Module 3

Cost and Quality Management

Introduction

This module examines the two core project management functions – cost and quality management. Project Cost Management encompasses the processes required to ensure that a project is completed within an approved budget. The four key processes involved in cost management are resource planning, cost estimating, cost budgeting and cost control.

At the end of this Module, you will be given an assignment, which is based on the body of knowledge of cost management. You will complete an earned value analysis based on a question provided.

Upon completion of this module you will be able to:

Outcomes

- *describe* the importance of cost management and the fundamental reasons for the project cost over runs.
- *construct* a basic project calendar incorporating the different types of durations, e.g. effort hours and elapsed time.
- *construct* a basic Responsibility Assignment Matrix to allocate the resources of a project.
- *explain* the three most common organisation structures in project management.
- *discuss* the attributes of various cost estimation tools and techniques used in project.
- *apply* the Earned Value Analysis (EVA) concept and calculation in analysing the progress of a project.
- *explain* the common definitions of quality in project management.
- *discuss* the three main processes in project quality management.
- *apply* various quality tools; cause-and-effect diagram, control chart, Pareto Analysis, in project management.

Terminology

Project cost management:	The management processes required to ensure that a project is completed within an approved budget.
Life cycle costing:	Considers the total cost of the project including both development (capital) costs, support (maintenance) costs and disposal costs (when the project is no longer useful).
Cash flow analysis:	A technique used to determine monthly or annual costs and benefits for a project.
Internal rate of return:	Discounted (interest) rate that would make the net present value of a project equal zero.
Direct costs:	Directly related to the project (e.g., salaries of project staff, consultants, material).
Indirect costs:	Intangible and indirectly related to the project and cannot be traced back in a cost-effective way (e.g., overhead costs such as office supplies, general utilities).
Sunk costs:	Money that have already been spent and are likely to be not recoverable.
Resource responsibility matrix:	Table or matrix assigning available individuals/contractors/resources to the appropriate tasks.
Project calendars:	Tasks and resources are scheduled and applied on workdays (excludes holidays and rest days).
Matrix organisation structure:	The members of this organisation structure reports to the functional department manager as well as the project manager.
Analogous estimates or top-down estimates:	Use the actual costs of a similar project as the basis for estimating current project costs.
Bottom-up estimating:	Costs are estimated for individual work items and then summed to get a total costs for the project. Applicable for small projects only.
Earned value analysis:	A project performance measurement technique that takes into consideration project scope, time, and cost and compares actual performance to a project baseline.
Cost variance:	The difference between the budgeted and actual cost of work performed.

Schedule variance:	The difference between the work performed and the work scheduled.
Cost performance index:	The ratio of the work performed to actual costs incurred.
Schedule performance index:	The ratio of work completed to work scheduled or planned.
Project quality management:	Conformance to project owners' and key stakeholders' expectations.
Quality planning:	Identifying and mandating quality standards relevant to the project and cascading down to the plans and processes.
Quality assurance:	Periodically evaluating overall project performance to ensure the project will satisfy the relevant quality standards.
Quality control:	Measuring specific project outputs to ensure that they comply with the stipulated quality standards and identifying ways to improve overall quality.

Required Reading

Reading

Cost Estimation, COCOMO II:

http://sunset.usc.edu/csse/research/COCOMOII/cocomo_main.html

Quality Management Works by Tony Yep (if available)

The Deming System of Profound Knowledge:

http://deming.org/index.cfm?content=66

Product Quality – A Prescription for the West:

http://www.juran.com/elifeline/elifefiles/2009/11/Product-Quality-A-Prescription-for-the-West_JMJuran-94.pdf

Quality is Free – The Art of Making Quality Certain (if available)

American Society for Quality:

http://asq.org/index.aspx

Project cost management

The importance of project cost management

There are many reasons for project cost over runs:

- Poor scope definition
- Cost estimates that were too low to begin with
- Poorly defined requirements

- Many projects involve the use of new technology or business processes where there is no previous cost track record
- Poor overall planning.

Because projects cost money and take away resources that could be used elsewhere in the organisation, it is important for project managers to understand project cost management.

Project Cost Management – *the processes required to ensure that a project is completed within an approved budget.*

The four core processes involved in cost management are:

1. **Resource planning** – developing a list of project resource requirements. What resources are required (people, materials, equipment) and in what quantities?
2. **Cost estimating** – developing an estimate of the cost of resources needed to complete the project.
3. **Cost budgeting** – allocating the overall cost estimate to individual work items to create a performance measurement baseline.
4. **Cost control** – controlling changes to the project budget.

Principles of cost management

Life cycle costing considers the total cost of the project including both development (capital) costs and support (maintenance) costs. Net present value calculations are often used to compare total costs and benefits over the expected life of the development.

Cash flow analysis is used to determine monthly or annual costs and benefits for a project. This is especially important when a company is undertaking a number of projects simultaneously to ensure that they don’t create a “cash crunch” or severe cash shortage in any one given period.

Internal rate of return (IRR) or time-adjusted rate of return - This is the discount (interest) rate that would make the net present value of a project equal zero.

Tangible cost and benefits are those costs or benefits that can be monetised or easily measured in dollars.

Intangible costs and benefits are difficult to measure in monetary terms.

Direct costs are those costs directly related to the project (e.g., salaries of project staff, consultants) that can be traced back in a cost-effective way.

Indirect costs are related and allocated to the project but cannot be traced back in a cost-effective way (e.g., overhead costs such as hydro, office supplies, etc.).

Sunk costs are funds that have been spent in the past. Sunk costs should not be considered in future project investment decisions. This can lead to "escalation of commitment". The logic goes something like this – "We've already invested too much in this to let it die. If we just spend $XXX more, we will see some benefit."

Learning curve theory states that when a task is done repetitively, the time and effort (and therefore the cost) it takes to do the task decreases in a regular pattern the more often it is done. For example, the first time you create a work breakdown structure in MS Project it will take you a fair amount of time. However, after you have done 50 of them and as you get more familiar with the software, the amount of time and effort it takes you to do one will likely decline. If your project involves the production of a large quantity of items, learning curve theory should be used to estimate the costs because when many items are produced repetitively, the unit cost of those items normally decreases as more units are produced.

