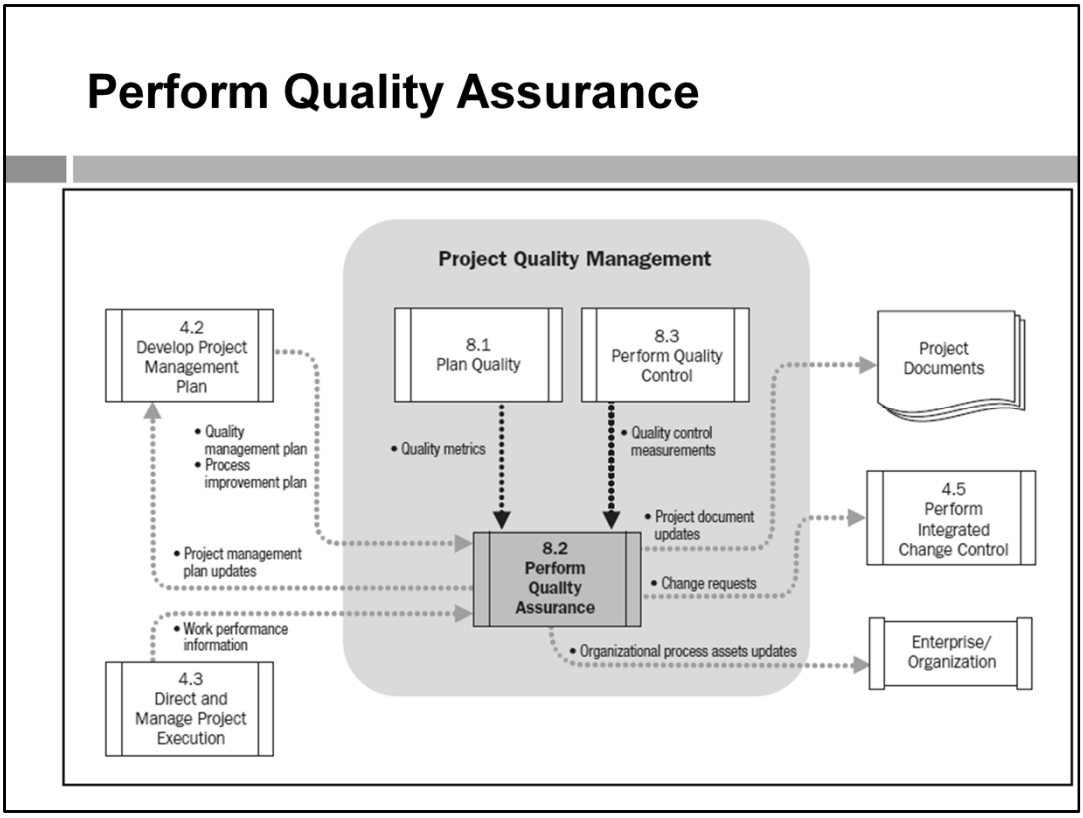
Organization breakdown

R = Responsible
A = Accountable
C = Consultation
I = Information

Product/work package breakdown

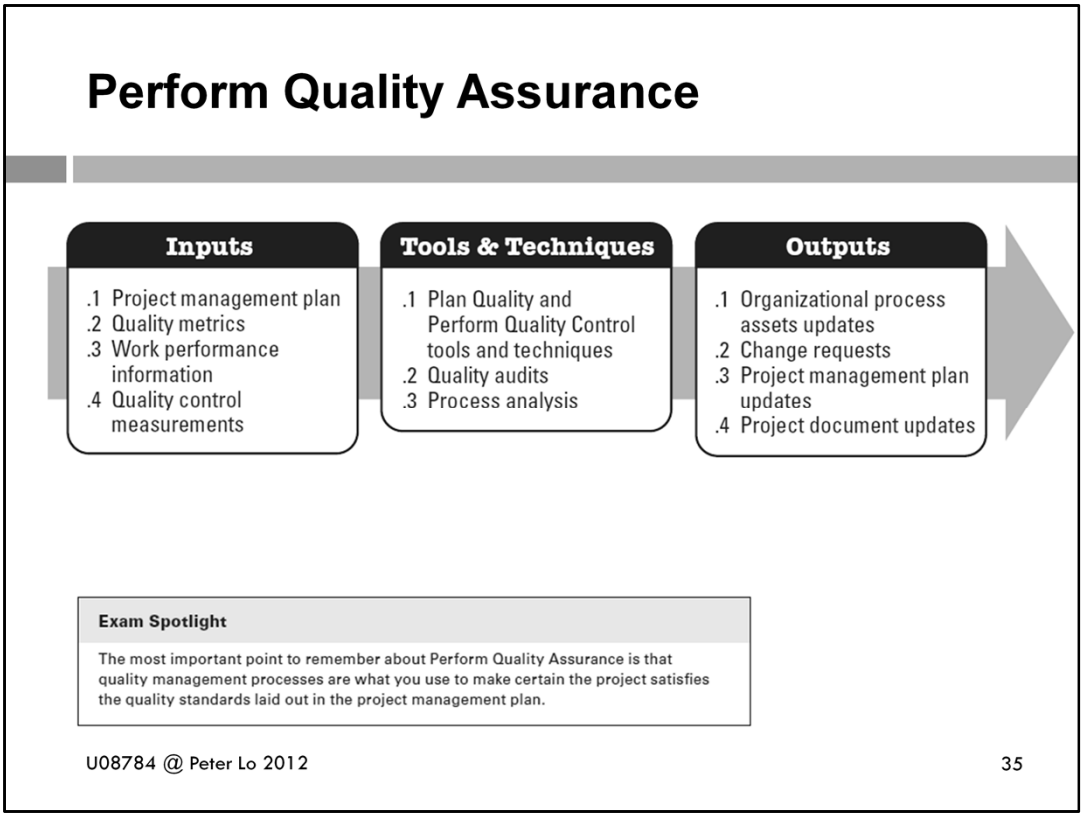
	Project sponsor	Project manager	Analysis team leader	Chief designer	Development manager	Test manager	Project support assistant	Senior user
Interview notes	I	A	R	I				C
Requirements catalogue	I	A	R	I				C
Use case diagram	I	A	R	I	I			C
Package review	I	A	R	I	I	I		I
Report text	I	A	R	I				I
Report illustrations	I	A	R					I
Report appendices	I	A	R	I				I

OR, could use
I = Initiation
E = Execution
A = Approval
C = Consultation
S = Supervision



The process of **auditing the quality requirement and the result of quality control measurements** to ensure appropriate quality standards and operational definitions are used.

