INTRODUCTION

In today's unforgiving business world, standard IT is no longer acceptable. Demands and expectations are placed upon organizations and IT managers to reliably deliver high quality results in short periods of time called projects.

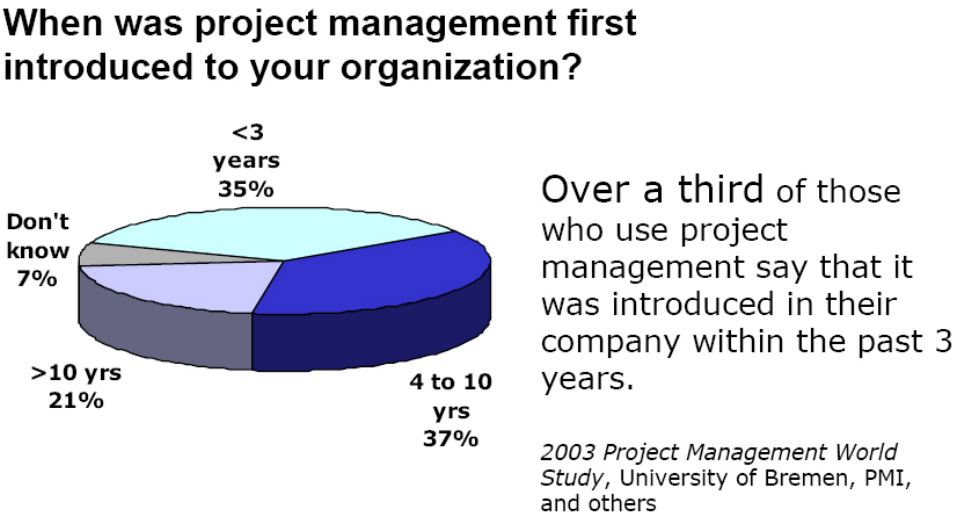


Figure 1-1 (Balestrero, 2004)

This trend is increasing and the demand for projects and project managers continues to grow especially in the United States.

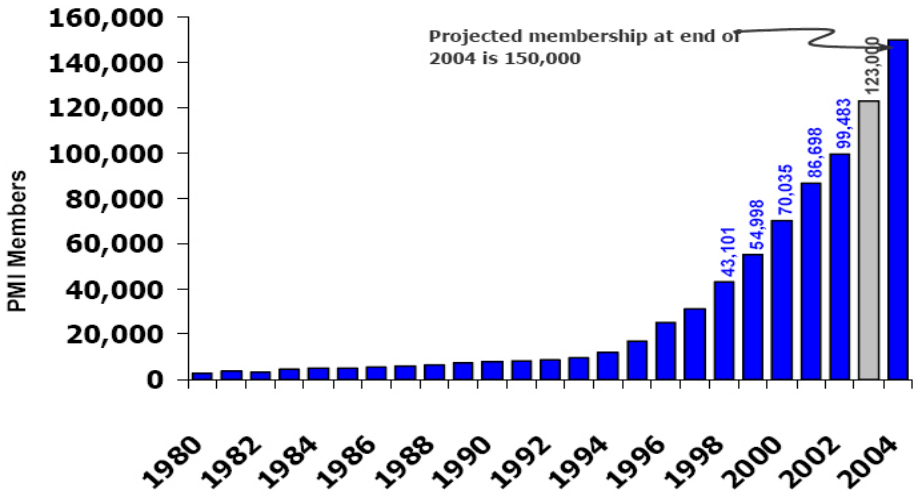


Figure 1-2 (Balestrero, 2004)

Amongst the companies using project management, over seventy percent state that it has been a large factor in their increased success of their organization in the past few years (Balestrero, 2004).

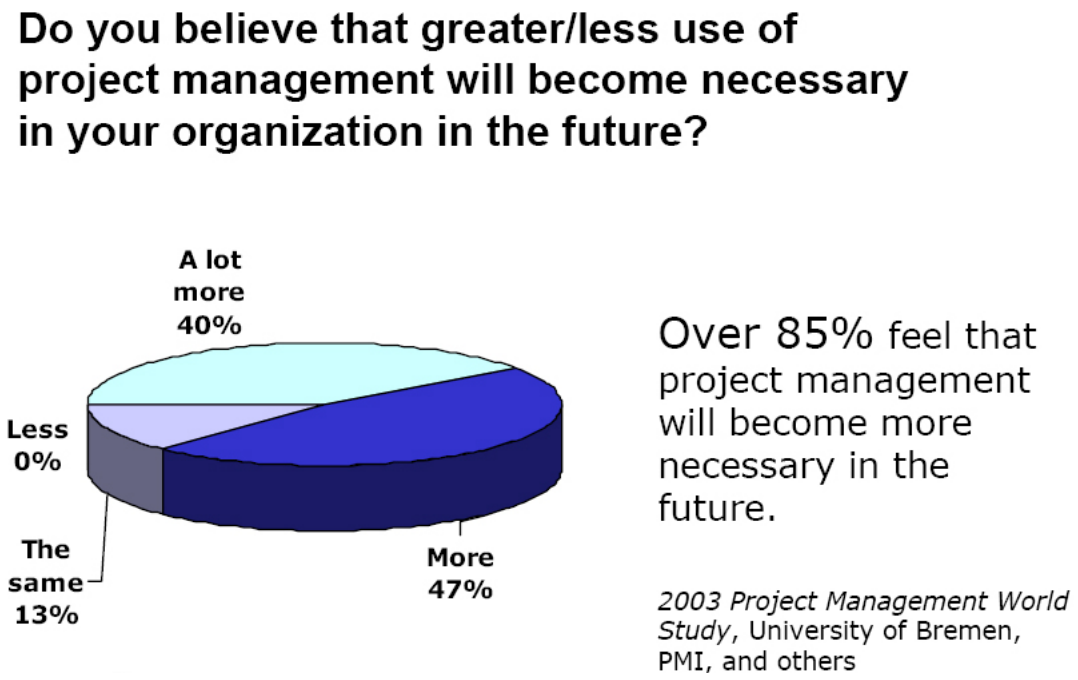


Figure 1-3 (Balestrero, 2004)

PMI's PMP certification has recently became the most valued certification within IT over certified security and certified Oracle professionals. The have also showed the largest growth in pay in the last two years. PMI states there are 4.5 million potential practitioners nationally and 16.5 million globally spending nearly $10 trillion on projects.

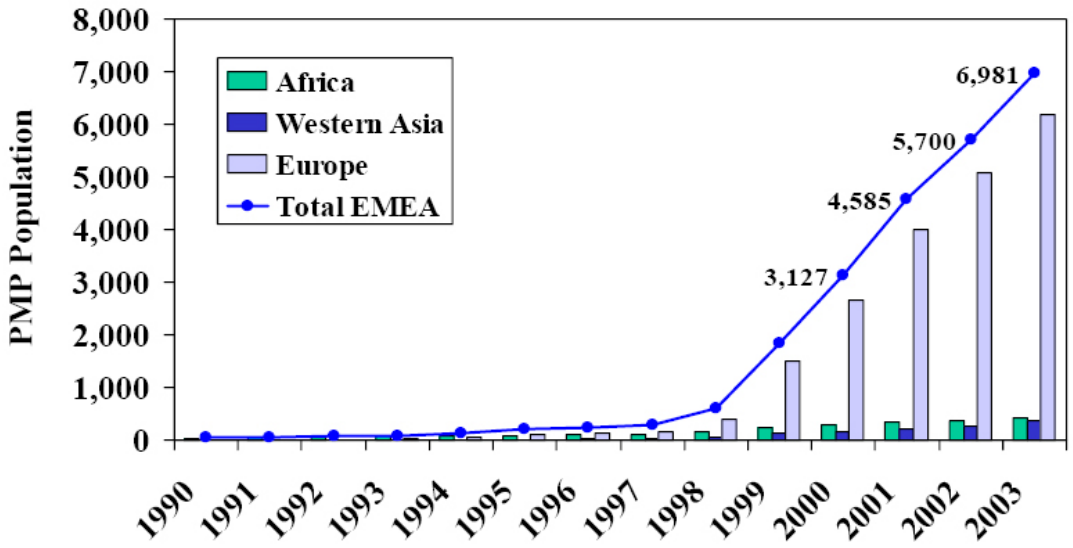


Figure 1-4 (Balestrero, 2004)

With fewer resources, less tolerability for failure, higher expectations, and shorter timelines, quality within the project becomes exponentially imperative. From the very beginning of a project to after its release quality must not be forgotten.

DEFINITION

A successful project execution is directly related to how well it is monitored and performed. Hyperthot (Chapman, 2005) defines a project as “a temporary effort to create a unique product or service including the constraints and risks regarding cost, schedule or performance outcome.” Hyperthot (Chapman, 2005) also defines project management as “a set of principles, practices, and techniques applied to lead project teams and control project schedule, cost, and performance risks to result in delighted customers.” The Project Management Institute provides "A Guide to the Project Management Body of Knowledge" (PMBOK) which covers most of the rudimentary subject matter regarding project management. It is used as a general guide and set of practices for comprehension of project management and can also be used as a general training guide.

Wikipedia (2005) states, “The term quality is used to refer to the desirability of properties or characteristics of a person, object, or process.” Referencing Google (Google.com, n.d.) quality management is management which “includes strategic planning, allocation of resources and other systematic activities for quality, such as quality planning, operations and evaluations.” Its goal can also be defined as “a process to achieve maximum customer satisfaction at the lowest overall cost to the organization while continuing to improve the process.” A broad approach is stated as “all the activities that determine policy objectives and responsibilities, implemented by means such as quality planning, quality control, quality assurance and quality improvement with a quality system.” A manufacturer’s perspective would define quality management as “the systems, organizations, and tools which make it possible to plan, manufacture, and deliver a quality product or service.” Most importantly a project based quality management definition according to Google (n.d.) is defined as “a subset of project management that includes the processes required to ensure that the project will satisfy the needs for which it was undertaken.

A system of organizational structures, procedures, responsibilities and evaluation mechanisms which ensures that the organization is capable of delivering its product to specified standards.” (Google, n.d.)

As we can see there are many different definitions to managing quality and that is why there are so many approaches to doing such. According to the Tasmanian State Government (2004), the purpose of project quality management is “to increase certainty, and reduce the risk of project failure.” Throughout the paper many methodologies and approaches both proprietary and standard will be discussed on how to achieve this.

BACKGROUND

It is often stated that no individual has had more influence on quality management than Dr. W. Edwards Deming (1900-1933). Trained in statistics and physics, Deming relates a lot of quality management ideas statistically. Unlike many other quality gurus he never defined quality precisely probably because he continued to learn and change his philosophy. His philosophy stressed high importance on top management leadership. He often philosophized by using a Socratic method of finding solutions. He thought variation was the chief culprit of poor quality. He was an advocate for ceasing mass inspection and adopting a philosophy of prevention. Deming wanted to constantly improve systems and workers, institute worker training, instill leadership among supervisors, and eliminate fear among employees and barriers between departments. Most famous for his 14 points of worker training and education programs his overall philosophy (Evans and Lindsay, 2005) can be summarized as "continual improvements in product and service quality by reducing uncertainty and variability in design, manufacturing, and service processes, driven by the leadership of top management."

Joseph Juran published the *Quality Control Handbook* which is one of the most comprehensive quality reference manual written to date and is still constantly under revision. Interestingly Juran taught quality to the Japanese in the 1950s and was an important part of their quality reorganization after World War II. He also believed that quality included all levels of management comprising of training and experience. Comparatively though, he did not impose a cultural change within organizations like Deming, and instead implored educating using programs that would fit into a company's culture with little risk of rejection. He also differed from Deming in that he though fear in employees was good and motivated them to perform on certain anticipatory levels. Juran believed quality should be looked at from both the internal and external perspectives. He focuses on three major processes known as the "Quality Trilogy" consisting of quality planning, quality control, and quality improvement. Quality planning is the process of preparing to meet quality expectations and objectives. Quality control is the process of actually meeting the quality expectations during the performance

and execution, and quality improvement is the task of extending a company to new levels of quality for enhancement. Juran specified detailed methodologies determining what to control, establishing objectives and standards, and acting upon these matters to achieve better quality. With this much detail however, Juran also kept into consideration the "cost of quality" and believe it to be important factor in establishing objectivity. Quality was not to be so overextended to cause a process to become unprofitable or infeasible.