Reserves are a monetary amount included as part of a cost estimate to manager risk by allowing for future situations that are difficult to predict

- **Contingency reserves** (known/unknowns). These funds are included in a cost estimate to allow for future situations that may be partially planned for and are included in the project cost baseline (e.g., risks that have been identified in a work package)
- **Management reserves** (unknown/unknowns). These funds are included in a cost estimate to allow for future situations that are unpredictable (e.g., a supplier goes out of business, acts of god, etc.)

Resource planning

If you know who's doing what in your project, you're halfway to a decent estimate. To start the process of resource allocation, there are some fundamental questions that a project manager needs to ask:

1. What skill set do you require to complete the major project activities?
2. Who is available to complete the activities?
3. Do the available resources have the required skill sets to complete the activities?
4. What level of authority do you need to free up internal resources? Procure external resources?
5. How will the resources obtained affect the schedules and costs?
6. How will you use these resources?

The answers to these questions will go a long way toward driving how your project performs in terms of scheduling and cost control. To further clarify resource requirements use the WBS to plan out your resource requirements. Then ask the question:

7. What level of excellence is essential given the project constraints and the tasks identified?

Personnel affect schedules and costs based on their hourly rate and their ability to handle the tasks at hand (skill sets). These issues often drive the differences as to whether or not an organisation can meet schedule or quality demands of a project. The best and the brightest in any field often cost more than those who are less professionally adept, which in turn, drives costs.

Another factor for the project manager to consider is that the best resources are always in demand and become over-allocated very quickly, as they are often assigned too many projects. The project manager needs to ensure that there is a clear understanding up front on the availability and commitment of these resources for their project.

Start the process of resource allocation by developing a Resource Responsibility Matrix (RRM). The RRM is developed after completion of the WBS. The project manager can use the WBS to create a matrix to assign resources according to the key deliverables of the project. Below is an example of a simple resource matrix using WBS activities/tasks to assign resources.

Resource responsibility matrix

Project: xyz

Resource WBS	Fred	Rose	Bob	Barb	Fran	Len	Sue
1.0 Design	P	S	A	P	I	P	I
2.0 Development	A	S	P	P	I		I
3.0 Test	R	S	A			P	I
4.0 Pilot	A	S	P		P	I	P
5.0 Implementation	A	S	P	P	I	P	I
6.0 Training		S	A	P	P		P
7.0 Documentation		S	P	A	I	I	I

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Legends are an important part of the responsibility matrix: simply putting Xs into the boxes will not designate roles clearly. The PMBOK ™ uses:

P = Participant

A = Accountable

R = Review

I = Input

S = Signature required

The development of a responsibility matrix is an elementary project management process. First identify the available individuals and place them on the matrix against the appropriate tasks. The second and most important task is to ensure that everyone knows what task he/she is assigned to. This is to ensure that who does what becomes an integral part of the project baseline.

Project calendars

Once the project resources have been identified and committed the focus is now on establishing a project calendar. In today's flexible work environment, project team members work many different hours, shifts and days. Project calendars must be established up front. Consistent work calendars are necessary to ensure that tasks and resources are not scheduled and applied on non-workdays. Project calendars also establish a common frame of reference with the project sponsor, customer and the team. This makes it essential that the project manager develops a project calendar related to each resource on the project in order to ensure that there is an accurate assessment of the project timelines. Here are some key concepts to consider:

1. What are the working hours?
2. How about the teams?
3. How many hours do they work? Depending on the organisation, some employees work seven, eight or ten-hour days and modified work weeks.

A base calendar has a standard number of workdays per week, recurring holidays, and special, company-wide one-time holidays; these should be adjusted to reflect the work schedules of the individual team members.

Multiple calendars should be established for each team member. Some team members may be willing to work Christmas or other statutory holidays. The project manager can establish a calendar for each major variance or standard. This critical information has a significant impact on the project manager's ability to meet the client deadline.

Definitions (durations)

Effort hours: Total resource hours required to complete a task (24 hours = three resource days) e.g. effort is three resource days if three people work on a task that can be completed in eight hours

Elapsed time: Calendar durations including weekends, holidays, and breaks (24 hours = one day)

Working time: Activity duration based on number of hours in a workday or work week (24 hours = three days)

Productivity: Rate at which work is produced, e.g. if a resource is twice as efficient it can get the work done in half the time.

Availability: Resource is present and ready to work, e.g. resource only available half time.

Contiguous duration: Work time that cannot be interrupted

Interruptible duration: Work time that can be interrupted

A project manager must clearly understand and communicate with the team, sponsor and stakeholders, the type of durations being used in the project. A difference in interpretation of working time vs. elapsed time can make several months of difference in project completion.

Task durations

The project manager can use different approaches to modify the project duration that may allow the project manager to buy some time he/she did not know existed.

The project manager must examine the established time frame for the project and then establish the time frames for individual activities/tasks. The project manager will need specific and accurate information to ensure that the activity/task is completed within the time allotted and to the agreed upon specifications. This can be accomplished by developing project completion criteria. It is important to establish clear and agreed to completion criteria for the project. Completion criteria are developed from clear objectives that are specific, measurable, agreed upon, realistic and time constrained. Each project activity must produce a defined deliverable.

As discussed earlier, it is essential that the project manager obtain commitment to the resources required to complete the project activities within the timeframe. If the resources available do not have the full skill set required for the project, then project durations will be impacted. Availability of the correct resources is critical to determining the overall duration of an activity and the entire project completion.

If the ideal resources are not readily available, it is often necessary to take on lesser-qualified individuals. The project manager is then faced with a challenge. This is where reviewing approaches to task duration will assist the project manager. Usually, we only ask the standard question of how long an activity will take without clearly understanding all of these issues which are critical in controlling the project. Looking at the options for task distribution will provide us with some ability to affect change by modifying an activity. For example:

- Must the activity bear a contiguous duration? Must it keep going?
- Is the activity/task Interruptible? Can it be broken up or interrupted?

Without considering this information the activity/task duration becomes static and lacking potential for well-considered change.