- Applying the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirement.
- Perform continuous improvement
- Determine if project activities comply with organization and project policies, processes and procedures (quality audit)
- Identify the improvement company need to make
- Recommend changes and corrective actions to integrated change control
- Correct deficiencies
- Mostly done during project execution
- Quality assurance is an iterative means for improving the quality of processes
- Involves performing systematic quality activities and uses quality audits to determine which processes should be used to achieve the project requirements and to assure they are performed efficiently and effectively



Input
- Project Management Plan
- Quality Metrics
- Work Performance Information
- Quality Control Measurements

Tools & Techniques
- Plan Quality and Perform Quality Control Tools and Techniques
- Quality Audits
- Process Analysis

Output
- Organizational Process Assets
- Change Requests
- Project Management Plan Updates
- Project Document Updaets

Perform Quality Assurance (Input)

- Project Management Plan
  - Part of management plan that includes Quality Management Plan (QMP) and Process Improvement Plan (PIP).
- Quality Metric
  - Used to translate customer needs into performance measurement.
- Work Performance Information
  - Tells about project deliverable status, actual work done, time progress and cost incurred.
- Quality Control Measurements
  - The results of quality control activities.

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- Project Management Plan
  - Quality management plan
  - Process improvement plan
- Quality Metrics
- Work Performance Information
  - Technical performance measurement
  - Project deliverables status
  - Schedule progress, and
  - Cost incurred
- Quality Control Measurements
  - The results of quality control activities

Perform Quality Assurance (Tools and Techniques)

- Plan Quality and Perform Quality Control Tools and Techniques
  - Plan quality and perform quality controls tools and techniques
  - Tools like cost benefit analysis, cost of quality, control charts, benchmarking, design of experiments, statistical sampling, flowcharting, etc.

As stated before in Plan Quality and would come in Quality Control later.

Perform Quality Assurance (Tools and Techniques)

- Quality Audits
  - Structured, independent review to determine whether project activities comply with organization and project policies, processes, and procedures of their quality management activities
  - Objective of quality audits is to identify inefficient and ineffective policies, processes, and procedures
  - Carried out by trained internal in-house auditors or by third parties
  - Look for lesson learned in the project that can contribute to the performing organization

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Quality Audits are structured and independent review to determine whether project activities comply with the ones spelt out in QMP and project policies & processes.

- Are Independent reviews performed by trained auditors or third party reviewers, to identify ineffective and inefficient activities or processes used on the project.
- Are structured and independently reviewed to check the project activities comply with organizational policies and procedures
- Identifying all of the good/best practices being implemented
- Identifying all the gaps/shortcomings
- Sharing the good practices introduced or implemented in similar projects
- Proactively offering assistance in positive manner to improve implementation of process to help the team raise productivity
- Highlighting contributions of each audit in the lesson learned
- To see if you are complying with company policies, standards & procedures
- Determine whether they are used efficiently & effectively
- Identify all the good practices being implemented
- Identify all the gaps/shortcomings
- Look for new lesson learned & good practices

The Project Audit Process

- Audit leader should possess:
  - No direct involvement or direct interest in the project
  - Respect (perceived as impartial and fair)
  - Willingness to listen
  - Independence and authority to report audit results without fear.
  - Broad-based experience in the organization / industry

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Guidelines to Conducting a Project Audit

- Keep to project issues, not to what happened and by whom
- Audit activities should be intensely sensitive to human emotions and reactions
- Accuracy of the date should be verifiable and judgmental
- Senior management provides access to all information, project participants and project customers
- The objective is to learn and conserve organizational valuable resources where mistakes have been made.

The Audit Report

- Classification of the project
- Analysis of the information gathered
- Recommendations
- Lessons learnt
- Appendix

Information and Data Collection & Analysis

- Was the organizational culture supportive and correct for this type of project
- Was senior management support adequate
- Did the project accomplish its intended purpose
- Were the risks of the project properly identified and assessed? Were contingency plan used?
- Were the right people and talents assigned to this project?
- What does evaluation from outside contractors suggest?

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Project Team View

- Did the project confirm to plan
- Were interfaces with stakeholders adequate and effective
- Did the team have adequate access to organizational resources
- What does the evaluation from outside contractors suggest

Perform Quality Assurance (Tools and Techniques)

- Process Analysis
  - Looks at the process improvement from an organizational and technical perspective. It includes root cause analysis to identify a problem and solution and to develop preventive actions.
  - Happened in projects has similar installation or similar projects
  - Lessons learned on first project are used to improve the process on remaining one
  - Part of continuous improvement

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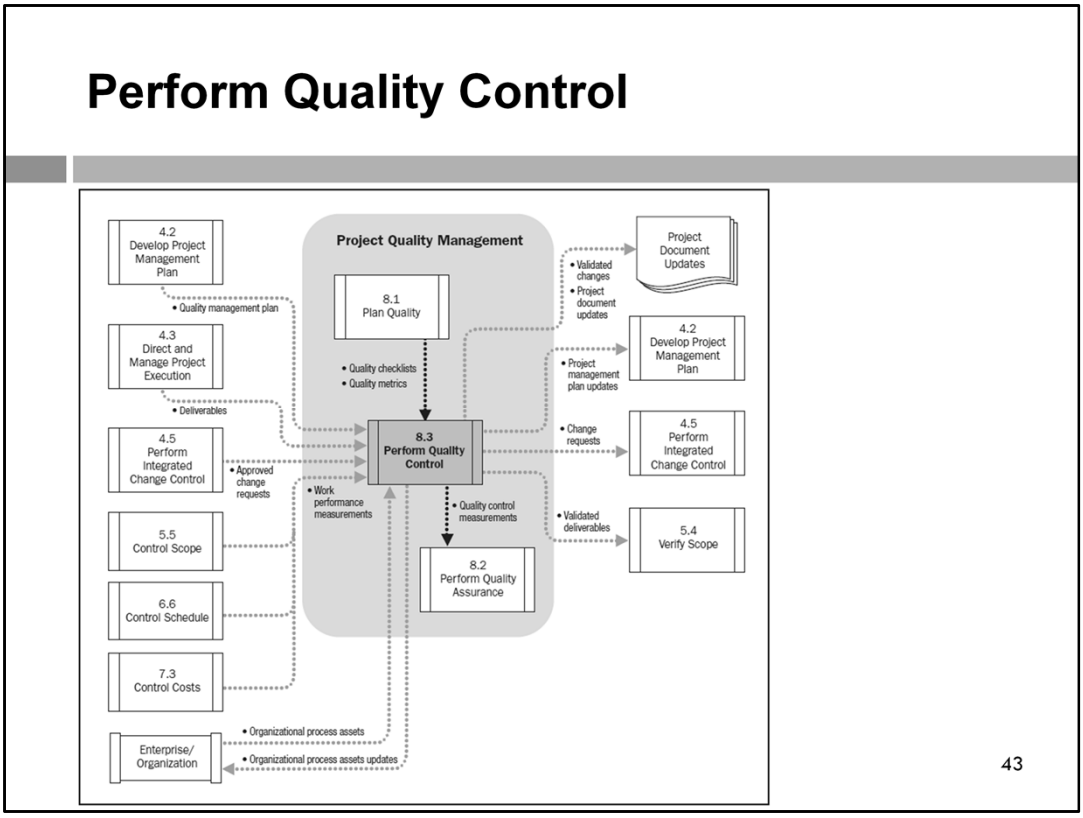
Process Analysis is carried out to identify the effectiveness of process and suggest improvement, if required.