Another quality guru is Phillip B. Crosby who published the book *Quality is Free* which was mostly responsible for bringing quality to the attention of many top level corporate managers in the United States. Crosby developed the "Absolutes of Quality Management" and "Basic Elements of Improvement." These included some basic principles (Evans and Lindsay, 2005) including: 1) Quality means conformance, not elegance 2) Quality problems do not exist, individual or department problems do 3) Economics and cost of quality (Juran) do not exist; doing a job right the first time is always cheaper 4) The only performance measurement should be the expense of nonconformance 5) The only performance standard is "Zero Defects" meaning people should perform their work correct the very first time. Overall Crosby was a very people focused person and used management and organizational processes to improve quality instead of statistical techniques.

Other quality gurus worth mentioning are A.V. Feigenbaum, Kaoru Ishikawa, and Genichi Taguchi. Feigenbaum is best known for his book *Total Quality Control* in which he viewed quality as a strategic business tool that requires the involvement from everyone in the organization. His philosophy is summarized in his Three Steps to Quality. The first step is Quality Leadership, followed by Modern Quality Technology, and lastly Organizational Commitment. Ishikawa was a key to the Japanese quality movement and built upon Feigenbaum's concept of total quality by further promoting involvement of all employees. He had a bottom up view of quality and was one of the largest advocates of education. He designated the first step in quality as knowing the customer requirements. His ideal state of quality is when inspection is not necessary and believed responsibility should remain with all workers and all hierarchal divisions.

Taguchi much like Deming explained the economic value of reducing variation. Taguchi focused on problems that happened in the design phase and developed orthogonal arrays to minimize number of different factorial experiments saving much money in design of experiments.

All of the views and philosophies of these quality gurus provided much direction and intelligence to many managers around the world leading to quality awareness and recognition. Many awards and certifications developed from the best quality management practices thanks to these early quality experts.

CERTIFICATIONS

One of the most well known frameworks for managing quality is Six Sigma. The concept of Six Sigma is facilitated through the use of simple and advanced quality improvement and control tools by teams whose members are trained to provide fact-based decision making information. The term six sigma comes from a statistical measure (Wikipedia, 2005) where "the total number of failures in quality, or customer satisfaction, occur beyond the sixth sigma of likelihood in a normal distribution of customers. Here sigma stands for a step of one standard deviation; designing processes with tolerances of at least six standard deviations will, on reasonable assumptions, yield fewer than 3.4 defects in one million." Organizations adopt a Six Sigma philosophy in which all processes are at a Six Sigma level.

This core philosophy is based on a few key concepts. First an outlook where key business processes and customer requirements are thought of while still keeping a concise focus of overall strategic business objectives is adopted. Focus is needed on corporate sponsors who are responsible for championing projects, supporting team activities, and helping to overcome resistance to change. All aspects of the organization need to be quantified and measured, most often by defects per million including administrative, software, and other departments. Appropriate metrics are assigned and identified before the processes so there is some incentive to perform quality work and have accountability

for the business results. Extensive training is followed by project team deployment to improve the profitability, minimize non-valued activities, and achieve a reduced cycle time. Key players in the organization are educated by highly qualified process improvement experts and are given titles (“green belt, black belt, master black belt, champion) who can then later return to their organization and implement newly developed improvement tools and lead project teams. Lastly, but still very important, objectives and goals are set to continue the stretch for future improvement.

Six Sigma provides an outline for the implementation of a total quality system. It is the embodiment of the concepts composed of a total quality management system. It focuses not only on the product or service but very heavily on the integration of human processes including management leadership, cultural issues, and team processes. It is a disciplined problem solving approach which can be used for rapid project completion encompassing all aspects of an organization.

Six Sigma developed two very basic methodologies for processes. To improve existing processes the DMAIC methodology is used. First a tolerance range is Defined. Second, key internal processes critical to quality are Measured. Occurring defects are then Analyzed. The process is then Improved while still remaining within the desired tolerance. Lastly the process is Controlled to stay within goals. The other methodology, DMADV, is very similar but is used for introducing new processes. First the process and customer requirements are Defined. Next the process is Measured is determined if it meets customer requirements. Options to meet the customer requirements are Analyzed. Designs in changes to the process happen to meet the customer needs, and lastly the changes are Verified.

There are many benefits to Six Sigma but the most desired end result is saving money and making a larger profit. Customers who are satisfied with quality projects will come back along with recommending others to do business with the organization too. In the opinion of Peter Drucker, Six Sigma has become so popular because it tests the validity of a company and delivers measurable, tangible, economic benefits (Bisgaard

and Freiesleben, 2004). Six Sigma needs to be recognized as an investment not only fiscally but also culturally. It takes a significant amount of time, often multiple years, for Six Sigma to take effect and should not be abandoned hastily.

In 2001 Ford Motor Co. began to launch its Six Sigma improvement program. At the time Ford was ranked last among the big-seven automakers and was determined to improve its quality systems. Ford has since climbed the quality ladder and is ranked fourth amongst the big-seven and is striving to be number one. Since the initial launch Ford has saved approximately $1 billion in waste elimination. Last year an estimated $359 million was saved and customer satisfaction has risen five percentage points in Ford's internal customer satisfaction survey. Ford did the right thing in treating Six Sigma as an investment and not an expense. (Smith 2003) It currently has over 3,000 Project Champions and has closed over 6,000 projects in the past three years. Ford also designed and implemented a project tracking system where members of other project teams can view what other project members are working on via a database. With over 200 Master black belts, 2,200 Black Belts, and 40,000 Green Belts, Ford is trying to provide Green Belt training to nearly all of its employees. Initially the employees treated Six Sigma with much skepticism. Recently more and more Ford employees are accepting the Six Sigma quality approach as it exhibits itself as a success.

Another very popular certification is ISO 9000. Wikipedia (2005) defines the Industry Standard Organization 9000 as "requirements for a Quality Management System overseeing the production of a product or service. It is not a standard for ensuring a product or service is of quality; rather, it attests to the process of production, and how it will be managed and reviewed. ISO 9000:1987 was the first version of ISO 9000 and was used to focus on quality control issues by sampling and taking corrective measures. It was used mainly for manufacturing companies to meet harsh demands of the US Department of Defense Military Standards. ISO 9000:1994 implemented quality insurance by using preventive methods and including the documenting of processes. This caused many organizations to create lots and lots of paperwork including large manuals and quickly became cumbersome. ISO 9000:2000 implemented using performance

metrics to show processes were in effect so burdening paperwork could eliminated if an organization could prove its processes met specification from yielding metrics.

Timothy Falk, Special Project Operations Manager, of Audubon Metals LLC states ISO 9000 defines quality system standards on a principle in which certain generic characteristics of management practices can be standardized, and that a well designed and well implemented and carefully managed quality system provides self-assurance that the outputs will meet customer expectations and requirements. These quality standards were constructed to meet five objectives ((Evans and Lindsay, 2005). The first objective is to achieve, maintain, and seek to continuously improve product quality in relationship to requirements. Secondly to improve the quality of operations to continually meet customers' and stakeholders' stated and implied needs. Thirdly, to provide confidence to internal management and other employees that quality requirements are being fulfilled, and that improvement is taking place. Fourth, to provide confidence to customers and other stakeholders that quality requirements are being achieved in the delivered product. Lastly, to provide confidence that quality system requirements are fulfilled.

The Industry Standard Organization only develops the ISO 9000 standards and does not certify organizations. Instead accreditation and certification bodies are used to see if organizations are compliant. The organization is assessed by taking a list of functions, processes, services, problems, etc during visitation in which the organization can receive an ISO 90001 certificate upon completion of an improvement plan from management. An ISO 9001 must be renewed at regular intervals recommended by the certification body generally every 3 years. Each site, not a company, must be individually certified, and can cost from $10,000 to $40,000.

There are some criticisms that face ISO 9000 in which it does not specifically fit certain companies. Certain organizations such as software engineering companies may not mix with management standards. There are little or few global metrics to objectively measure effectiveness for ISO 9000, but many diverse organizations have realized

benefits from it. Overall ISO 9000 is at least a good basis for a quality system that can decrease expenses, increase productivity, and increase customer satisfaction.

IMPORTANCE

Quality IT projects within the General Motors Corporation Information Systems and Services organization is of extreme importance. Ralph Szygenda, GM's CIO, states installing systems on time and within budget is given, but the ultimate measurement, the business results, is what matters most. GM (Accenture, 2004) has reduced product development time from 4 years to less than 2 years, decreased vehicle delivery time from 70 days to 30 days, and saved millions each year in vehicle crash testing by moving to digital simulation since Szygenda has taken over the functions of GMs IT department. Quality makes for many successful business results and is not important to just GM but many other companies too.

Quality for project managers is not only about quality but also about quality management. Quality management is vital for business success regardless of the industry. More and more businesses today are coming to the realization that in order to remain competitive in the marketplace they must meet the customers' quality expectation levels. Businesses must establish quality concepts, tools and techniques into their organization. This encompasses defining quality standards, determining performance measurements, and continuously improving processes. Quality management is the long term key to be able to compete and survive. Quality management in project management can increase control over objectives and performance greatly enhancing projects success.

PROJECT QUALITY MANAGEMENT

Many IT managers define quality in various ways (Withrow, 2004). Obviously quality is a desired goal in a project but how can someone achieve a goal without first knowing what area to focus on. Many times IT engineers or managers will only include quality during the design or development phase, but it should be including during all phases of the project life cycle. Quality should be taken into consideration during requirements discovery, testing, design, etc. According to PMI (1996), "Project Quality Management includes 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 responsibilities and implements them by means such as quality planning, quality control, quality assurance, and quality improvement, within the quality system." Quality planning consists of preemptive planning in which quality standards are identified, tested for relevancy, and determined how they can be satisfied. Quality Assurance is the assessment of the project as a whole on a continual basis at set intervals in order to ensure the project will be a success and gain assurance that all aspects will satisfy quality standards. Quality Control is the observing of particular project results to see if the results meet quality standards and figuring out ways to eradicate the origins of dissatisfaction. All of these overlap each other and should transpire in every phase of a project. Careful consideration may be needed because this quality process can be easily forgotten unless certain individuals are assigned the task of watching over them.