Key questions to ask when establishing duration:

1. What are the completion criteria? (Twenty computers, installed, networked)
2. Are the data sources of the durations relevant, current, and realistic?
3. Are the required resources available? (Len Jones for three days.)
4. Is this a contiguous duration? (Yes, all machines are required to be installed before networking can be completed)
5. What can we do with this data? (Have another resource pulling cables while Len does the installation of each computer)

Acquiring resources

How can the project manager gain commitment from functional managers for critical project resources? Good planning and communication will provide you with the best tools to get what you need, when you need it!

Organisations vary in structure. The three most common structures in place are:

1. Functional
2. Project
3. Matrix.

Functional

In a functional organisation people are organised into function groups or specialties such as human resources, marketing, operations, sales, information technology and finance. The projects are staffed with resources from these functional groups. In essence this means that the functional manager is responsible for each and every project.

Project

A project organisation has staff aligned around major projects. All the people required for the project are assigned full time to the project manager. The project manager is the functional head.

Matrix

A matrix organisation is a hybrid of the functional and project organisation. The resources are assigned to a functional group but will be temporarily assigned full or part-time to a project. The team members' workload is assigned organisationally by the functional manager and for the project by the project manager. This can create conflicts in priorities and is the most common form of organisation today. The matrix is most efficient in using people's time and skills and if the project does not require full time commitment from the people in the functional groups. However, this type of structure only works if the functional manager and project manager recognise the challenges and work together.

Most of us work in some type of matrix structure when managing projects. In order to gain commitment for resources for our projects we need to establish good internal relationships with the functional managers and negotiate for our key resources. This process is often difficult due to conflicting operational priorities and demand for the most skilled resources. The functional manager has personal and organisational objectives to meet and sees the project manager as depleting the available resources to accomplish these objectives. This is where planning and effective communications will assist the project manager. What normally happens during the discussion of resources is the project manager requests a key resource full time for a period of time. This takes the person away from the operational tasks and impacts the functional organisation. By developing a detailed Task Assignment Matrix, the project manager can reflect a much better estimate of the time required for a specific resource, which in turn may facilitate better negotiations with the functional manager for the resource time, you are then asking for resources only when you need them. Below is an example of a Task Assignment Matrix (TAM) – developed from the Resource Responsibility Matrix.

Task Assignment Matrix (TAM)

Task Days Resource	Fred	Rose	Bob	Kate	Steve
Conceptual Design	10	5	8	3	8
Prototype specification	12	15	1	2	6
Prototype design	10	5	8	3	10
Prototype development	30		21		15
Coding	35		24		14
Develop Test Plan	15	10		5	5

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This is only one example of how you might visually view the task assignments. Project management tools such as MS Project ™ have facilities to provide resource allocation reporting as well. By using a tool such as the TAM, the project manager can plan out the activities in the project schedule against the defined task duration and resource. A great negotiating and communications tool!

A proactive communications strategy should follow this planning effort. Monthly meetings should be scheduled with the functional managers that you are sharing resources with. Use the TAM as a tool to communicate requirements. Remember, you need the resources to accomplish the project tasks but you do not normally own them. The onus is on you, the project manager to communicate requirements and gain commitment to the resources you need when you need them!

Cost estimating

One of the key outputs of project cost management is a cost estimate. There are several types of cost estimates including:

1. **Order of magnitude**: This estimate is made very early in project planning with an accuracy of –25 per cent to +75 per cent (often mistaken for SWAG – Silly Wild Ass Guess).
2. **Budgetary estimate** is a cost estimate used to allocate money into an organisation's money. (As in, "Jane we need a number to put into next year's budget for your project. How much should we allow for it?") Accuracy is typically – 10 per cent to +25 per cent
3. **Definitive estimate** is the most accurate of the three types. Based on itemized costing of all anticipated project resources, it is usually made within one year of project completion. Accuracy is typically –5 per cent to + 10 per cent.

All cost estimates should include supporting documentation that describes the assumptions used in arriving at the estimate.

A **cost management plan** is a document that describes how project cost variances (i.e., costs that are higher or lower than the original estimates) will be managed.

Cost Estimation Tools and Techniques

- *Analogous Estimates or Top-Down Estimates*
  - Use the actual costs of a previous or similar project as the basis for estimating current project costs.
  - Accuracy depends on how close the two projects actually are in terms of scope.
- *Bottom-Up Estimating*
  - Costs are estimated for individual work items and then summed to get a project total.
  - Accuracy is determined by the size of the work items and the experience of the estimators.
  - Usually too time-consuming to be practical on large projects.
- *Parametric Modelling*
  - Uses project parameters (or characteristics) in a mathematical model to predict project costs (e.g., $50 per line of programming code or $10,000 per workstation, cost per square foot in construction)
  - Can be quite simple or very complex.
  - Accuracy depends on accuracy of historical information used to create the model, whether those parameters are quantifiable, and the scalability of the model.

- *COCOMO (Constructive Cost Model)*
  - COCOMO is a parametric model for estimating software development costs developed by Barry Boehm. COCOMO II is the latest computerised model that allows you to estimate cost, effort and schedule when planning new software development. For more information, check out the following website: http://sunset.usc.edu/csse/research/COCOMOII/cocomo_main.html.

Typical problems with cost estimates

Problem	Possible solution
Cost estimation for large projects is complex and requires significant effort. Cost estimates are often asked for before there is a clear understanding of the requirements.	Recognise the need to re-do estimates at various stages of project completion. Anticipate that later more accurate estimates will likely be larger than earlier estimates. Use progressive resource commitment and 'stage gates' as decision points to weigh costs against anticipated benefits. Don't get caught in 'escalation of commitment'. Be prepared to kill a project if the benefits no longer outweigh the costs.
Lack of experience on the part of estimators and lack of data on which to base estimates.	Establish a repository of project information to assist in future project cost estimation. Provide training and mentoring to estimators.
Human nature is to underestimate costs. Also easy to forget items on a large project.	Get peers and senior managers to review cost estimates and ask questions to improve accuracy.
Cost Goal Seeking – senior managers or others may have 'a figure in mind' for a project.	Project managers must develop confidence in their estimates and be prepared to defend them.