- Identifying needed improvements
- Examining experienced problems, constrains, and non-value added activities
- Includes root cause analysis (problem, cause, preventive actions)

Perform Quality Assurance (Output)

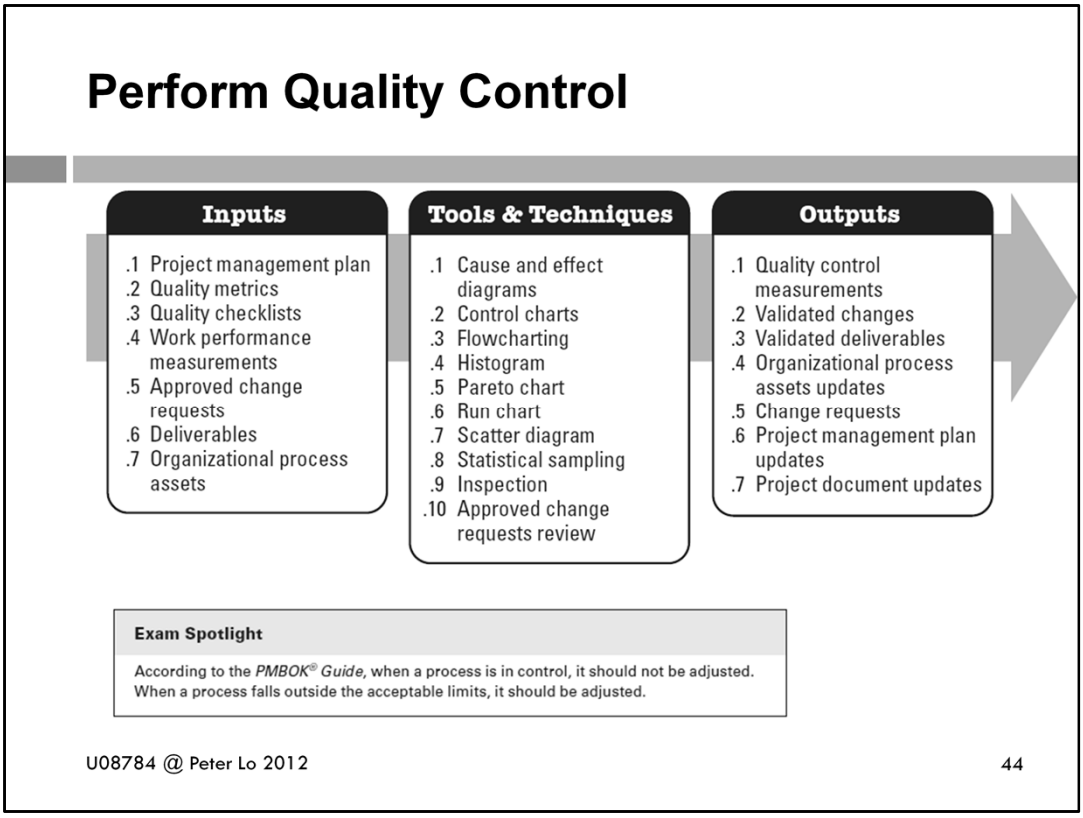
- Organizational Process Updates
  - Any updates to established quality standards
- Change Requests
  - Generated to take corrective actions, preventive actions and perform defect repair.
- Project Management Plan Updates
- Project Document Updates
  - As a result of Quality Assurance include quality audit reports, training plans, and process documentation

- Organizational process assets updates
  - Quality standards
- Change requests
  - To increase the effectiveness and/or efficiency of the policies, procedures
  - Through Integrated Change Control process
  - Corrective, preventative, or defect repair
- Project management plan updates
  - Quality management plan
  - Schedule management plan
  - Cost management plan
- Project document updates
  - Quality audits reports
  - Training plans
  - Process documentation



This process is concerned with monitoring work results to see whether they comply with the standards set out in the Quality Management Plan, the standards include project processes and product goals.

- Measure specific project results against standards
- Implement approved changes to quality baseline
- Identify quality improvements
- Repair defects
- Recommend changes, corrective and preventive actions and defect repair to integrated change control
- Mostly done during project monitor and control
- The process of monitoring and recording results of executing the quality activities to assess performance and recommend necessary changes
- Quality standards include project processes and product goals
- Project results include deliverables, and PM results such as cost and schedule performance
- Identifies cause of poor process, or product quality and recommend and or take actions
- Terminology
    - Prevention (keeping error out of process) and inspection (keeping error out of customer's hand)
    - Attribute sampling (conforms or not conforms), variables sampling (degree of conformity)
    - Tolerance, specified range of acceptable results) control limits (threshold indicating if the process is out of control)



Input
- Project Management Plan
- Quality Metrics
- Quality Checklists
- Work Performance Measurements
- Approved Change Requests
- Deliverables
- Organization Process Assets

Tools & Techniques
- Ishikawa's basic tools of quality
  - Cause and Effect Diagrams
  - Control Charts
  - Flowcharting
  - Histogram
  - Pareto Chart
  - Run Chart
  - Scatter Diagram
- Statistical Sampling
- Inspection
- Approved Change Request Review

Output
- Quality Control Measurements
- Validated Changes
- Validated Deliverables
- Organizational Process Assets Update
- Change Requests
- Project Management Plan Updates
- Project Document Updates

Perform Quality Control (Input)

- Project Management Plan
  - Part of management plan that tells how to carry out quality control.
- Quality Metric
- Quality Checklist
- Work Performance Measurements
  - Include comparison of planned and actual performance (technical, time & cost).
- Approved Change Requests
  - The activities coming out of integrated change control.
- Deliverables
  - The tangible products or services to be delivered.
- Organization Process Assets
  - Include quality standards, policies, guidelines and communication policies.