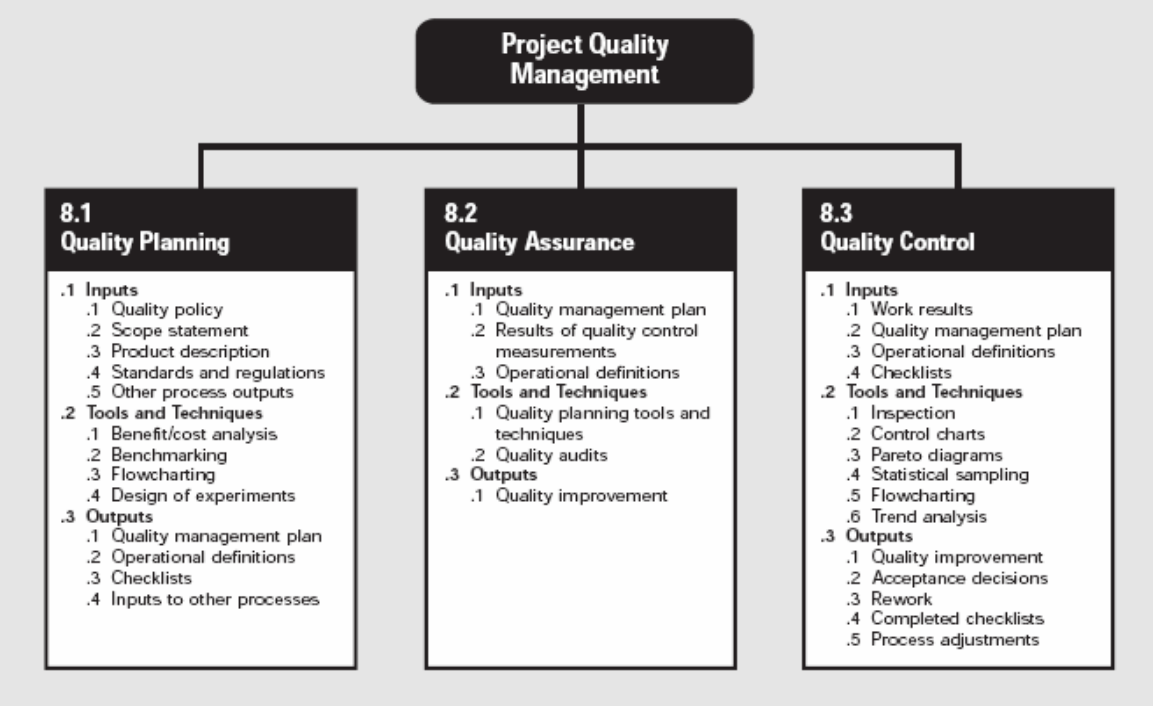


Figure 2-1 (PMI, 1996)

The Project Quality Management process is compatible with ISO 9000 and the philosophies of Deming, Juran, Crosby, and others mentioned above. Project quality management must also focus on the people and not just the service or product being created. If the management aspect is forgotten employee motivation and performance can decrease or an employee may see a high rate of turnover. Management must be responsible for requiring all members of the project to participate to use all available resources to achieve the highest quality project.

Quality can often be confused with grade. Grade is associated with attributes being ranked but still having the same function. Quality is concerned with fulfilling the actual functional requirement. It may be acceptable to have a low grade with high quality but it is not acceptable to have low quality regardless of the grade.

Quality planning, the preemptive planning in which quality standards are identified, tested for relevancy, and determined how they can be satisfied must be performed often throughout the project including during other planning processes.

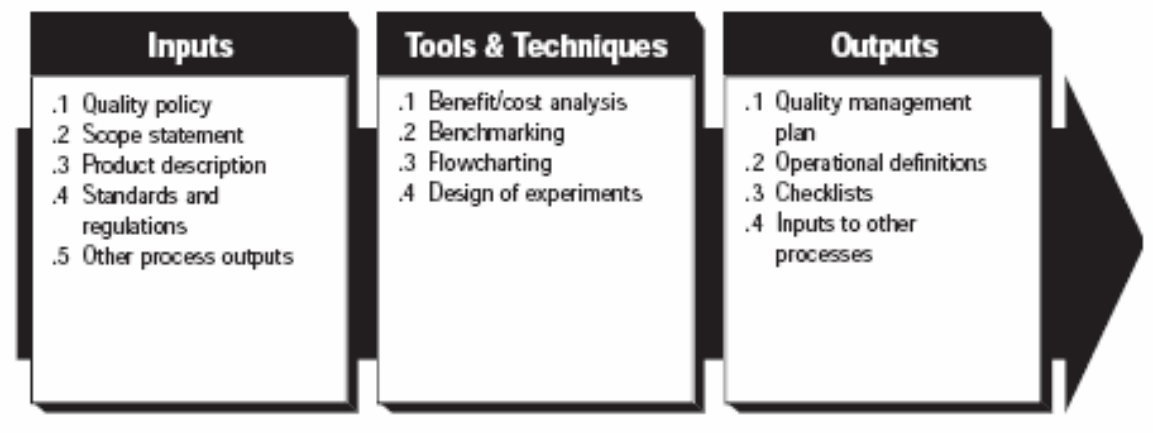


Figure 2-2 (PMI, 1996)

Many inputs go into quality planning, the first input being quality policy. Quality policy is how management and the organization feel about quality. A formal quality policy is preferred for active traditional project teams but often an "as is" policy is used when new teams are formed. Despite the quality policy it is the responsibility of the project manager or management to inform the project stakeholders of the quality policy employed for the project. The next input to quality planning is designing a well defined scope statement. This statement documents all the deliverables designed to fulfill the project requirements. Product description is another input to quality policy which contains all comprehensive aspects about the product and provides for a checklist of matters that may effect quality planning. Another input to forming a quality plan is fulfilling any standards and regulations, e.g. ISO 9000, which may be required of the project or organization. Other quality planning inputs may also need to be addressed in many situations. For example, the procurement process, or a decision making process, may have particular quality guidelines which may effect quality planning.

There are four tools and techniques usually associated with quality planning. The first technique is a cost analysis. It is imperative that the project benefits at least compensate for the project costs. Will the project be beneficial in regards to expense? The quality requirements must result in something advantageous to the organization or the project would not be worth executing. If all the requirements are met the project should require minimal change control resulting in a higher productivity level with

decreased project duration yielding a better gain and increasing stakeholder approval. Benchmarking is another tool used for comparison purposes. In a project sense benchmarking is used to compare current situations to that of another previous project's situations. By doing so, a standard can be captured on what is an acceptable level of performance. This can help estimate time, resources, and cost for both project management and project stakeholders. Flowcharting is another quality tool for quality planning. By using a flowchart management can see how a system correlates and what areas may cause a quality concern. Lastly, an analytical technique called design of experiments can assist in exposing which aspects of the project will have the most influence in the end result. This is one area where Taguchi excelled at, and in a project sense can be very helpful for making schedules or deciding on project trade-offs. How things will be executed and who will be performing these tasks, e.g. a senior analyst compared to a junior analyst, are easier to choose when using a design of experiments approach. With this technique the most desirable outcomes can be exposed.

What will the inputs and tools produce during quality planning? The first result is a quality management plan which details how quality policy will be implemented in the project. The plan does not necessarily have to be formal but should provide for a basic level of understanding of the quality responsibilities, procedures, processes, and resources used for the project quality management. Operational definitions are used to describe very intricately what something consists of, and the process for gauging the quality. In the definitions start and finish times are detailed along with what individuals are responsible for deliverables and performance. Checklists are another output of quality planning. These are simple questions as to what has and has not been completed. Using checklists helps keep the project and people on track and can be used as a tool to check if everything specified has been performed.

Quality Assurance, the assessment of the project as a whole on a continual basis at set intervals in order to ensure the project will be a success and gain assurance that all aspects will satisfy quality standards, also is performed parallel to other quality aspects and should be done throughout the project. Quality assurance in large organizations is

usually performed by a specialized Quality Assurance Department which is not involved in the actual work or project and is an external source of quality assurance. However in many projects is project team must perform the quality assurance responsibility and is considered an internal source of quality assurance.

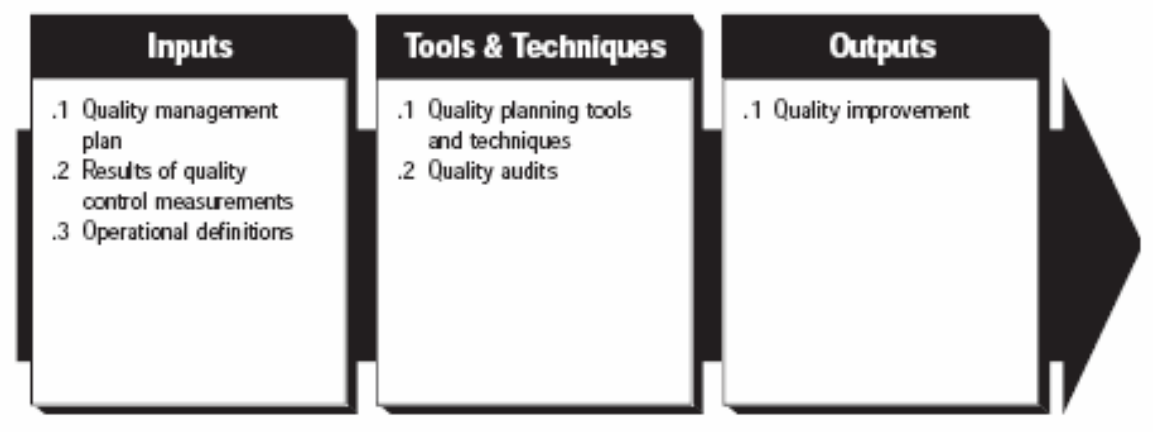


Figure 2-3 (PMI, 1996)

The inputs of quality assurance are related to the outputs of quality planning. A quality management plan is used, along with operational definitions. Another input, results of quality control measurements, is used for analysis to compare measurements of prescribed quality areas that may be of concern.

All tools and techniques of quality planning may be reused for quality assurance. Quality audits are also used to serve as an examination of all quality management activities. Quality checks concerning quality measures may seem a bit repetitive, but may discover useful lessons learned which can improve performance during the current project or future projects. Audits are often done randomly and objectively by internal professional auditors or externally by quality system registration agencies.

One object results from quality assurance and it is quality improvement. Quality improvement happens by making changes or corrective actions for existing procedures or processes and using them to increase the projects efficiency.

The Tasmanian State Government (2004) has a project Steering Committee that is responsible for deciding the amount of quality assurance needed. Their government requires a project to have appropriate measures for quality assurance to meet project requirements in the project execution plan for large projects. In this project execution plan is a quality management plan. To make certain the project is a quality success and executed according to guidelines quality management is supposed to check that a valid methodology is being adhered to, change is being managed, formal review and acceptance procedures are being followed, surfacing problems or issues are resolved, and supervise the project's progress.

The first section of the quality plan outlines the standards for quality management such as ISO 9000 standards or other internal management systems, the output development methodologies, the Tasmanian Government Project Management Guidelines, and any other project management methodologies that will be used. The government also requires a section to describe what will happens if new methodologies or standards come out before the project is finished and how new changes to these will effect the project and what will happen to the previous copies of the methodologies or standards. The development environment is detailed and summarized, and processes for the recording or changing of the environment are given. All aspects of inspection, measurement, and testing equipment are detailed along with the process for using them, acquiring their outputs, and verifying the equipment. The elements development cycle are listed along with the phases being used and what life cycle it adheres to. All outputs are listed and explained how they will be managed. A large section near the end is for explaining the project evaluation. The guidelines state the evaluation form is a valuable tool for continuous improvement for the subsequent phases of the project or future projects. Areas of improvement are given about the planning, development, utilization, and project management processes. Last of all is a section for record keeping. A list of all the possible records is given along with who will be keeping them and storing them. Another list is made with who will have access to them and how one goes about acquiring access.

The government also talks about change control in its quality management guidelines. Changes are split into two categories, planned and unplanned, and how each will be managed. In the quality guidelines it is suggested that larger projects are best divided into smaller interlinked projects for a multitude of reasons that all help quality. The advantages and disadvantages of this are given and the section ends with which projects would be more or less appropriate to be made into smaller interlinked projects. Overall, the Tasmanian State Government is very on top of its project management as a whole. Many tools and templates are listed on their project management website, and many resources are featured including project and quality management review services.

The state government of Washington is also current with project quality management as well as having a quality assurance plan. Quality assurance plans are guidelines are given along with templates for the quality assurance plan and report including examples. They explain quality assurance management helps ensure a project will be according to schedule and budget. They however require their quality to be done separately from their Project Manager and quality functions and reviews are performed and given to the Project Sponsor. The independence of the Project Sponsor helps report the progress of the project objectively and ensures it will be of satisfaction (Washington). Here is a list of best results as well as a checklist used for the quality assurance management given from their website.