Cost budgeting

Project cost budgeting is the process of allocating the overall project cost estimate to individual work items to establish a baseline for measuring project performance. Required inputs are the WBS to identify individual work items and the project schedule to allocate costs over time.

Cost control

Project cost control is basically controlling changes to the project budget. It includes monitoring cost performance; ensuring only appropriate project changes are included in a revised cost baseline, and informing project stakeholders of authorised changes to the project that will impact project costs.

Earned value analysis (EVA)

Note it!

If you're planning on writing the PMP certification exam, I can guarantee there will be several questions on this, and you will need to memorise the formulas!

EVA is a project performance measurement technique that takes into consideration project scope, time, and cost and compares actual performance to a project baseline. The **baseline** is the original project plan plus any approved changes. Earned value analysis requires the calculation of three values for each activity of summary activity from the work breakdown structure:

1. **Budgeted Cost of Work Scheduled (PV- Planned Value)** – the amount budgeted for that activity
2. **Actual Cost of Work Performed (AP – Actual Cost)** – the actual cost (direct and indirect) for that activity over a given time period
3. **Budgeted Cost of Work Performed (EV) or Earned Value** – the percentage of the work actually completed multiplied by the planned cost.

   EV = PV x percent complete (% complete obtained from person working on the actual work package).

There are several conventions used to calculate the percentage complete.

1. **The 50-50 estimate rule**: Fifty per cent completion is assumed when the task has begun, and remaining 50 per cent when the work is complete.
2. **The 0-100 per cent rule**: There is no credit for work until the task is 100 per cent complete. With the project following a flat curve (S-curve) it seems to be running late until the very end of the project, then it appears to suddenly catch up.
3. **Critical input use**: Sometimes the rule is based on critical input that has been used in a project in terms of skilled labour or machine.
4. **The proportionality rule**: It calculates the percentage complete. The rule divides "planned time-to-date by total scheduled time" or "actual cost-to-date by total budgeted cost" to calculate percentage complete.

Other earned value calculations – variance and performance indices

Cost Variance (CV) – the difference between the budgeted and actual cost of work performed.

CV = EV - AP

Schedule Variance (SV) – the difference between the work performed and the work scheduled.

SV = EV - PV

Cost performance index (CPI) – the ratio of the work performed to actual costs. If the CPI is < 1, the project is over budget; if the CPI is > 1 the project is under budget.

CPI = EV/AP

Schedule performance index (SPI) – the ratio or work performed to work scheduled. If the SPI < 1, the project is behind schedule; if the SPI is >1, the project is ahead of schedule.

SPI= EV/PV

Note: Negative variance numbers or index values less than 1 indicate that a project is in trouble.

The earned value for the entire project is determined by summing the EV values for the individual project activities.

Time and cost projection calculations

Budget at completion (BAC) – the original time and cost estimate

Estimate at completion (EAC) – an estimate of what it will cost to complete the project based on performance to date. Calculated by dividing the original project budget by the cost performance index

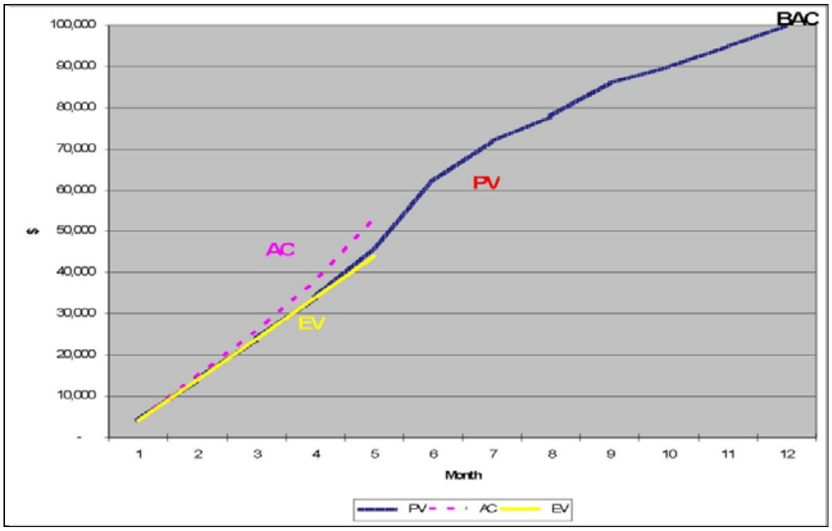
EAC = BAC (cost)/CPI

Estimated time to complete (ETC) – estimated time it will take to complete the entire project based on schedule performance to date. Calculated by dividing the original total time or duration estimate for the project by the schedule performance index

ETC = BAC (time)/SPI

Often, the easiest way to evaluate project status and performance over time is by displaying some of these key performance indicators in a graphical form. (See example)

Sample Earned Value Calculations



Sample Earned Value Calculations

Example 1

Given:

Original Total Project Budget (BAC = $250,000 for a two year or 24-month project)

Budgeted Cost of Work Scheduled to date (PV = $50,000)

Actual Cost of Work Performed to date (AP = $45,000)

Percentage of work actually completed that was scheduled to be done by now: 80%

Calculations:

Earned Value

= Budgeted Cost of Work Performed (EV = PV x % complete)

= $50,000 x 80% = **$40,000**

Cost Variance = CV

= EV – AP = $40,000 **-** $45,000 = **-$5,000**

Schedule Variance = SV

= EV – PV = $40,000 **-** $50,000 = **- $10,000**

Cost Performance Index = CPI

= EV/AP = $40,000/$45,000 = 0.89 or **89%**

Schedule Performance Index = SPI

= EV/PV = $40,000/$50,000 = 0.80 or **80%**

Estimated Cost at Completion = EAC

= BAC/CPI = $250,000/0.89 = **$280,899**

(In other words, at the rate we're going we will end up $30,899 over budget.)

Estimated Time to Complete (ETC)

= BAC/SPI = 24 months/.80 = **30 months**

(In other words, at the rate we're going we will end up six months behind schedule.)

Based on the performance to date, this project is in fairly serious trouble.

Example 2

A mini project was estimated to be $25,000 and to be completed on 15 December 2009. The calculated actual cost at the end of September 2009 is $18,500. The remaining 20 per cent work is to be completed as soon as possible to maintain the completion due date.