- Project management plan
- Quality metrics
- Quality checklists
- Work performance measurements
  - Planned vs. Actual technical performance
  - Planned vs. Actual schedule performance, and
  - Planned vs. Actual cost performance
- Approved change requests
  - Defect repairs, revised work methods, and revised schedule
  - Should have been decided on when to apply
- Deliverables
- Organizational process assets
  - Quality standards and policies
  - Standard work guidelines, and
  - Issue and defect reporting procedures and communication policies

Perform Quality Control (Tools & Techniques)

- Ishikawa's Basic Tools of Quality
  - Kaoru Ishikawa believes quality is a continuous process that relies on all levels of the organization
  - Advocated the use of easy-to-use statistical tools
  - Developed seven basic visual tools of quality so that the average person could analyze and interpret data.
  - These tools have been used worldwide by companies, managers of all levels and employees.
    - Cause and Effect Diagrams
    - Control Charts
    - Flowcharting
    - Histogram
    - Pareto Chart
    - Run Chart
    - Scatter Diagram

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The Seven Basic Tools of Quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues. The seven tools are:

- Cause and Effect Diagrams (also known as the "fish-bone" or Ishikawa diagram)
- Control Charts
- Flowcharting
- Histogram
- Pareto Chart
- Run Chart
- Scatter Diagram

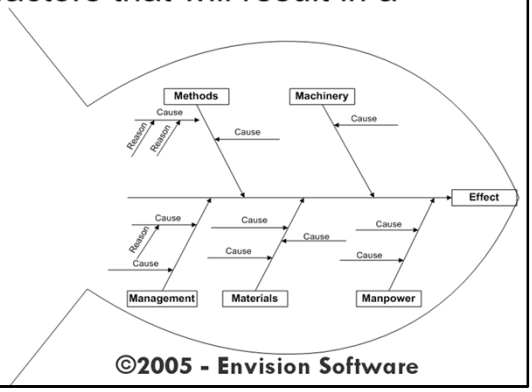
The designation arose in postwar Japan, inspired by the seven famous weapons of Benkei. At that time, companies that had set about training their workforces in statistical quality control found that the complexity of the subject intimidated the vast majority of their workers and scaled back training to focus primarily on simpler methods which suffice for most quality-related issues.

The Seven Basic Tools stand in contrast to more advanced statistical methods such as survey sampling, acceptance sampling, statistical hypothesis testing, design of experiments, multivariate analysis, and various methods developed in the field of operations research.

Ishikawa's Basic Tools of Quality – Cause and Effect (Fishbone/Ishikawa) Diagrams

- Stated before in Plan Quality and would come in Quality Control later.
- Helps stimulate thinking, organize thoughts, and generate discussion.
- Can be use to explore the factors that will result in a desire future outcome

Also known as Ishikawa or fishbone diagram.



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Cause and effect diagram (also called Fishbone diagram or Ishikawa diagram)

- Stimulate thinking and discussion, use template as a base
- 6 M's, 8 P's or 4 S's rule
  - **The 6M:** Machine, Method, Materials, Measurement, Man and Mother Nature (Environment) (recommended for manufacturing industry)
  - **The 8P:** Price, Promotion, People, Processes, Place / Plant, Policies, Procedures & Product (or Service) (recommended for administration and service industry)
  - **The 4S:** Surroundings, Suppliers, Systems, Skills (recommended for service industry)

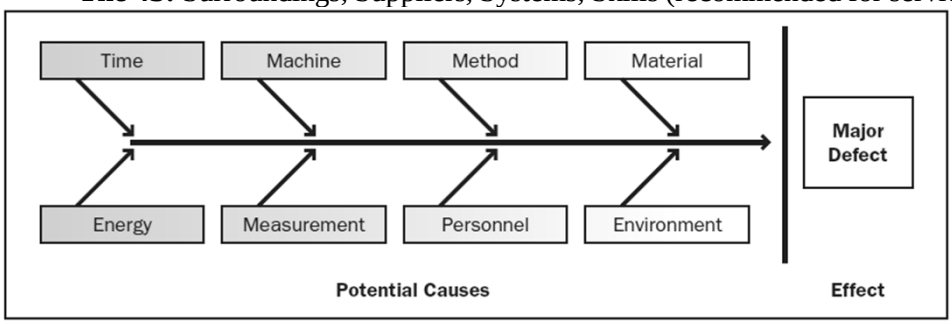


Figure 8-12. Classic Sources of Problems to Consider

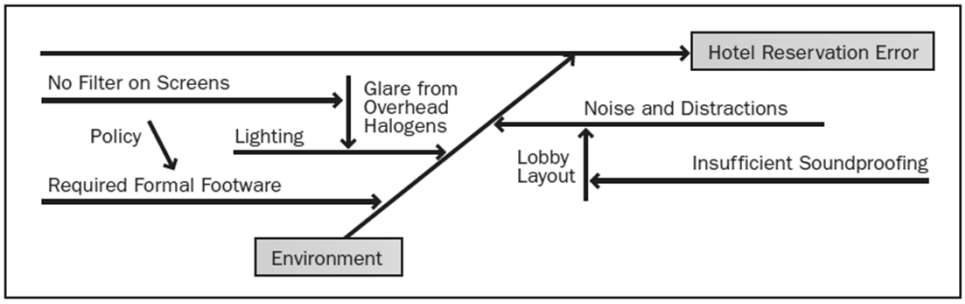
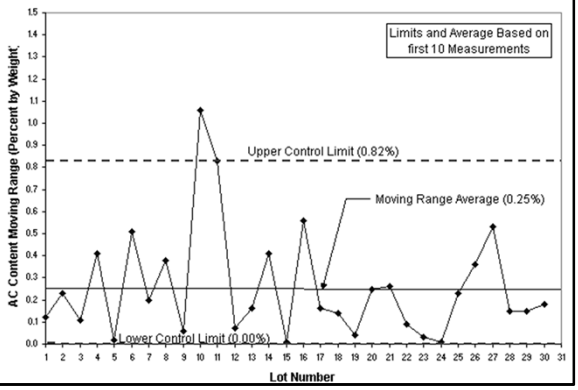


Figure 8-13. Environment Bone Expanded by Brainstorming

Ishikawa's Basic Tools of Quality – Control Charts

- Used to observe process behavior over a period of time and assess that when it is required to be adjusted or replaced.
  - How a process behaves over time
  - Is the process variance acceptable
  - When is it out of control
  - ±3σ