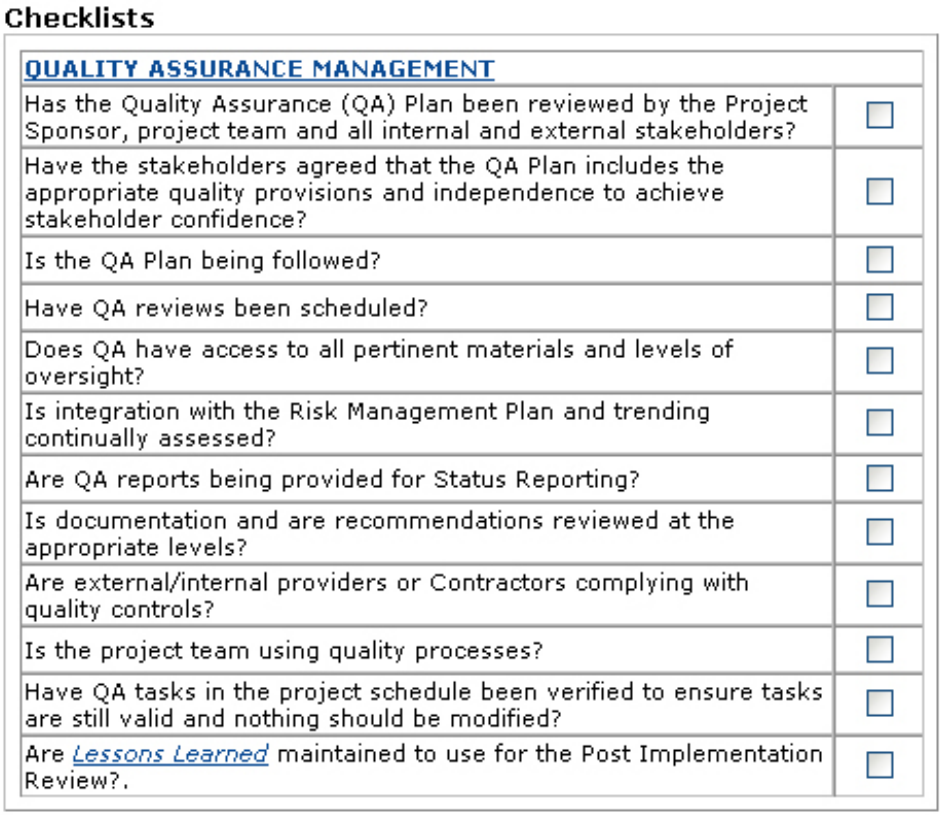
For Best Results

- Make sure that the Project Sponsor articulates the value and use of the QA Plan and quality processes to the project team members and stakeholders.
- Verify the decision-making structures and processes for advising corrective actions and implementing QA recommendations in a timely manner.
- Maintain the independence necessary for objective QA. The QA function should report independently to the Project Sponsor.
- Use external sources and/or independent staff not reporting to the project manager early in the project.

- Arrange for QA representation at key meetings and project activities.
- Prepare QA reports according to the schedule in the QA Plan.
- Address points of risk identified in QA reports. Utilize the Risk Management Plan to assess risk trends and evaluate recommendations and risk mitigation strategies.
- Position the QA function to confirm what is being done right by use of due diligence within acceptable risk levels.
- Validate that the Risk Management process parallels QA reporting intervals.
- Respond quickly to implement QA recommendations or revise processes.
- Utilize other quality resources such as a Quality Agreement to address QA issues.
- Scale QA functions to the size of the project.
- Provide a balanced perspective for technology choices to reaffirm business decisions.
- Maintain thorough and accurate documentation of all inputs and outputs of the processes, reporting, tracking, recommendations and corrective action activities.

Also Consider

- Monitoring the QA provider for adherence to schedule, reporting elements, assessment methods and meeting coverage.
- Reaffirming QA roles and responsibilities to reduce resistance.
- Instituting more formalized quality methods for high-risk project elements.
- Providing two-way feedback mechanisms for process assessment. Early identification of mistakes avoids costly corrections later in the project.
- Pacing the introduction of new processes that require more frequent monitoring than well-established practices.
- Utilizing logs, checklists and automated tools to track implementation of recommendations, risk management measures and schedules.
- Using a mix of quality monitoring methods such as reviewing Deliverable Expectation Documents (DED).



Checklists

QUALITY ASSURANCE MANAGEMENT	
Has the Quality Assurance (QA) Plan been reviewed by the Project Sponsor, project team and all internal and external stakeholders?	☐
Have the stakeholders agreed that the QA Plan includes the appropriate quality provisions and independence to achieve stakeholder confidence?	☐
Is the QA Plan being followed?	☐
Have QA reviews been scheduled?	☐
Does QA have access to all pertinent materials and levels of oversight?	☐
Is integration with the Risk Management Plan and trending continually assessed?	☐
Are QA reports being provided for Status Reporting?	☐
Is documentation and are recommendations reviewed at the appropriate levels?	☐
Are external/internal providers or Contractors complying with quality controls?	☐
Is the project team using quality processes?	☐
Have QA tasks in the project schedule been verified to ensure tasks are still valid and nothing should be modified?	☐
Are *Lessons Learned* maintained to use for the Post Implementation Review?.	☐

Figure 3-1 (Washington State Department of Information Services)

The U.S. Environmental Protection Agency (EPA) is another example of how a quality system depends on an organization's structure. The quality system is an organization's approach to quality, who it assigns certain quality responsibilities, and the processes and procedures for planning and implementation of quality. All projects within the EPA (2001) require following of a general quality management plan which can be used in conjunction with specific project quality assurance plans. Sometimes a quality assurance project plan and quality management plan can be combined into a single document but is up to the discretion of the Quality Assurance Manager for the EPA organization sponsoring the project work that will also defined the plan's contents and requirements. The EPA has general content found in nearly all quality assurance plans but also gives some content specific to the EPA such as data sampling and handling methods and inspection criteria. The QA project plan can be prepared by anyone within the EPA organization or any other Federal agency under an interagency agreement and is

reviewed and approved by an authorized EPA reviewer to certify the QA project plan has the appropriate amount of content and level of detail. The plan can be changed and approved later in the project and is not totally inflexible except in cases where human health and environment operations would be jeopardized.

Quality control, the observing of particular project results to see if the results meet quality standards and figuring out ways to eradicate the origins of dissatisfaction is also performed throughout the project and is centered on project results. It is often performed by a specialized quality control department but can be performed by a project management team with statistical quality control knowledge that can sample, analyze and evaluate the outputs. The team should be proficient in the prevention, sampling, special causes, and tolerances.

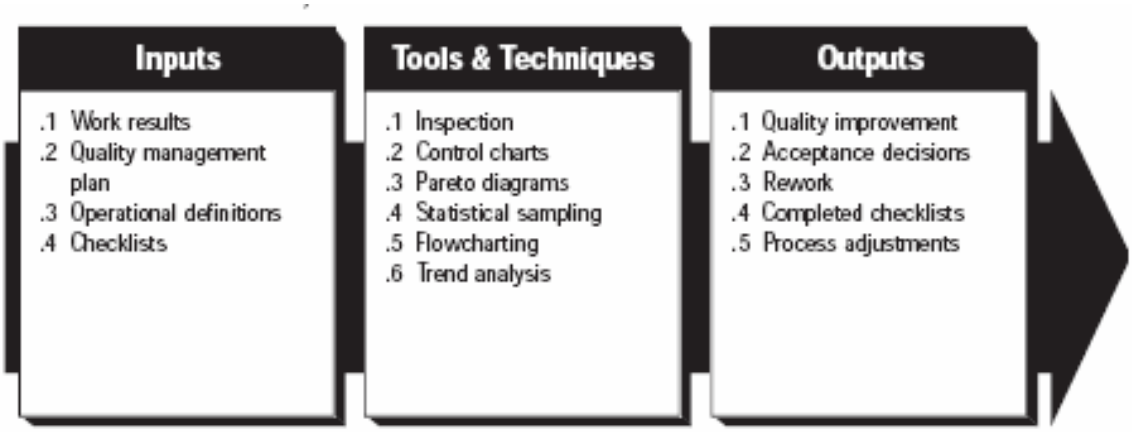


Figure 2-4 (PMI, 1996)

The inputs of quality control consist of the quality management plan, operational definitions, checklists, and work results. The work results are process and product results gathered which can lead to predictions for future results.

Many tools and techniques used in quality control are statistical. The first technique is that of inspection. Inspection consists of quantifying, observing, and testing to see if results are conforming to specification and requirements. Inspections are given to final products such as a product review and to processes such as an audit. Control

charts are a tool for quality control and they are a graphical display of variation. Points of data are plotted on a graph with upper and lower control limits defined. Hopefully the process is within the limits or it may need to be changed. Control charts are often used in projects for cost and schedule variances, volume and frequency of scope changes, errors in project documents, and other management results. Pareto analysis is another technique used to in quality control to determine which factors are affecting the process or product the greatest. Pareto diagrams are histograms with bars labeled by category to measure the frequency of the event. The frequencies are ranked from greatest to least and used to determine the majority cause for a product or process defect. Statistical sampling is another technique used for quality control purposes. This kind of sampling should be done randomly with a small portion of the overall population. If done appropriately statistical sampling can greatly reduce the cost of quality control. Flowcharting is also used for quality control as well as quality planning and can help with figuring out how problems are occurring. Trend analysis is another mathematical technique to predict results. Outcomes are made based one history of previous results. It is used to track errors in performance and to monitor activities in project phases in regards to cost and schedule performance.

There are many outputs to quality control, the first being quality improvement as mentioned above as the output and the goal of quality assurance. Acceptance decisions are also made as a result of quality control and items or tasks will either be rejected or accepted. Some items or tasks in the project might also be sent back for work to meet acceptance standards if possible and fiscally feasible. This is often called rework which is another output of quality control. Checklists are completed as a result of quality control and then documented or included in the project's records according to the quality plan. In order to make processes run more efficiently and conforming process adjustments are also made as a result of quality control. This can be seen as a preventive measure for the future of the project or as a corrective measure to fix current issues. Process adjustments need to be documented and follow the guidelines of any change control measures of the project. Poka-Yoke (Mistake-Proofing) is a process production adjustment for mistake proofing processes using automatic devices or methods to avoid

simple human error (Evans and Lindsay, 2005). These adjustments such as, automatic sensors in machines to tell the operator parts are positioned improperly or the beveled edge on a 3.5" floppy to ensure correct orientation, help prevent processing errors, setup errors, missing parts, wrong parts, and adjustment errors. These errors arise from forgetfulness, lack of concentration, proper attention, lack of experience, absentmindedness, judgment delays, and equipment malfunctions. Another process adjustment approach is kaizen blitz. It is an intense and rapid improvement process in which a team or a department throws all its resources into an improvement project over a short time period on a part-time basis. An example of this would be the gathering of the best developers, testers, analysts, etc on the project team to quickly work on a project issue to get it back on schedule.

METRICS

"There shall be one measure of wine throughout our kingdom and one of ale, and one of measure of corn, to wit the London quarter, and one breadth of dyned cloth, russets, and haberjects, to wit two ells within the lists. And with measures so shall it be also with weights"…Magna Charta (PMForum, n.d.)

Metrics are a critical part to determining and monitoring the quality of a project. Metrics are often listed in the project charter and in a project's quality plan. Based on customer's needs the necessary metrics are determined. They should be designed to gauge how well requirements are being met and fulfilled, and be meaningful and simple to understand by all. Metrics should be carefully created and tailored to each individual project because there is generally not one particular metric that will fit every requirement of the project. Brainstorming can be an effective method to drafting metrics for a project. Ideas should be based on the problem being solved or the reasons the project was created. Metrics should aid in helping better the performance of the project and its processes. Stakeholders and executive management should be continually informed of project metrics so everyone knows what the actual goal is. If the metrics are to add value to the

project then they must be created carefully and examined during various phases of the project. Metrics do not only measure the end result but the process used to create an end result.