What are the cost and schedule variances at this stage?

If the original project duration was 18 months and total budget was $35,000, can you calculate the estimated cost of completion and estimated time to complete?

Calculation:

Earned Value

= Budgeted Cost of Work Performed (EV = PV x % complete)

= $25,000 x 80% = **$20,000**

Cost Variance = CV

= EV – AP = $20,000 **-** $18,500 = **$1500 (within control)**

Schedule Variance = SV

= EV – PV = $20,000 **-** $25,000 = **- $5,000 (-ve means beyond control)**

Cost Performance Index = CPI

= EV/AP = $20,000/$18,500 = 1.08 or **108%**

Schedule Performance Index = SPI

= EV/PV = $20,000/$25,000 = 0.80 or **80%**

Estimated Cost at Completion = EAC

= BAC/CPI = $35,000/1.08 = **$32,407**

Estimated Time to Complete (ETC)

= BAC/SPI = 18 months/.80 = 22.5 months (that means 4.5 months delayed)

The project is doing fairly well in cost and in serious trouble in time perspective based on the performance to date.

Project quality management

Quality management is a key core function in project management. Quality is a somewhat nebulous term that is somewhat difficult to define.

Quality – *the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs*. (ISO definition)

Others have defined quality in terms of conformance to requirements or fitness for use. The main purpose of project quality management is to ensure that it satisfies stakeholder expectations. This is why it is important to identify the key stakeholders early in the project and clearly define their expectations. As one experienced project manager puts it, the key questions to ask are:

1. How do we know when we've won?
2. How do we know when we're done?
3. Who gets to decide 1.and 2.?

Project quality management involves three main processes:

1. **Quality planning** – identifying which quality standards are relevant to the project and how to satisfy them,
2. **Quality assurance** – periodically evaluating overall project performance to ensure the project will satisfy the relevant quality standards, and
3. **Quality control** – monitoring specific project results to ensure that they comply with the relevant quality standards and identifying ways to improve overall quality.

Modern quality management gurus

Several noteworthy people have contributed to the current understanding of quality management and the emphasis on customer satisfaction, prevention versus inspection, and management responsibility for quality. They include:

- W. Edwards Deming
- Joseph M. Juran
- Philip B. Crosby
- Koaru Ishikawa
- Genichi Taguchi
- Arnold V. Feigenbaum

The following is a brief overview of the contributions of some of these key contributors. More detailed articles on some of these quality practitioners can be found by exploring the Web links that appear throughout this module.

Deming

Dr. W. Edwards Deming gained his reputation for his work on quality control in Japan after World War II. He taught that higher quality resulted in greater productivity and lower cost. This is captured in the phrase "it's cheaper to do it right than to do it over". Deming is known for his 'Cycle for Improvement – plan, do, check and act' and his 14 Points for Management. Also visit the following websites: http://www.deming.org and http://www.qualitygurus.com/gurus/list-of-gurus/w-edwards-deming/.

Juran

Joseph M. Juran also helped Japanese manufacturers improve their productivity before his theories were discovered by United States firms. His *Quality Control Handbook*, first published in 1974, remains a perennial favourite. It is now in its sixth edition. Juran stressed the difference between the product and manufacturing focus on meeting specifications versus the customers' focus on 'fitness-for-use'.

He developed what is known as the Juran Quality Trilogy and the 10-step programme for quality improvement:

1. Quality improvement
2. Quality planning
3. Quality control.

Also see the following websites for more details: http://www.juran.com/ and http://www.qualitygurus.com/gurus/list-of-gurus/joseph-juran/.

Crosby

Philip Crosby is best known for suggesting that organisations strive for zero defects and that the costs of not doing the job right in the first place are so high that companies can afford to spend unlimited amounts on improving quality. His book *Quality is Free* was first published in 1979. In it, he developed 14 steps for quality improvement. In 1995, he published *Quality is Still Free: Making Quality Certain in Uncertain Times.*

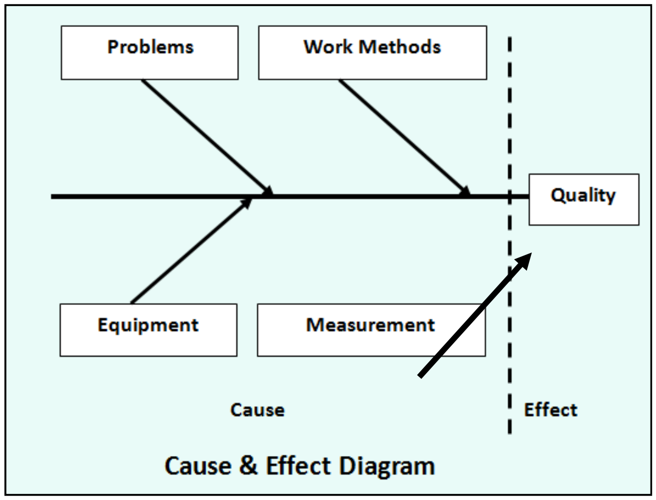
This work provides an analysis of the author's entrepreneurial experiment in which he took quality ideas learned in corporate settings and adapted them to the business world at large. It re-examines concepts such as "The 5 Erroneous Assumptions about Quality" and "Zero-Defects Mantra". Please visit the following websites: http://www.philipcrosby.com/pca/index.html and http://www.qualitygurus.com/gurus/list-of-gurus/philip-crosby/.

Ishikawa

Kaoru Ishikawa developed the concept of quality circles and the use of fishbone diagrams. Quality circles are groups of non-supervisors and work leaders in a single organisation department who volunteer to conduct group studies on how to improve the effectiveness of work in their department. Fishbone diagrams trace complaints about quality problems back to the responsible production operations. His ideas were published in a 1972 book entitled *Guide to Quality Control.*

Kaoru Ishikawa paid particular attention to making technical statistical techniques used in quality attainment accessible to those in industry. At the simplest technical level, his work emphasised good data collection and presentation, the use of Pareto Diagrams to prioritise quality improvements, and cause-and-effect (or Ishikawa or Fishbone) diagrams.