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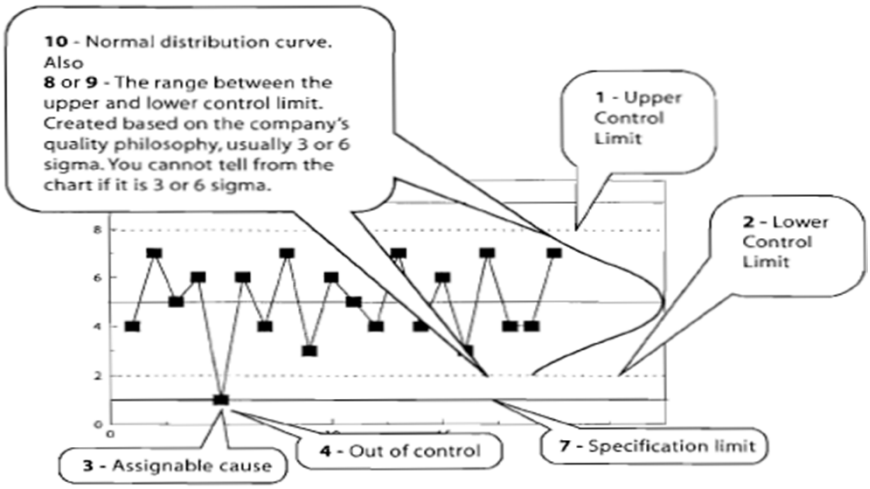
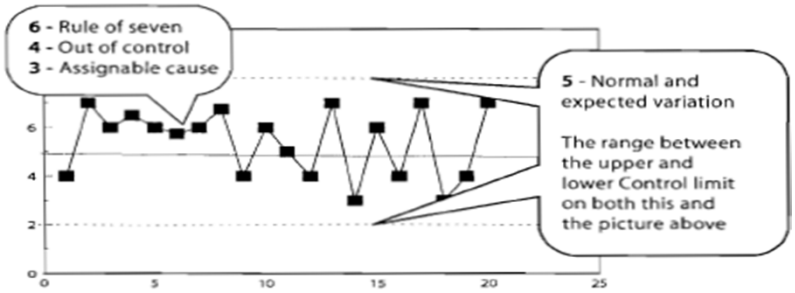
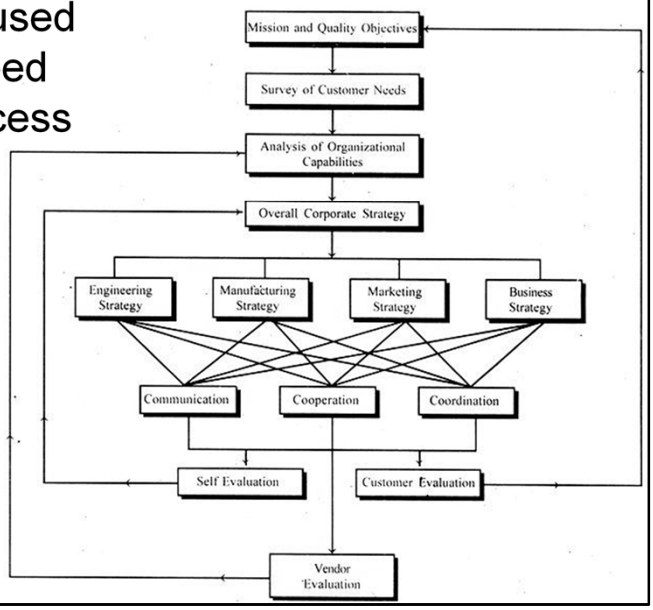
Measure the results of processes over time and display the results in graph form.
They are a way to measure variances to determine whether process variances are in control or out of control
They are based on sample variance measurements
They are used most often in manufacturing settings where repetitive activities are easily monitored





Ishikawa's Basic Tools of Quality – Flowcharting

- Flowcharting is used to identify the need for potential process improvement opportunities.



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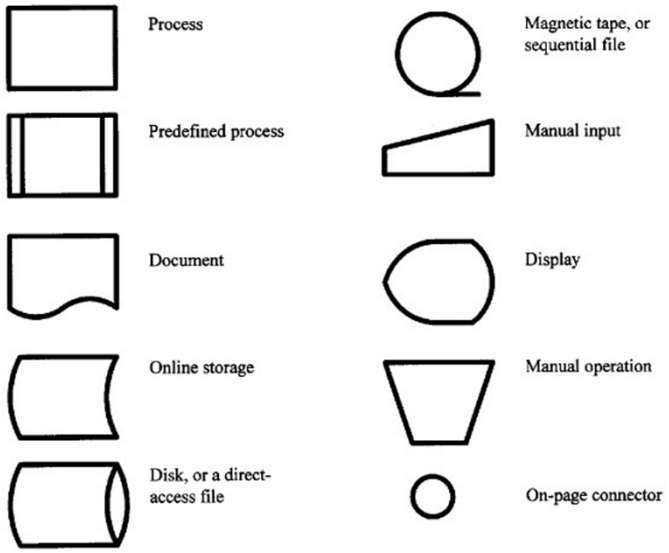
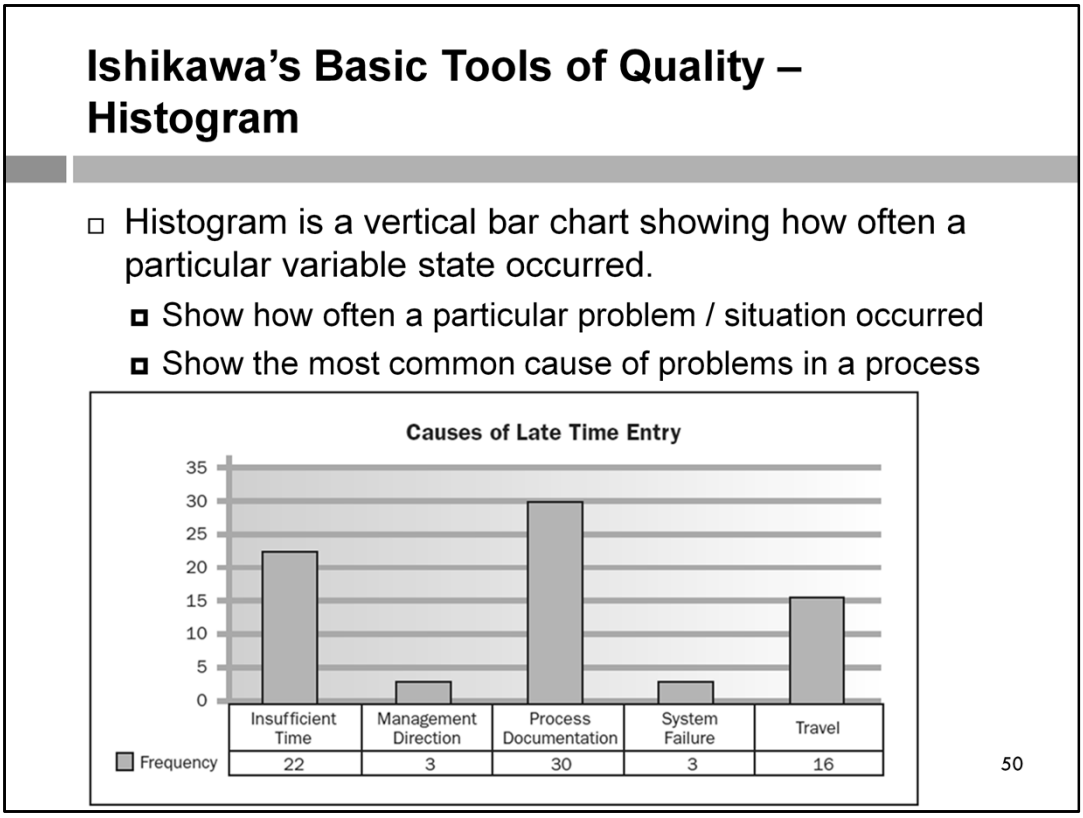
- Use to determine a failing process step(s) and potential process improvement opportunities
- Identifies potential problem areas, such as bottlenecks, redundancies, single point of failure
- Top-down, layout, workflow
- Show step-by-step events to reduce problem complexity
- Identify procedures and has little value added to the overall results
- Used in process improvement
- Used to help analyze the causes of problems