Balanced Scorecard (2005), developed in the early 1990s, is an explicit method to assist in the selection of project metrics. Four areas or perspectives, financial, customer, internal processes, and employee learning and growth are used to determine project performance. This approach contains leading and lagging measures as well as financial and non-financial ones. Although brainstorming is a great approach to coming up with metrics it can sometimes leave important preexisting metrics out. For this reason typical project metrics are given in the Balanced Scorecard. All the metrics may not fit the project so a combination of brainstorming first and then carefully selecting from a preexisting list may lead to more success (iSixSigma, n.d.)

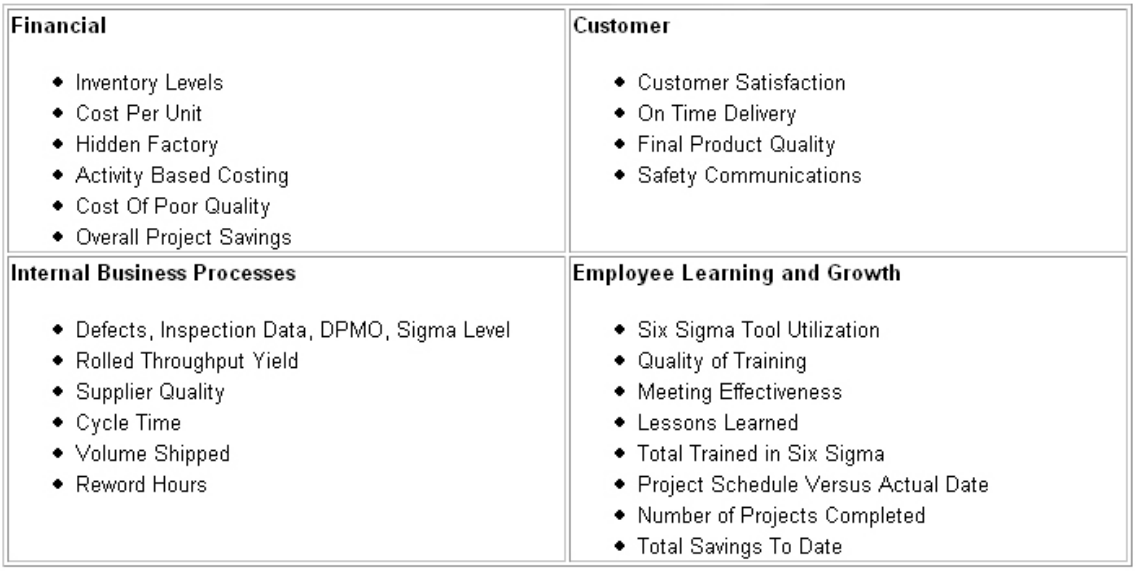


Figure 4-1 (Balanced Scorecard Institute, 2005)

Sometimes it is difficult and time consuming to make an all inclusive Balanced Scorecard for large projects or organizations. Much effort is required and can cause difficulty. Unless full commitment is given to the Balanced Scorecard methods this may only cause more problems. Some industry people feel the Balanced Scorecard is a fad that will soon pass. Although this is a new approach with a catchy name the original

concepts of the Balanced Scorecard will not pass quickly. The concepts of strategic thinking, preemptive planning, measuring, evaluating, and obtaining feedback will keep the Balanced Scorecard around for a significant amount of time. People fail to understand the Balanced Scorecard is not a form of project management, a tool or technique, an evaluation system, a scoring system, but instead a strategic learning system to help interlink business activities with project goals and requirements.

Another method for brainstorming and choosing methods is to answer some questions from each perspective. The model below from Six Sigma serves as guidance to assist in selecting more valuable project metrics.

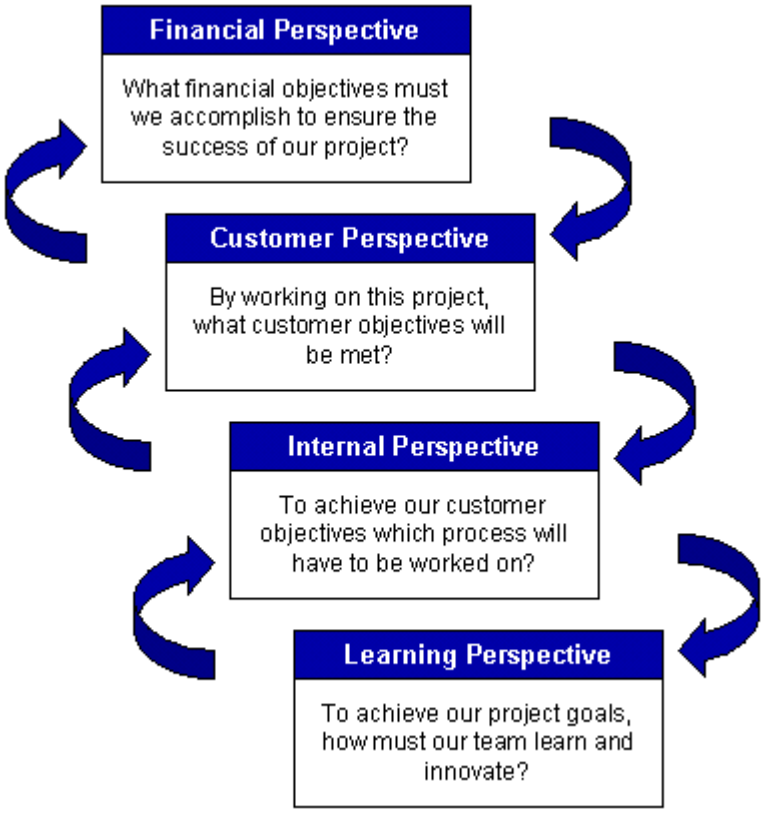


Figure 4-2 (Balanced Scorecard Institute, 2005)

After the brainstorming session and using the model above objectives can be mapped with the use of a strategy map which links each perspective with each other and

the overall strategy of the business. The arrows, called strategy links help show cause and effect relationships. An example of a strategy map from Six Sigma is shown below.

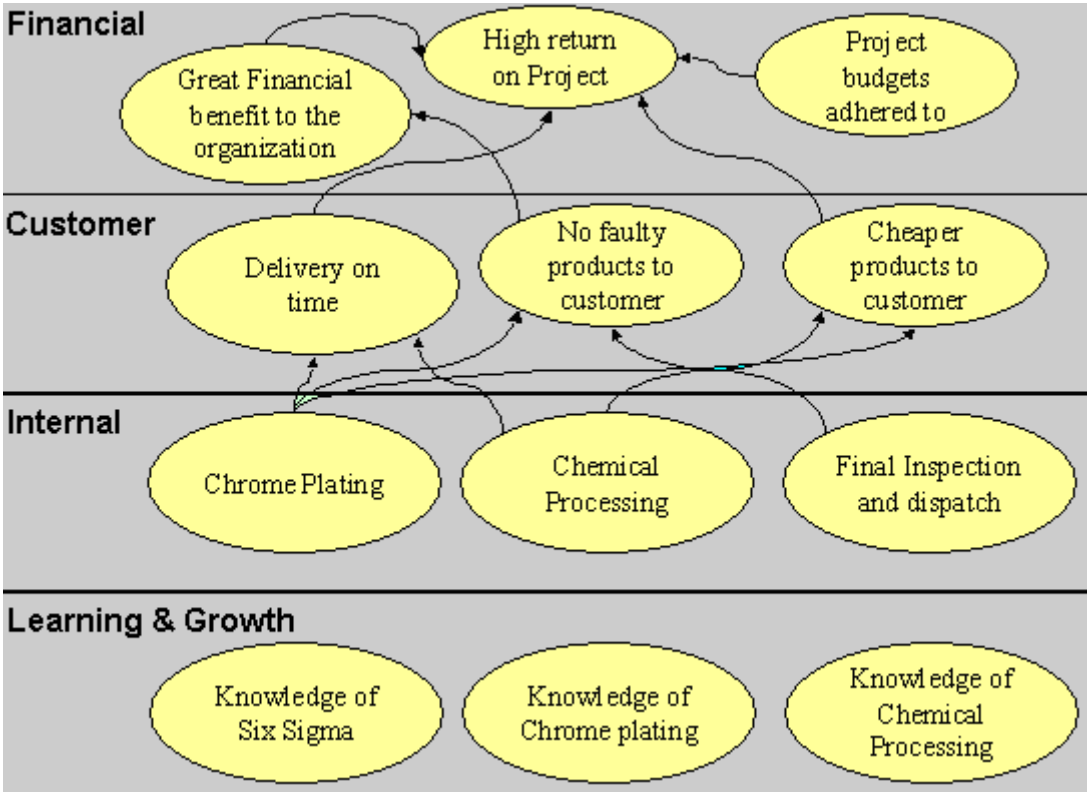


Figure 4-3 (Balanced Scorecard Institute, 2005)

With the strategy map designed, project team members can more appropriately select metrics that will reflect the objectives. In the actual training seminar from the Balanced Scorecard organization there are 9 steps to implementing the Balanced Scorecard.

1. Organizational Assessment
2. Identify Strategic Themes
3. Define Perspectives and Strategic Objectives
4. Develop a Strategy Map
5. Derive Performance Metrics
6. Craft and Prioritize Strategic Initiatives
7. Automate and Communicate

8. Cascade the BSC Through the Organization
9. Collect Data, Evaluate and Revise

According to the Balanced Scorecard Institute (2005) Mobil Oil, now Exxon Mobil was at the bottom end of its industry in 1993 and losing almost $1 million a day. In 1995 it became first in the industry after fully implementing the Balanced Scorecard and saved over $3.5 billion in 1998. This is just one example that the Balanced Scorecard is a valid and credible approach to quality in an organization. Implementing the Balanced Scorecard correctly seems to be the key to its success. Opponents of the Balanced Scorecard may have just not seen or have implemented it properly. It must be completely implemented throughout the organization in order to align IT and business together. Employees will develop a different job approach only if the organization is prepared for the change, there is backing from upper management including financing, and the plan is followed through to its completion. After the completion periodic reviews and revisions of the scorecard should take place to keep things current. This can be done with employees and stakeholders in an iterative manner. In IT specific organizations the customer is internal instead of being external consumer. In project based situations the customer are the project stakeholders and end users. The Balanced Scorecard can also be used in project selection helping to rank, choose, or even eliminate projects or project portfolios.

Test Case Point (TCP) Analysis (Patel, 2001) is an approach for estimating the testing of functional projects. It determines the complexity of the testing cycles and provides a way to interpret test execution efforts. Basically, Test Case Points are representative of the effort involved in testing during the project. Project testing is categorized into four different models, although most projects will have testing that will fall into a combination of the four models.