Ishikawa saw the cause-and-effect diagram, like other tools, as a device to assist groups or quality circles in quality improvement. As such, he emphasised open group communication as critical to the construction of the diagrams. Ishikawa diagrams are useful as systematic tools for finding, sorting out and documenting the causes of variation of quality in production and organising mutual relationships between them. Other techniques Ishikawa has emphasised include control charts, scatter diagrams, Binomial probability paper and sampling inspection. For more information, please see the following websites: http://www.skymark.com/resources/leaders/ishikawa.asp and http://www.qualitygurus.com/gurus/list-of-gurus/kaoru-ishikawa/.



Taguchi

Dr. Genichi Taguchi was the Executive Director of American Supplier Institute. Dr. Taguchi is best known for developing the "Taguchi Methods" and "Robust Design" methods which focus on eliminating defects by using a scientific approach rather than trial and error to control product quality. Key concepts of the Taguchi method are that quality should be designed into a product rather than inspected into it and that quality is best achieved by minimising deviation from the target value. For more information on Dr. Taguchi and his approaches to quality management, visit the following website: http://www.qualitygurus.com/gurus/list-of-gurus/genichi-taguchi/

Feigenbaum

Arnold V. Feigenbaum developed the concept of total quality control (TQC) and proposed that responsibility for quality should lie with the people who do the work. Workers should be empowered to stop production when a quality problem occurs. These concepts were first published in 1983 in a book entitled *Total Quality Control: Engineering and Management*. The third edition of this book was published in 1991. Feigenbaum says the two critical success factors to implementing total quality control are:

1. Building quality controls into every phase of operations - product and service development, production, engineering, marketing, distribution, sales, customer service.
2. Driving communication and the implementation of quality control strategies down and across organisational lines, mobilising commitment at every level.

For more information on Feigenbaum's 40 steps to quality improvement see the following website: http://www.qualitygurus.com/gurus/list-of-gurus/armand-v-feigenbaum/.

Quality Standards and Awards

ISO 9000 - a quality system standard developed by the International Organisation for Standardisation (ISO) that includes a three-part continuous cycle of planning, controlling and documenting quality in an organisation. See the following website for further information: http://www.iso.ch/

Malcolm Baldrige Award – an award started in 1987 to recognise companies that have achieved a level of world-class competition through quality management. See the following website for further details: http://www.quality.nist.gov

Canadian Quality Awards - The Canada Awards for Excellence (CAE) programme is administered by the National Quality Institute. The criteria for the Quality Award are rigorous. Organisations considered for an award must show outstanding continuous achievement in seven key areas: Leadership, Planning for Improvement, Customer Focus, People Focus, Process Optimisation, Supplier Focus and Organisational Performance. See the following website for further details: http://www.nqi.ca

European Quality Awards - The European Quality Prizes are presented to organisations that demonstrate excellence in the management of quality as their fundamental process for continuous improvement. Each year several prizes are presented for each of the following categories: Companies, Operational Units of companies, Public Sector organisations, and Small and Medium-sized enterprises. See the following website for further details: http://www.efqm.org/award.htm

Quality planning

Quality planning consists of identifying which quality standards are relevant to the project and determining how to satisfy them. **Design of experiments** is a quality technique that helps identify which variables have the most influence on the overall outcome of a process.

Quality planning inputs include:

- Organisational policies
- Project scope statement and product descriptions
- Related standards and regulations.

Key quality planning outputs are:

- Quality management plan
- Project quality checklists.

Key quality aspects that should be clearly defined in the scope and business requirements of information technology projects are:

- **Functionality** – the degree to which a system performs its intended function.

- **Features** – special characteristics that appeal to users. Functions and features may be mandatory (must-have) or optional (nice-to-have).
- **System outputs** – usually screens and reports.
- **Performance** – how well a product or service performs the customers' intended use. In IT systems this is often related to speed, response time and ability to handle a large volume of transactions or users.
- **Reliability** – the ability of a product or service to perform as expected under normal conditions without unacceptable failures.
- **Maintainability** – the ease with which maintenance can be performed on a product.

It is up to the stakeholders to define their most critical quality needs and communicate them to the project team. However, the project manager is ultimately responsible for quality management.

Quality assurance

Quality assurance involves periodically evaluating overall project performance to ensure the project will satisfy the relevant quality standards. Another goal of quality assurance is continuous quality improvement.

Tools used in quality assurance:

1. **Design of experiments**
2. **Benchmarking** – a technique used to generate ideas for quality improvement by comparing specific project practices or product characteristics to those of other projects or products within or outside of the performing organisation (How are we doing compared to those other guys?).
3. **Quality audits** – structured reviews of specific quality management activities that help identify lessons learned and can improve performance on current or future projects.

Quality control

Quality control involves monitoring specific project results to ensure that they comply with the relevant quality standards and identifying ways to improve overall quality.

The three main outputs of quality control are:

1. **Acceptance decisions** – decisions that determine if the products or services produced as part of the project will be accepted or rejected
2. **Rework** – actions taken to bring rejected items into compliance with product requirements or specifications or other stakeholder expectations

3. **Process adjustments** – adjustments made to correct or prevent further quality problems based on quality control measurements

Tools and techniques for quality control

Pareto analysis

Pareto analysis involves identifying the few vital contributors that account for the majority of quality problems in a system. This is often referred to as the 80-20 rule because often 20 per cent of a system causes 80 per cent of the problems.

Pareto diagrams are histograms (bar graphs) that help to identify and prioritise problem areas. Problems are grouped into categories; totals are calculated for each category and then graphed as bar graphs to illustrate the relative magnitude of each problem area.

Statistical sampling and standard deviation

Statistical sampling consists of choosing part of a population of interest for inspection. The key steps in statistical sampling are:

1. determining the relevant population
2. determining the appropriate sample size to provide the desired level of confidence
3. ensuring the sample is taken randomly (i.e., it is not biased)

Standard deviation is a statistical measure of variability. A small standard deviation indicates relatively little variability. In a normally distributed population, 68.27 per cent of the population falls within one standard deviation of the mean, 95.45 per cent falls within two standard deviations and 99.73 per cent falls within three standard deviations of the mean or population average. Standard deviation is represented by the Greek symbol sigma (σ). Thus three sigma or three standard deviations would represent a 0.3 per cent defect rate or 2.7 million defects in a billion. Many companies strive for **six sigma or two defects per billion** as their quality standard.