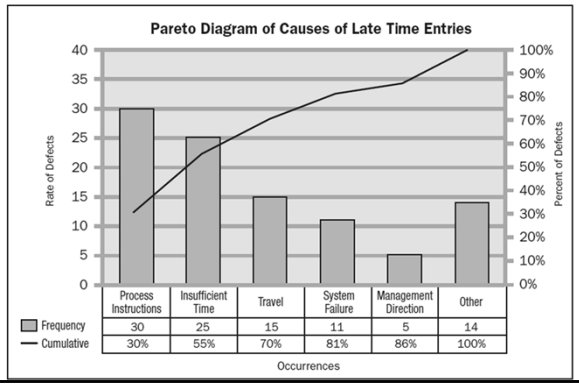
In statistics, a histogram is a graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable and was first introduced by Karl Pearson.[1] A histogram consists of tabular frequencies, shown as adjacent rectangles, erected over discrete intervals (bins), with an area equal to the frequency of the observations in the interval. The height of a rectangle is also equal to the frequency density of the interval, i.e., the frequency divided by the width of the interval. The total area of the histogram is equal to the number of data. A histogram may also be normalized displaying relative frequencies. It then shows the proportion of cases that fall into each of several categories, with the total area equaling 1. The categories are usually specified as consecutive, non-overlapping intervals of a variable. The categories (intervals) must be adjacent, and often are chosen to be of the same size. The rectangles of a histogram are drawn so that they touch each other to indicate that the original variable is continuous.

Histograms are used to plot density of data, and often for density estimation: estimating the probability density function of the underlying variable. The total area of a histogram used for probability density is always normalized to 1. If the length of the intervals on the x-axis are all 1, then a histogram is identical to a relative frequency plot.

An alternative to the histogram is kernel density estimation, which uses a kernel to smooth samples. This will construct a smooth probability density function, which will in general more accurately reflect the underlying variable.

Ishikawa's Basic Tools of Quality – Pareto Chart (80/20 principle)

- Histogram ordered by frequency of occurrence which used to focus attention on the most critical issues
- 80% of the problems are due to 20% of the causes
- Pareto Chart is also vertical bar chart that is ordered by the frequency of occurrences. It helps in finding the causes resulting into greatest number of defects.



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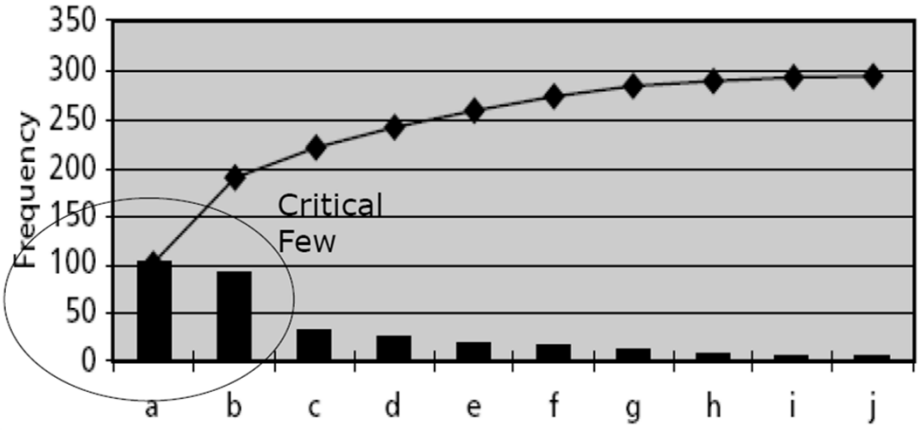
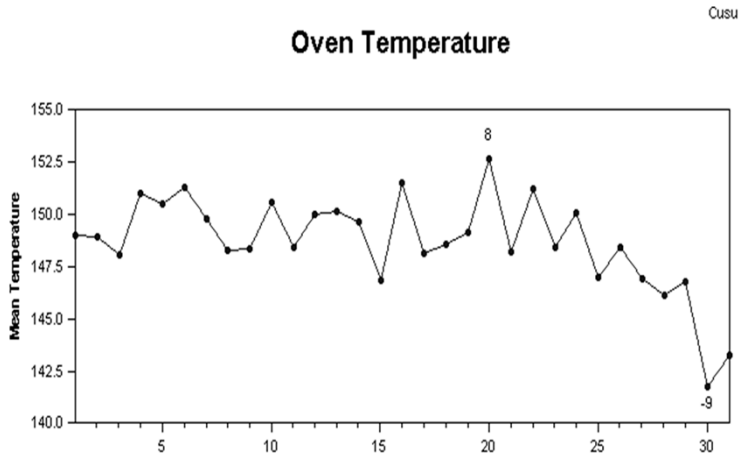
Helps focus attention to the most critical issues.
Specific type of histogram ordered by frequency of occurrence (Rank ordered)
Prioritize potential causes of the problem (80/20 principle)
Separate the critical few to the uncertain many



Defect	Frequency of Occurrence	Cumulative	Percent of Total Defects by Defect
a	100	100	34.014
b	90	190	30.612
c	30	220	10.204
d	22	242	7.483
e	17	259	5.782
f	14	273	4.762
g	11	284	3.741
h	5	289	1.701
i	3	292	1.020
j	2	294	0.680
Total	294		

Ishikawa's Basic Tools of Quality – Run Chart

- Run Chart is a sort of control chart but without boundaries. It shows the history and pattern of a variation.