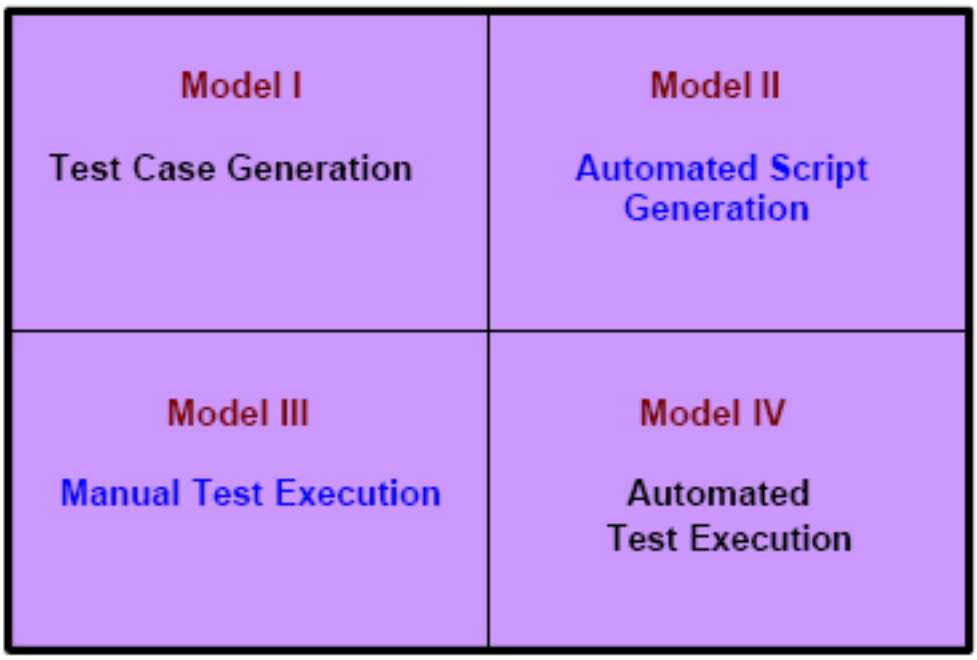


Figure 5-1 (Patel, 2001)

Model I includes well-defined test cases generated from use cases. Model II includes the automation of test cases with the help of an automated test tool which creates generated scripts. Model III includes reporting the results and the execution of the test cases previously generated in Model I. Model IV includes reporting the results and execution of the test scripts generated in Model II.

TCP Analysis uses 7 steps in its process:

1. Identify Use Cases
2. Identify Test Cases
3. Determine TCP for Test Case Generation
4. Determine TCP for Automation
5. Determine TCP for Manual Execution
6. Determine TCP for Automated Execution
7. Determine Total TCP

The number of steps, the amount it interfaces with other test cases, and the results of a test case will determine the complexity of a test case. Test cases are weighted from 0 to 3 in each category and summed. The amount of test cases that fall in a certain category are then multiplied by weights to result in a number called the Rough Test Case Points. This number might need slight adjustment if certain points of functionality might require special understanding or knowledge making them a bit more complex. In this case small factors can be added to Rough Test Case Points number to reflect its complexity. This results in a final number which reveals the amount of testing involved in the project that falls under the category of Model I (Test Case Generation). Each of the other three models have similar weighting formulas that include, amount of data, numerical computation, UI components, database check points, verification, and other criteria determining the amount of complexity of the testing involved. All the TCP numbers are totaled yielding a very unique and intricate metric to measure the amount of quality in a project.

The TenStep Project Management Process (2005) is a special methodology for Project Management. Their consulting services offer methodology deployment, project audits, lifecycle customizations, and other services. TenStep will even rescue troubled projects if needed. Quality is important to the TenStep plan and is discussed thoroughly. Their quality management purpose is to find errors and defects as early in the project as possible and collecting metrics is a vital process to that.

The TenStep methodology is dependent on the size of the project. For small projects, quality management only needs to be concerned about quality control steps. Deliverables should be reviewed and approved, and the main focus is on the quality of the deliverable to be determined in testing.

Medium sized projects first require a quality plan that also discusses a description of the quality assurance and control plans so that they can be implemented and included in the work plan. Quality should be ensured by making sure the control activities are performed for every deliverable during the project. All quality assurance activities

specified in the work plan should be carried out. The quality plan is evaluated on a monthly basis or after the completion of each milestone and updated if necessary. After the completion of a project feedback is given on the quality process and metrics captures. The best practices and metrics can then be repeated in future projects.

Large sized projects expand on the guidelines for a medium sized project and are more metric intensive. Careful consideration is given to the metric creation process. Special sophisticated metrics, not standard metrics such as finance and duration metrics, are designed. Process metrics created should capture things such as involving client satisfaction with project team communication, the amount of rework caused because of incorrect or poor analysis, and the amount of time spent on resolving problem issues. Product metrics should capture things like errors discovered during testing, response time of application software, and average time it takes a product to fail. Metrics should be captured at least monthly and client satisfaction surveys at least quarterly. Some metrics should be captured every day. After capturing the metrics they should be analyzed and determined what can be done to make an improvement to the project work process. Implementation improvements from the analysis are added to the project and metrics are continued to be measured.

The TenStep (2005) quality process defines “goldplating,” as the delivering of more requirements than what the client requested. It may appear as a good, but is usually a bad thing. The original focus of the project is to deliver what the client wants on time and on budget. Adding further work can jeopardize the project timeline or budget. Also, adding requirements or assuming business decisions can change what is most valued. Decisions should be made by the client and not project management.

Other key concepts of TenStep (2005) are: quality management focuses on processes and not people, quality is everyone’s responsibility, quality is a mindset and not an event. Quality control techniques and testing are discussed along with quality assurance techniques. This shows the interconnections between the two and how they can be performed in parallel.

RISK-BASED TESTING

Project managers need to make sure quality will not be harmed due to external circumstances. Risk-based testing (Compuware, n.d.), is done with software that allows organizations to prioritize requirements and maximize resources based on business needs and IT goals. Costs associated with time can be reduced and profitability maximized with early market penetration. Risk-based testing also prioritizes project testing and permits a better understanding of what is being tested. Risk-based testing tries to eradicate the failure to meet deadlines and budgets, to make a reliable product, to meet business needs, and to communicate testing results to managers successfully.

Not all aspects of a project can be effectively tested completely. Scope during testing is often limited due to over allocation of resources and restricted time. Testing is often done based on past experiences or perceptions. With many products or services being constantly upgraded under many different platforms and multiple tiers, it is nearly impossible to do adequate testing to ensure the quality of a product after it is deployed and released to the end user. Using a risk-based testing approach allows for IT to understand which requirements are the most critical to business needs. The most important functions are always tested first regardless of scheduled time or narrowed scope.

Test plans are developed by user-defined business requirements entered in the software to be used in a risk-based testing approach. The essential and critical things to the business objectives will then be quality tested and the metrics relayed to managers. Risk-based testing is seen as a medium or tool for IT and business to communicate effectively to deliver the most it possibly can as a result of the project.

IBM RATIONAL

In order to execute a successful project there must be a continual quality presence throughout the life cycle. Laura Rose in charge of quality assurance from IBM's Rational (Rose 2005) stated, "To produce a high-quality product, you must have a process that involves all project participants in ensuring quality throughout the software development lifecycle." IBM Rational has come to understand it must really know its product in order to ensure quality. Developing high quality requirements and conducting requirement reviews, testing code early and often, tracing features back to requirements and business models, and analyzing root causes for defects and preventing further defects were listed as the better known practices for continually ensuring quality in IBM's Rational Unified Process (RUP) that guides its development activities. RUP have four phases: Inception, Elaboration, Construction, and Transition.

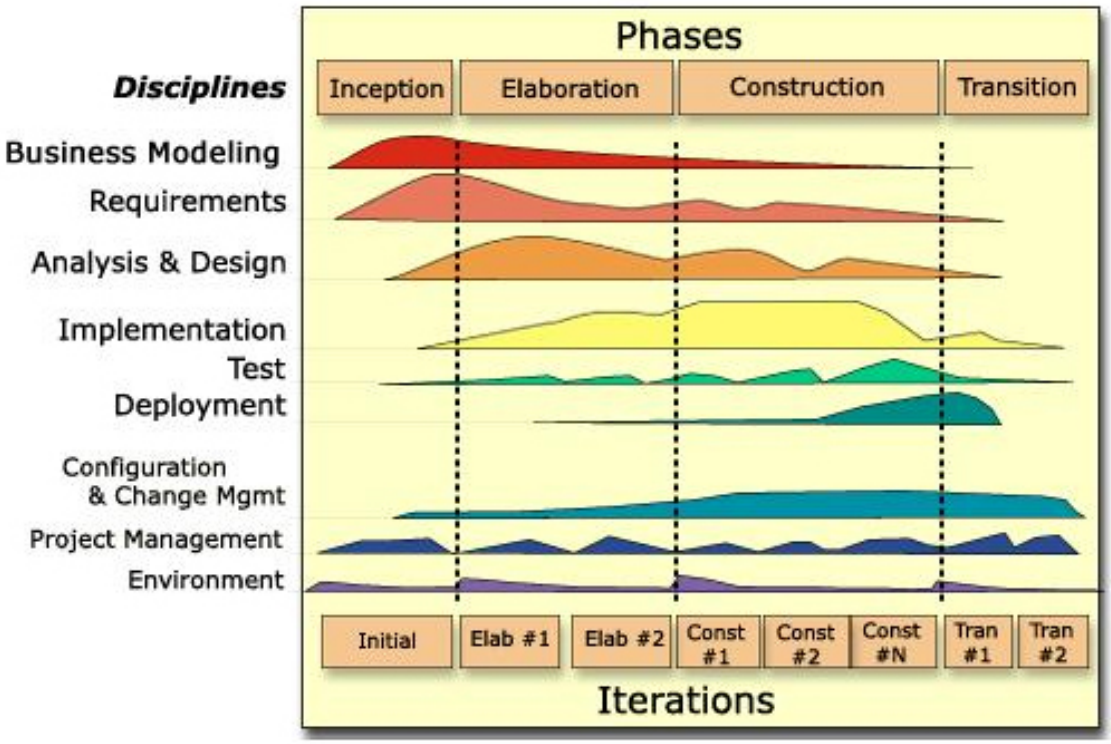


Figure 6-1 (Rose, 2005)

Laura Rose summarizes what happened in her last Rational software project while using IBM's RUP approach. In the Inception stage the business analysts and product managers provided the project management with a long wish list of features and a timeline for delivery to be in a competitive market window. It was vital to be on time because other competitors would grab a larger share of the target market. Meetings were held between the product manager, developers, testers, and technical writers to slim down the number of requests to what functionality could be put in the product in the small timeline. Mangers then met to make requirement statements and assigned priority of high, medium, or low based on business priority and amount of effort required. After prioritization the rest of the team members joined back in and feasibility and risk were discussed. Prototypes were defined and Rational Rose and UML were used for viewing component interaction and how they might affect use cases. Riskier items were either removed or improved.

The Elaboration phase was used to make sure certain requirements meet system imperatives. This was because the product was to be a small part of a larger product in which they must interact. Value may not have been added at this point, but it was a necessary step to ensure compliance. The project team then cut its feature list and held another round of quality evaluations. All the remaining requirements were entered into IBM Rational RequisitePro, a requirements management tool. The last part of the Elaboration phase consisted of completing requirements documents as thoroughly as possible with little ambiguity that might cause trouble during construction. Previous experience had taught them that describing requirements very precise and clear caused fewer defects during system testing and would save them time and resources. This process was performed by using a checklist of "good specification attributes" and "problem words to watch out for" shown below to make better design documents.

Requirement review tools (from Software Testing by Ron Patton)

Requirement Review Checklist

List of attributes to test against:

- **Complete.** Is anything missing or forgotten? Is it thorough? Does it include everything necessary to make it stand alone?
- **Accurate.** Is the proposed solution correct? Does it properly define the goal? Are there any errors?
- **Precise, Unambiguous, and Clear.** Is the description exact and not vague? Is there a single-interpretation? Is it easy to read and understand?
- **Consistent.** Is the description of the feature written so that it doesn't conflict with other items in the specification?
- **Relevant.** Is the statement necessary to the feature? Is it extra information that should be left out? Is the feature traceable to an original customer need?
- **Feasible.** Can the feature be implemented with the available personnel, tools, and resources within the specified budget and schedule?
- **Code-free.** Does the specification stick with defining the product and not the underlying software design, architecture, and code?
- **Testable.** Can the feature be tested? Is enough information provided that a tester could create tests to verify its operation?

Problem words in a specification

- **Always, Every, All, None, Never.** If you see words such as these that denote something as certain and absolute, make sure that they are indeed, certain. Think of cases that violate them when reviewing the spec.