A **control chart** is a graphic display of data that illustrates the results of a process over time. Control charts are primarily used as a monitoring and preventative rather than a diagnostic tool. They are typically used to monitor manufacturing processes but can also be used to monitor project change requests, documentation errors, costs, and schedule variances.

Processes are deemed to be "in control" when deviations from the mean are caused by random events. When non-random events occur, the graph will trend above or below the mean and the process is said to be "out of control". The **seven run rule** says that any time seven data points in a row are all above or below the mean, or are all increasing or decreasing it is likely a non-random event is occurring and the process will run out of control if corrective action is not taken. Sample control chart – mean is depicted by the X on the chart and UCL = Upper control limit, LCL is lower control limit.

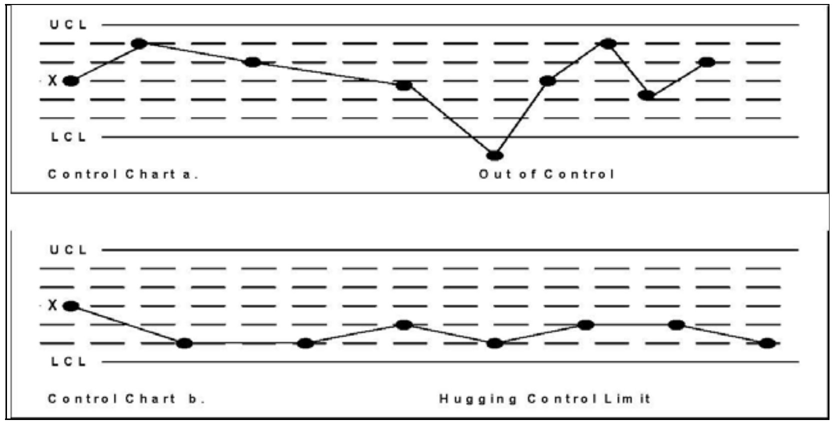


Diagram used with Permission Enterprise Project Management Ltd.

Information technology project testing

In order for testing to be effective in IT projects, it should be conducted at every major phase of the product development life cycle, not just at the end. The key types of tests to be employed in a software development project are as follows:

1. **Unit testing** – testing of each individual component or program to ensure it is defect free
2. **Integration testing** – testing of functionally grouped components to ensure that subsets of the system work together without error
3. **System testing** – testing of the entire system as one entity to ensure that all components of the entire system are working properly
4. **User acceptance testing** – independent testing performed by the end user to ensure it meets specified requirements prior to accepting the delivered system

Improving information technology project quality

There are several other factors that can contribute to the quality of projects. These include strong leadership, understanding the cost of quality, providing a supportive workplace and working towards higher maturity levels in project management.

Leadership

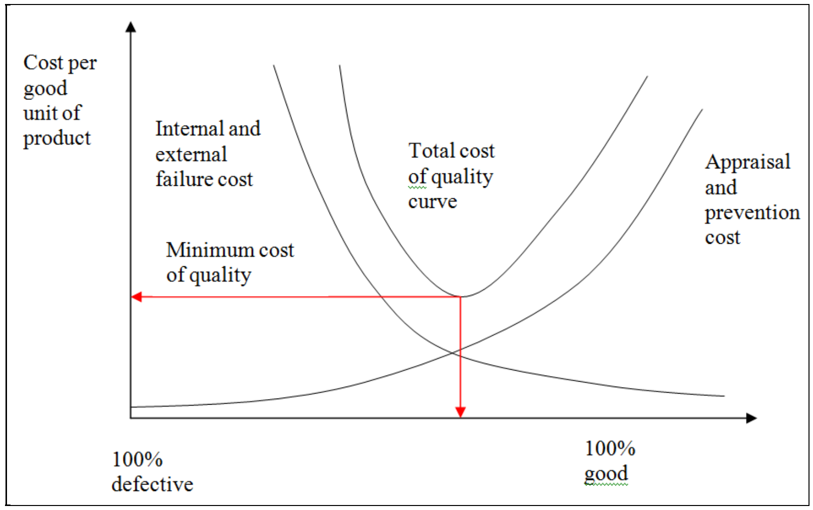
Juran and other quality experts argue that leadership is key to improving quality. Senior management must take responsibility for creating, supporting and promoting quality programmes.

Cost of quality

The cost of quality is defined as the cost of conformance plus the cost of non-conformance, where conformance means delivering products that meet requirements and fitness for use. The cost of non-conformance means taking responsibility for failures or not meeting quality expectations. In other words – what is it cost associated with it not working properly? American Airlines estimates it costs them more than $20,000 per minute if their reservation system is not functioning. The five major cost categories related to quality are as follows:

1. **Prevention cost** – the cost of planning and executing a project so that it is error-free or within an acceptable error range. This includes the cost of any action taken to investigate and prevent non-conformities. Examples include design/review; training on quality and reliability; vendor quality planning; design, development, installation and testing of equipment; and preparation of quality manual standard and procedure.
2. **Appraisal cost** – the cost of evaluating processes and their outputs to ensure that a project is error-free or within an acceptable error range. It includes the cost of testing of raw material, semi-finished products and component parts that are received from outside vendors. Examples include testing and inspection, routine maintenance and calibration, analysis and regular reporting of tests results and Vendor rejection.
3. **Internal failure cost** – a cost incurred to correct and identified defect before the customer receives the product. That means the cost resulting from a product/service failing to meet quality requirement prior to delivery. This happens quite often if something is not done right first time. Examples include faulty products or scrap used, rework/repair, re-inspection/ retesting.
4. **External failure cost** – a cost related to all errors not detected and corrected before delivery to the customer. That means the failure cost arise when the customers reject the product/service due to poor quality. Examples include complaints, rejection, warranty claim, loss of sales.
5. **Measurement and test equipment costs** – the capital cost of equipment used to perform prevention and appraisal activities. The cost incurred in procuring and implementing this equipment would prevent the quality cost discussed in the other four categories above.