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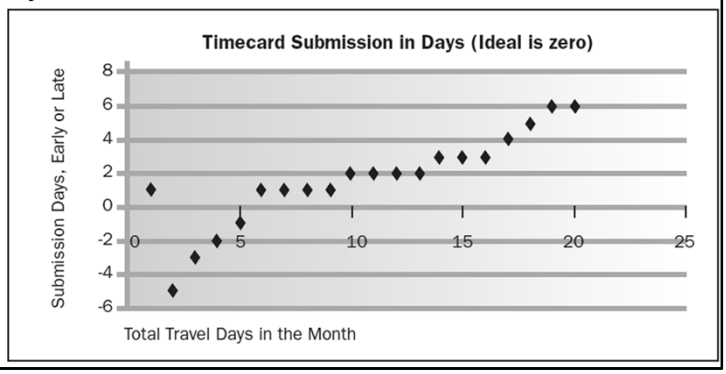
- A line graph showing data in order they occur
- To look at history and see a pattern of variation
  - Based on historical results over time
  - Shows trends in process over time, variation over time, declines or improvements in a process over time
- Uses mathematical techniques to forecast future outcomes based on historical results
- Trend analysis is used to monitor:
  - Technical performance
    - Errors or defects identified, corrected, and remaining uncorrected
  - Cost and schedule performance

Ishikawa's Basic Tools of Quality – Scatter Diagram

- Shows the relationship between two variables.
- Identify the possible relationship between changes observed in two variables
- Studying the correlation
- Regression analysis



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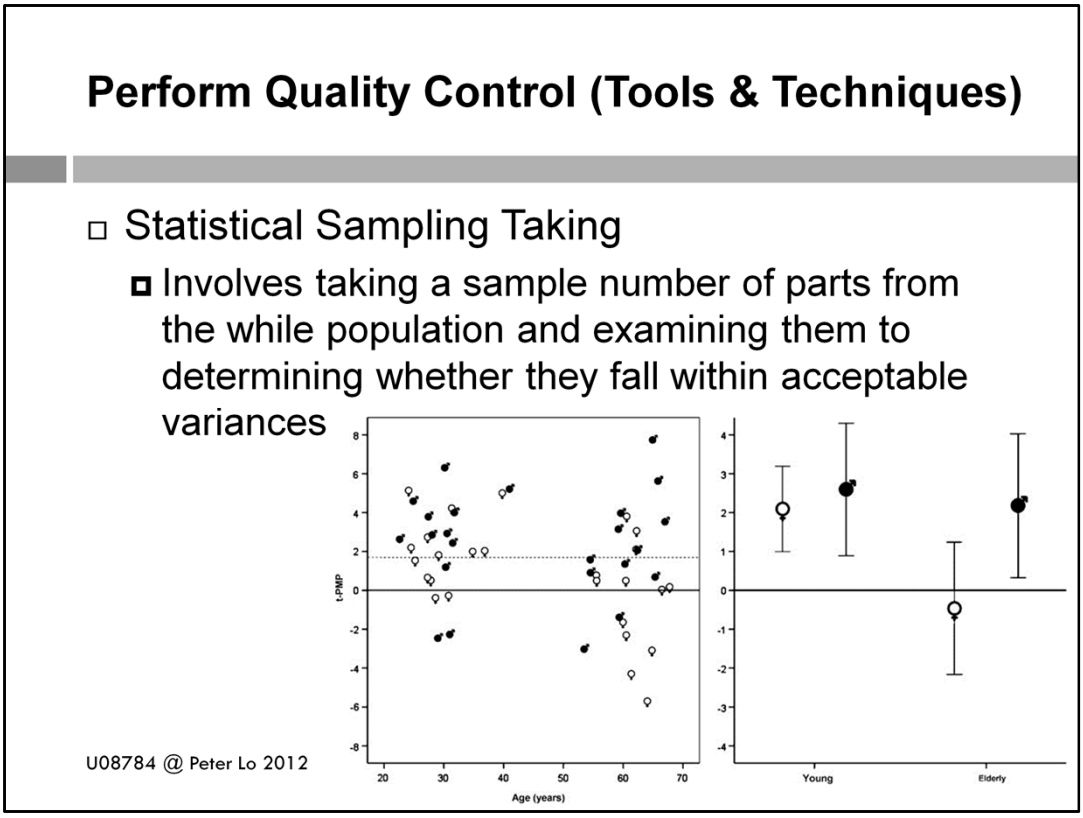

Statistical sampling is a way of identifying the quality of a service or product when it is impractical or too expensive to examine each item. Effective sampling is based on statistical probability theory which identifies the probability of error for a sample size. Using standard deviation and variance calculations, control charts can be constructed, which accurately predict the likelihood of a sample being representative of a population or lot size.

To be accurate, the sample size must be "representative" and "valid." Representative means that enough good and bad items must be included in the sample, so that it portrays the lot it is drawn from accurately. Validity is the measure, whereby the method of testing and the attributes measured are a true indication of what needs to be measured.

Key issues for ensuring accuracy are the proper determination of the sample size and the rejection level acceptable within the sample. Sampling methods include acceptance sample, attributes sampling, special attributes sampling, and variable sampling.

Acceptance Sampling tests selected items against an agreed upon list of necessary criteria. The inspection can be conducted in a variety of ways including electronic, stress testing, sample destruction, reaction testing, and temperature testing.

After the acceptance sampling method has been chosen, **Attributes Sampling** defines what exactly will be measured for quality control. This is often based upon past sample failure experience or customer feedback. The quality inspector merely checks the individual sample against the quality criteria. The attribute is measured by a simple "yes" or "no" that the item is acceptable. This method is often used in inspecting for size, color, finishing, marking, and packing. Data is recorded on a simple checklist sheet.

Statisticians have various sampling methods that simplify the inspection process, reduce time and cost, yet still ensure accuracy in the inspection process. These methods are referred to as **Special Attributes Sampling** and include continuous sampling, chain sampling, and skip-lot sampling. With continuous sampling, inspection occurs throughout production, like on an assembly line. This method is often used when storage facilities are inadequate or it is difficult to accumulate large lots for inspection.