- **Certainly, Therefore, Clearly, Obviously, Ordinarily, Customarily, Most, Mostly.** These words tend to persuade you into accepting something as a given. Don't fall into the trap.

- **Some, Sometimes, Often, Usually, Ordinarily, Customarily, Most, Mostly.** There words are too vague. It's impossible to test a feature that operates "sometimes."

- **Etc, And So Forth, And So On, Such As.** Lists that finish with these words aren't testable. There needs to be no confusion as to how the series is generated and what appears next in the list.

- **Good, Fast, Cheap, Efficient, Small, Stable.** These are unquantifiable terms. They aren't testable. If they appear in a specification, they must be further defined to explain exactly what they mean.

- **Handled, Processed, Rejected, Skipped, Eliminated.** These terms can hide large amounts of functionality and need to be specified.

- **If... Then (but missing Else).** Look for statements that have "If...Then" clauses but don't have a matching "Else." Ask yourself what will happen if the "If" doesn't happen.

The Construction phase had three iterations. During each cycle a feature subset was defined along with changing and eradicating certain requirements. Testing was done often and early by involving developers in both the feature verification testing and the system-level testing. This partnership of testing was done for better quality and because the developers far outnumbered the testers causing a bottleneck in the process. Developers learned to break their software and testers learned more about the product. Developers that had the understanding of certain data point validation and the demeanor of testing could design more testable code. Both worked with each other using IBM Rational PureCoverage which produces code coverage metrics. Rational TestManager and Rational Application Analyzer were used to manage and log test results for assessment against iteration exit criteria.

IBM realizes that many staff members have different quality concerns. Sometimes this interconnection of concern between project staff may cause poor communication or headache for others, and it is critical to get to know your staff well. One point easily recognized was that business analysts struggled to write well thought out, effective and communicable requirement specifications causing incorrect interpretation of customer needs. Another point was testers not participating in the requirements validation struggled to assess a product application's quality. During the project mentioned above test plan reviews were conducted to reduce the "pain chain," a term used for differentiation of quality concerns amongst staff members causing trouble in regards to communication, amongst key players in the project. The reviews were explicitly scheduled in the project schedule, but due to overloading of resources the number of reviews had to be reduced. Sometimes only one representative from each department performed the review making for a more serious report. After the reviews time was given to respond to each respondent. Knowing there was little time each respondent was asked in advance to commit to these meetings. This strategy proved valuable and a lot of insight was given to make for a more quality project in such a short amount of time.

Another critical component for a quality project is to know the customer. A product is not of quality if it does not satisfy the customer. Continually involving the customer and asking for input helps to achieve this quality satisfaction. This can be done by inviting customers to engage directly with development teams, holding customer focus groups, gathering feedback and conducting beta testing surveys, letting customers do UI reviews, involving customers in formal reviews, conducting milestone assessments based directly on customer requirements, and involving customers to participate in usability evaluations and validations.

Knowing the project schedule well is also very critical to a quality project. The schedule will constantly be under revision and change. According to the RUP the best way to keep on task is to test software iteratively to eliminate risks and errors.

Milestones and tasks are evidence of the product being developed during the lifecycle and can be used make changes when easiest to do so. Testing iteratively will help meet customer requirements to give them what they are truly asking for. After each iteration phase testing was performed and developers fixed issues when fit. Problem issues not easily fixed were reported to upper management on a weekly basis. Using this approach will ensure a project is ran efficiently, contains minimal errors, and develops what the customer needs. Below is a figure that illustrates the phases in a Construction iteration.

Iteration activity	Task summary
Planning	Specification updates
	Requirement updates
	Requirement reviews
	Test planning
Coding	Test case Identification
	Test case implementation
	Programming
FVT	Test execution and logging
Defect fixing	Some developers conducted defect fixing, while other developers and testers continued with FVT testing and defect validation
Assessment	Review of exit criteria
	Usability and test assessment reports
	IBM Rational PureCoverage metrics review
	Application analysis metrics review
	Test pass/fail results review

Figure 6-2 (Rose, 2005)

MATURITY MODELS

Maturity models are frameworks that help an organization improve its processes. Several groups are working on project management maturity models. The Software Engineering Institute Capability Maturity Model (SEI-CMM) is a model that describes the principles and practices underlying software development process maturity. It helps identify the level of maturity of a process from chaotic to well-disciplined. The CMM

serves as a framework that stresses repeatable, mature, and well-documented practices. The goal is to implement quality features that will continue to improve the organization.

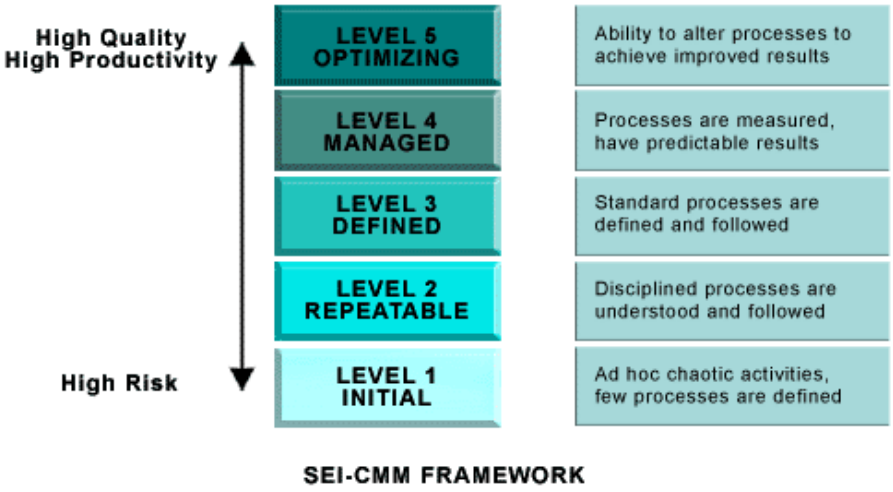


Figure 7-1 (Wipro Ltd., 2005)

The Organizational Project Management Maturity Model (OPM3) is a standard introduced by the PMI in December of 2003. It helps organizations reexamine strategic objectives via best practices in project management. It is designed to assess an organization's capability and help make decisions for planning and implementing improvements, hence making the organization more mature. With advanced maturating, projects can be considered at program and portfolio levels and decisions can be made to what related capabilities and resources to implement when and at what level. Below is the OPM3 cycle by which organizations can improve their quality.

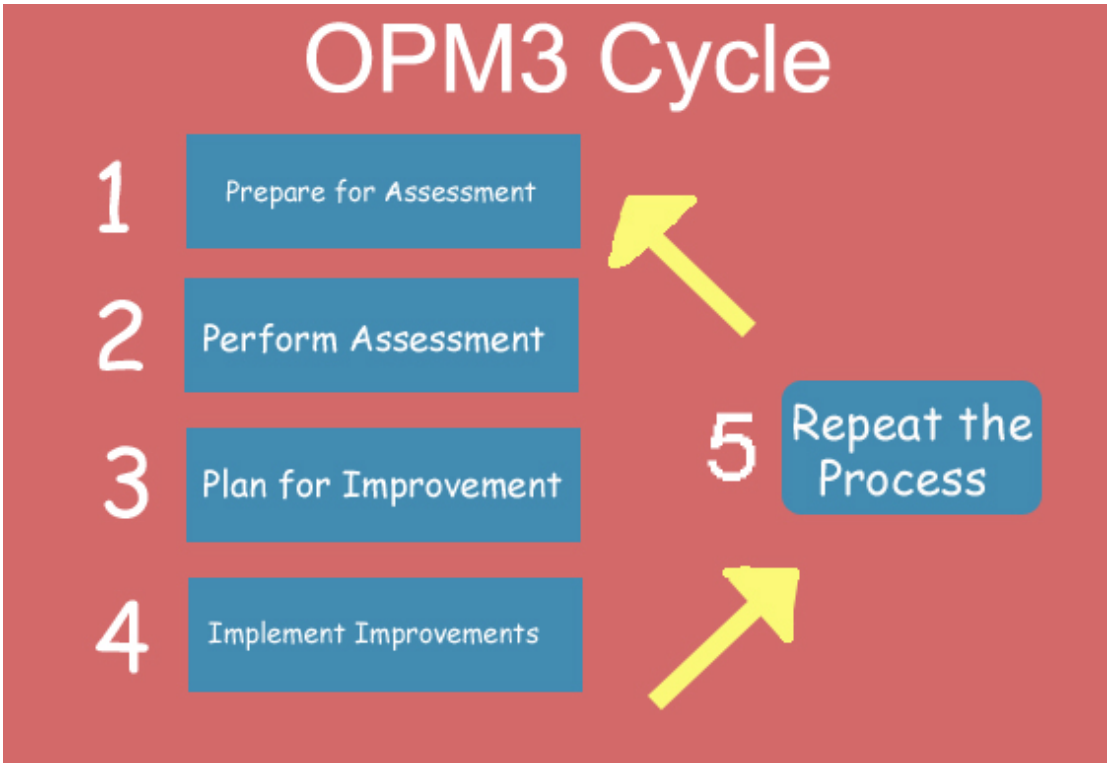


Figure 8-1

The Project Management Process Maturity Model $(PM)^2$ (Kwak and Ibbs) is a model used to measure the project management maturity of an organization. Initial levels of maturity are identified, and necessary steps are taken to improve project management growth. It consists of 5 levels that serve as reference points to an organization's ability to apply project management practices and processes. As the levels increase each stage gets more detailed and advanced. Each stage outlines quality aspects that show how mature a project is performed.

Level 1: The Ad-Hoc Stage contains no formal procedures or plans. No guidelines are given and tools and techniques are often inconsistent. Management does not understand key objectives for a successful project. Processes and practices are not defined.

Level 2: The Planned Stage is more team-oriented and manageable. Organizations can perform repeatable work but things are done informally, and project success is unpredictable due to cost and schedule problems.

Level 3: The Managed Stage includes formal documents and key practices and processes are identified. Metrics and data are collected and analyzed by many members of the project team. Efficient groups or cross functional teams work together to form a project that is more likely to succeed.

Level 4: The Integrated Stage incorporates processes that are well-defined and quantitatively measured. Data is standardized, collected, and stored in databases for evaluation and analysis. Results are used to predict processes that may have quality impacts. Organizations at this level can plan and control quality aspects of many projects.

Level 5: The Sustained Stage has many steps that indicate a project's success. Processes are continually being improved. All problem issues are understood and reworked or eliminated. Data is analyzed more harshly, and project teams are at their highest level of training and education.

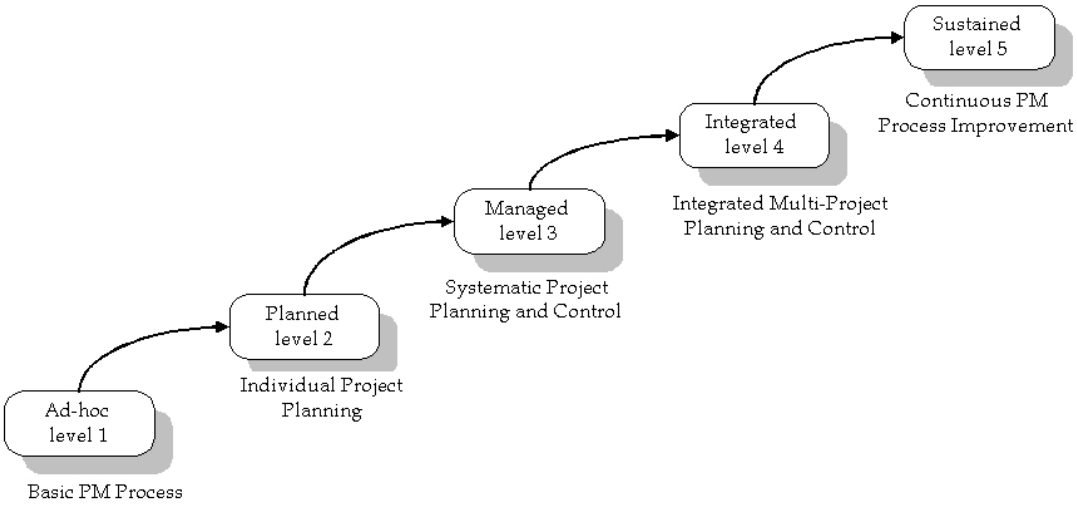


Figure 9-1 (Kwak and Ibbs)

The $(PM)^2$ model is very similar to the Project Management Maturity Model. Lately, maturity models have grown in popularity. Organizations are developing their own models used to evaluate their processes and practices compared to others. Effective improvement for one organization in project management may require following a maturity model different from other organizations. No matter which model is selected greater project maturity usually indicates a better quality success that will satisfy the customer. "Unfortunately, there is no consensus as to the contents of an organizational project management maturity model, or even the principles on which such a standard is constructed. Some 30 existing models serve the market, with more appearing all the time. Books on the subject are now beginning to appear. (Archibald, n.d.)"

PRINCIPLES

Genrich Altshuller, the founder of TRIZ, uncovered forty patterns to help find solutions to problems (Retseptor, 2003.) These are known as the 40 Inventive Principles and can be applied to many forms of project management. The author gives many examples where the 40 Principles are used in Quality Management and some are discussed below.

Principle 1: Segmentation. Quality system's effectiveness is increased if an object is divided into separate independent parts. The object or system should be easy to disassemble and fragment. Strategic quality goals are broken down. FMEA (Failure Mode Effects Analysis) and ANOVA (Analysis of Variance) are useful tools for multiple variable problems that need to be segmented.

Principle 2: Taking out. Depending on the situation, quality may be best left up to a quality department, should be outsourced, audited, and separated from certain people. Employees should not fear quality and quality assessment techniques should not scare or intimidate employees.

Principle 6: Universality. Objects or system that can perform multiple functions should. Any other parts should be eliminated. This can apply to multi-skilled personal, systems, templates, standards, etc.

Principle 21: Skipping. Process or stages can be done at high speed. Methods involving all project staff members simultaneously can make major breakthroughs to painful processes. Invalid or obsolete documents should be removed from the process to eliminate time and confusion.

Principle 23: Feedback. Feedback should be used to find improvements. If feedback is already present then its influence or magnitude should be changed.

TRACEABILITY

Traceability to original requirements is crucial to a project's success. It is important to have this in a quality system. The least project management should do is check that all requirements are implemented and tested to ensure quality. There is software currently available that can capture business and document-based requirements and integrate them into a project life cycle. The software can perform requirements traceability and analysis of the project. Priority ranking of requirements is performed using management tools in the software to make sure the most imperative functions are assigned the highest priority. Testing can be executed in regards to each requirement by critical priority number and the changes can be easily documented to any requirement. Requirements management is simplified and testing of the requirements can easily occur throughout the life cycle of the project with little question of quality in testing processes or traceability.

Requirements traceability software packages also help to eliminate another common problem in project management that may jeopardize a project's quality called "scope creep." Projects need to stay within the original planned scope or they will grow

in size and not be completed correctly or on time (P2C2 Group Inc, 2001). Quality techniques must be developed to monitor scope creep situations if:

- Customers are unable to use the services or products defined by the project. Efficiency tests or evaluations may need to be given.
- Customer's managers or organization has changed. Different priorities and requirements may arise. Communicated constantly with stakeholders and customers to monitor these may be necessary.
- Technology being used in the project or technology being produced change
- Project management, staff, or team members change
- Customer's budget and mission change

Requirements traceability software detects where developers independently defined new functionality on their own or when functionality from previous requirements is missing (Compuware, n.d.). Examples of such software are QACenter Enterprise Edition and DevPartner Studio Enterprise from Compuware or Serena RTM.

ALTERNATIVE APPROACH

Quality Research (Deltek, 2004), a large research and development company, experienced increases in revenue, company size, and number of projects. As the number of projects increased from around 20 to near 100, the amount of data the company could manage also increased. Client and manager information requests were tremendously taxing and meant scouring spreadsheets to obtain uncertain figures. The company's ability to produce accurate data was deteriorating. In 1996, the difficulty of producing billing information began to threaten the profitability of entire projects and impede the company's growth and success

Quality Research used Time Collection, a web-based, employee timekeeping solution made by Deltek to solve its problem. Later in 1999 they implemented Deltek Costpoint, an integrated back-office solution for large project-based firms with complex

business requirements. By 2002 (Deltek, 2004) Quality Research's revenue had nearly tripled, and the number of projects increased by five. Provided with up-to-date billing and payroll information, project managers had greater control over their projects causing them to be kept under budget and on time. Access was also given to project managers in regards to project status reports, labor information, profit percentage, etc. Fewer errors were passed through the system due to managers getting them directly.

Quality Research did not have a quality problem concerning project issues, but instead a problem internally in their organization that caused trouble. Some external quality issues may affect internal project issues. Quality Research is just one example to the pursuing of many solutions outside of the project management lifecycle to improve quality. Sometimes internal policies or procedures should be audited as to not negatively carry over into the project. In the same manner, external quality situations such as high morale, or pay bonuses could positively carry over and influence the project life cycle.

Bhilware Infotech Limited (BIL), an IT consulting and service company, makes quality a primary focus when developing its software. Quality processes and management exist throughout the project lifecycle. BIL (IBM, 2002) uses the Software Engineering Institute's Capability Maturity Model (SEI-CMM) Level 4. This helps BIL focus on quality, innovation, and people. BIL continued to look for ways to improve its quality control and shorten delivery time in customer's projects. They wanted an application to track all activities involved in the project lifecycle.

BIL created an application in 2002 which keeps track of all issues related to its software development process in a project's lifecycle. Users can add projects and team members so that the application can understand how people communicate, exchange, and resolve an issue. The application can assign teams, assign member roles, monitor problem issues, automatically generate emails concerning problem issues to proper personnel, generate reports, and provide risk management functionality in other web applications for viewing.

BIL has since become one of India's largest business conglomerates with $363 million annual revenue (IBM, 2002). BIL desires to be the most preferred global IT services provider in their markets by improving their customer's business success. BIL is another example of an improvement in project quality caused by improving something outside the project lifecycle. BIL created an in-house software application that was able to give customers what they needed in reduced amounts of time because their project management system was improved.

COST AND RETURN OF QUALITY

The concept of the Cost of Quality concept first emerged in the 1950s. It is the costs of conformance or delivering products that meet requirements and fitness for use. It can also be defined as the cost of nonconformance or taking responsibility for failures or not meeting quality expectations. Poor quality (TenStep, 2005) can make for more work, cause extra repairs and maintenance, client dissatisfaction, and poor morale. Below is a list of financial burden caused by quality issues in the amount of dollars per hour.

Business	Cost per Hour Downtime
Automated teller machines (medium-sized bank)	$14,500
Package shipping service	$28,250
Telephone ticket sales	$69,000
Catalog sales center	$90,000
Airline reservation center (small airline)	$89,500

Figure 10-1 (©Course Technology 2002)

There are numerous amounts of ways to report quality related costs. Juran said, "Money is the language of upper management." (Bisgaard and Freiesleben, 2004) but, quality is not easily translated into monetary terms. Quality problems such as units, defects, and errors have little impact on top managers who are concerned with financial

performance. To establish a cost of quality approach, the activities which generate cost must be measured and reported to make things meaningful for upper level managers. These activities can then be identified, analyzed, and improved. Quality costs can be structured into four major categories (Evans and Lindsay, 2005): prevention costs, appraisal costs, internal failure costs, and external failure costs. Prevention cost is the cost of planning and executing a project so it is error-free or within an acceptable error range. Appraisal cost is the cost of evaluating processes and their outputs to ensure quality. Internal failure cost is the cost incurred to correct an identified defect before the customer receives the product. External failure cost is the cost that relates to all errors not detected and corrected before delivery to the customer. Quality costs amongst the four categories are rarely distributed evenly.

Quality may not be as easy to implement as thought. Of all the quality practices currently in use, which ones will work for your organization? How will these practices or chosen methodologies be implemented? How will people react to a quality program?

The first step to ensuring quality is to lead from the top down and to implement from the bottom up. People must be empowered and have the knowledge and skills necessary to be accountable for their own actions. Without empowerment there is little room for improvement and a quality culture will not be developed. People will need to be informed and educated to understand. Active support needs to be generated starting with your CIO, CEO, General Manger, or other title. If resistance is given attention can be gained be highlighting problems and defects. Using these in a positive manner to persuade others such as financial savings, or defect reductions, can help establish a need for quality with current products or processes.

After management agrees to the need of a quality program you can now develop or adopt practices to solving quality problems that best fist the culture of the organization. Every organization has a unique culture which can be difficult to change. Recommendations for proceeding steps should be developed as well as long term planning for the implementation.

After an agreement has been made as to the best way to implement quality a quality mission statement can be created. This mission statement describes the commitment to quality the organization agrees upon and relates organizational operations to quality programs, projects, actions, and recognition. Quality goals should be created to keep quality efforts on task. The goal of implementing quality is the end result, or the return on quality (ROQ). ROQ is based on four main principles (Evans and Lindsay, 2005):

- Quality is an investment. Thus, it is not fundamentally different from investigating in equipment or buildings.
- Quality efforts must be made financially accountable. Because businesses evaluate other investments in this way, and quality efforts should be subject to the same types of financial justification
- It is possible to spend too much on quality. Customers might not be willing to pay the premiums associated with higher levels of quality, or the process improvement benefits might not justify the expense.
- Not all quality expenditures are equally valid. An improvement in product design or customer response might be much more important from a strategic point of view than improving the capability of a minor process in the manufacturing plant.

The desired benefits of ROQ are increased client satisfaction, higher productivity, lower costs, shorter duration, higher project team morale, and fewer errors or defects Evans and Lindsay, 2005).

Quality efforts should be carefully chosen based on these criteria before implementation. It may take many persuasive actions to ensure quality to employees by top and middle management, and a commitment to the long term is required. Employees should visibly see that the CIO or leader of the organization is also involved, and what is expected in the organization. Change is often faced with much resistance, and change management programs or courses may be of great help when leading a quality program that could affect an organization’s culture.

CONCLUSION

Quality is vitally important to a project's success. It is something that can not be overlooked or forgotten. Quality must be present before a project begins and continually applied in all stages of a project lifecycle regardless of the approach. Quality will continue to be brought to the spotlight as the amount of IT organizations increase and project management continues to expand. More advanced products and services continue to be developed as technology increases, and demand for them increases while timelines decrease, causing quality concerns. Organizations such as PMBOK, ISO, and Six Sigma are becoming more advanced and detailed to solve this crunching timeline problem.

Quality awareness has grown exponentially in the past century and will continue to trend upward. Quality experts have laid the foundation for many approaches and methodologies to increase the success of an organization. Quality recognition goes hand in hand with awareness and helps to show the world how important a quality influence can have. Awards and certifications, such as the Malcolm Baldrige Award and ISO 9000, demonstrate to the public how a quality capable organization outperforms the competition, and makes for a profitable party that can satisfy the needs of its customers.

Project quality management includes all the activities for management to determine quality policy objectives, monitor quality, and change processes within the quality system. It takes place throughout the project and all aspects of it often overlap each other. Many standardized and proprietary approaches have been developed for project quality management based on the needs, constraints, and sizes of organizations. Every one of them is simply a guideline or framework that will improve the efficiency and effectiveness of the project life cycle. Some methodologies are considered fads while others will clearly be around for quite awhile, but they are all still a step in the right direction to achieving a better quality world.

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