Variables Sampling collects data on possible variable items. When the error rate exceeds a combined level for several of the variables, the lot is rejected. The sample is rated on a scale against such criteria as time, distance, weight, strength, or purity. Instead of being tested as "acceptable" or "unacceptable," the sample is compared against historic values to determine problems. Variable sampling is used when the quality characteristic is measurable or quantifiable. Variables sampling allows a quality control team to accomplish more in its inspection and analysis process. Causal links can be explored as well, helping to determine the root problem in a product, process, or sub-process.

Perform Quality Control (Tools & Techniques)

- Inspection
  - Examination of product to determine its conformance.
  - It can be done at any time and are also used to verify defect repairs (At any stage).
  - Also known as review, peer review, audit or walkthroughs.

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- Involves measuring, examining, and testing to determine whether results conform to requirement
- Used to determine the level of performance vs. a predetermined standard
- Also referred to as reviews, peer reviews, audits and walk-through
- Performed at various points in the project, as determined in the quality management plan
- Are only used to verify the performance of the quality control effort, and not to guarantee quality or eliminate defects

Fagan Inspection

Phases	Inspections
I0 Initial Design	Initial Design Specification (include functional & module specification) is inspected against Statement of requirements.
I1 Detailed Design	Logic Specifications are inspected against the Initial Design Specification
I2 Coding	Source Code is inspected against Logic Specifications.
IT1 Test Plan Preparation	Test Plan is inspected against Functional Specification.
IT2 Test Case Preparation	Test Case Listings are inspected against Test Plan.

- Michael Fagan noticed that no inspection of designs was routinely practiced during software development in IBM during 1970s
- He developed a set of procedures for inspection of software designs, source code, test plans and test cases.
- Fagan argued that software development should
  - Clearly define the programming process as a series of operations, each with its own exit criteria.
  - Measure the completeness of the product at any point of its development by inspections or tests.
  - Use measurements to control the process.

- Effectiveness of Fagan Inspection
- "Amplification and detection" – single defect in high level spec. may give rise to many defects in detailed spec.
- Cost of defect detection – 6 to 8 times less than failure during test.
- Reduction in defect density – experiment show 38% few faults than informal walk-through.
- Improve productivity – experiment show 23% increase due to reduction of rework time.

Inspection Team

Role	Task
Moderator	In charge of the whole inspection. Chair the meeting. He should not be involved in develop material under inspection. A technical person.
Author	Give initial presentation. Rework to remove defect.
Inspector	Normally two inspectors participate, usually members of development team that produced the material under inspection (but not the same phase)
Secretary	Recording, enter data to database.

The Inspection Meeting

- 3-5 people only
- Lasts for two hours only
- The decision is based on standards which are specific to the organization.
- The moderator first outlines the material to be inspected and describes the intended function of the corresponding part of the system.
- The reader then reads through all the material.
- The inspection is extremely thorough
- At the end of the meeting, the defect list is approved by all participants, and the moderator decides whether or not a re-inspection will be necessary after the rework.

Exit Criteria

- To judge whether a given development phase is complete.
- It must be defined by individual organizations to meet the needs of their own development environment.
- Some examples:
  - I0: external specifications are completed
  - I1: design specifications must be structured
  - I2: module prologue up-to-date and complete

Inspection Procedure

Steps	Participants	Objectives	Remarks
1. Planning	Moderator	Schedule Activities & Distribute Material	Include higher-level document, checklists etc.
2. Overview	Author & others	Education	Author gives presentation to other participants
3. Preparation	All Participants	Familiarization	Study privately
4. Inspection	Entire Team	Find Defects	A 2 hour meeting. Defects are recorded. Moderator decides the material pass or not. Produce report.
5. Rework	Author	Correct Defects	
6. Follow Up	Moderator & Author	Assure Rework is Correct; Improve Development Process; Improve Inspection Efficiency	

Checklists

- Set of questions inspectors to ask themselves.
- Different set of checklists corresponding to different type of inspection & programming language.
- Should be continually added to improve inspection experience.

Defect Recording and Classification

- Defect is record with serial number, type, category, severity, line number in material, description and estimate time to fix.

Class	Value
Severity	Major, Minor
Category	Missing, Wrong, Extra
Type	As defined in checklist

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Inspection Database

- Record effort required for preparation, number of defect detected, size of material inspected.
- Use to monitor and control development process, and improve the effectiveness of the inspections.

Measures for Inspection

Attributes	Measures
Effort	Number of person-hours
Code Size	NCSS {non-Comment Source Statements}
Specification Size	NCSS
Rework Size	NCSS {statement added, modified or deleted}
Inspection Rate	Size of material / Person-hours
Rework Rate	Size of material / Person-hours
Defects Detected	Count {can grouped by inspection, module, type, category or severity}
Defects Present	Count {estimate number of defects before inspection}
Defects Remaining	Count {estimate number of defects after inspection}
Defect Density	Defects Count / Size of Module {can apply to present, detected or remaining}
Defect Removal Efficiency	Defects Removed / Defects present {in %, for an inspection step}

Use of Defect Type Distribution

- Inspection improvement (Can focus on prevalent defect)
- Programmer self-improvement
- Development process improvement (Guide management in providing training, standard and procedures)
- Defect-prone modules are those in which a higher than average number of defects are detected (or estimated to remain).
- It may due to badly written or more complex. Special attention should be paid on such modules.
- Inspection data MUST NOT used to assess people. Punishment will delay development process.

Perform Quality Control (Tools & Techniques)

- Approved Change Request
  - Review All approved change requests should be reviewed to verify that they were implemented as approved.

Perform Quality Control (Output)

- Quality Control Measurements
- Validated Changes
- Validated Deliverables
- Organizational Process Assets Update
  - Completed checklists
  - Lesson learned documentation
- Change Requests
- Project Management Plan Updates
  - Quality management plan
  - Process improvement plan
- Project Document Updates

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- Quality Control Measurements - It is the data collected after performing quality control over the product / service.
- Validated Changes - Any changed or repaired item inspected and approved/ rejected. Rejection leads to reworking.
- Validated Deliverables are the products liable to be accepted.
- Organizational Process Assets Updates - Completed checklists and lessons learnt.
- Change Requests - Any change request required after performing quality control.
- Project Management Plan Updates
- Project Document Updates

Reference

- Ch. 8, PMBOK Guide, 4th Edition
- Ch. 8, 11, 14, Project Management for Information Systems, 5th Edition
- Ch. 8, Software Engineering, A Practitioner's Approach, 5th Edition
- Ch. 27, Software Engineering, 7th Edition