We can draw a cost of quality curve to have trade off among all the failure costs discussed.



As we are moving from 100 per cent defective products/services in the left to 100 per cent good products/services in the right, the internal and external failure costs keep on decreasing while the appraisal and prevention cost keep on increasing. That means if the internal and external failure costs are kept to the minimum to get 100 per cent good products the appraisal and prevention cost might go abruptly high. We need to balance and establish a trade-off between these two groups of failure costs. That brings in a curve known as total cost of quality curve, the bottom-most tip of which explains the quality of a product or services at the minimum cost incurred.

Organisational influences

A study conducted in 1987 by DeMarco and Lister[3] showed that organisational issues had a much greater influence on productivity in software development companies than did the technical environment or programming languages. The study also showed that providing a dedicated workspace and quiet work environment were key factors in improving productivity.

Maturity models

Maturity models are frameworks for helping organisations improve their processes and systems. Three popular models include the Software Quality Function Deployment (SQFD) model, the Capability Maturity Model (CMM) and the Project Management Maturity Model. Developing and following maturity models can help organisations systematically improve their project management processes to increase the quality and success rate of projects. Maturity models will be discussed in greater detail in the final module of this course.

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[3]DeMarco, Tom and Lister, Timothy, (1987) *Peopleware: Productive Projects and Teams*, New York, Dorset House.

Module summary

Summary

This module explains the concept of project cost management, the principles and processes of cost management. There are two important aspects in cost management; resource planning and resource acquisition. The functions of project calendar in resource planning are essential. Consistent work calendars are necessary to ensure that tasks and resources are not scheduled and applied on non-workdays. Project calendars also establish a common frame of reference with the project sponsor, customer and the team. This makes it essential that the project manager develops a project calendar related to each resource on the project in order to ensure that there is an accurate assessment of the project timelines. Elements in project calendar are definition on duration and task durations. The next stage is resource acquisition. After resource planning is made, the project manager must acquire proper and adequate resources. One of the alternatives undertaken by the project manager is by allocating the individual to resource responsibility using the resource responsibility matrix. After allocating the resource responsibility, other tools such as cost estimating, cost budgeting, and control are used for managing project cost. This module also describes the project performance measurement such as EVA, Time Cost Project calculations. Finally, the module incorporates the quality management philosophy in project management by introducing quality gurus, quality planning, assurance, and control concepts, and quality control tools and techniques.

Assignment

Assignment

1. What do you understand by statistical sampling and standard deviation, and how are they applied to improve quality management in project?
2. Explain the following indicators of the performance of a project:-
   a. the Cost Performance Index; and
   b. the Schedule Performance Index.

Assessment

Assessment

1. Define the following terms: BAC, EAC and ETC.
2. Discuss the Earn Value Analysis concept. Indicate the formula for using EVA.
3. What are the quality principles highlighted by Feigenbaum and Taguchi?
4. What is quality planning? Identify the key quality planning inputs and outputs.
5. Explain in detail the purpose of using control chart .How does control chart work?
6. Describe in your understanding the meaning of acceptance decisions, rework, and process adjustments.

Assessment answers

1. Budget at Completion (BAC) – the original time and cost estimate.

   Estimate at Completion (EAC) – an estimate of what it will cost to complete the project based on performance to date. Calculated by dividing the original project budget by the cost performance index.

   EAC = BAC (cost)/CPI

   Estimated Time to Complete (ETC) – estimated time it will take to complete the entire project based on schedule performance to date. Calculated by dividing the original total time or duration estimate for the project by the schedule performance index.

   ETC = BAC (time)/SPI

2. EVA is a project performance measurement technique that takes into consideration project scope, time, and cost and compares actual performance to a project baseline. The baseline is the original project plan plus any approved changes. Earned Value Analysis requires the calculation of three values for each activity of summary activity from the work breakdown structure:

   - Budgeted Cost of Work Scheduled (PV- Planned Value) – the amount budgeted for that activity
   - Actual Cost of Work Performed (AP – Actual Cost) – the actual cost (direct and indirect) for that activity over a given time period
   - Budgeted Cost of Work Performed (EV) or Earned Value – the percentage of the work actually completed multiplied by the planned cost.

     The formula is:-

     EV = PV x per cent of work actually completed (Per cent complete obtained from person working on the actual work package).

3. ***Taguchi***

   Dr. Taguchi is best known for developing what are known as the "Taguchi Methods" and what he calls "Robust Design" methods. The key principles are:

   - Focus on eliminating defects by using a scientific approach (proactive) rather than trial and error to control product quality (reactive).
   - Quality should be designed into a product rather than inspected into it.
   - Quality is best achieved by minimising deviation from the target value.

Feigenbaum

A.V. Feigenbaum developed the concept of total quality control (TQC). The key principles are:

Responsibility for quality should lie with the people who do the work. Workers should be empowered to stop production when a quality problem occurs.

- Building quality controls into every phase of operations - product and service development, production, engineering, marketing, distribution, sales, customer service; and
- Driving communication and the implementation of quality control strategies down and across organisational lines, mobilising commitment at every level.

4. Quality planning consists of identifying which quality standards are relevant to the project and determining how to satisfy them. Design of experiments is a quality technique that helps identify which variables have the most influence on the overall outcome of a process. Quality planning inputs include:

   - Organisational policies
   - Project scope statement and product descriptions
   - Related standards and regulations

   Key quality planning outputs are:

   - Quality management plan
   - Project quality checklists

5. A control chart is a graphic display of data that illustrates the results of a process over time. Control charts are primarily used as a monitoring and preventative (what has gone wrong) rather than a diagnostic tool (why it has gone wrong). They are typically used to monitor manufacturing processes but can also be used to monitor project change requests, documentation errors, costs, and schedule variances etc.

   Sample Control Chart – mean is depicted by the horizontal line X on the chart and UCL = Upper control limit, LCL is lower control limit. Processes are deemed to be “in control” when deviations from the mean are within the UCL and LCL. Processes are also deemed to be in control if deviations out of the UCL and LCL caused by random events. For example, the regular machine operator is on medical leave and his place is taken by an untrained operator, this constitutes a random event. When non-random events occur, the graph will trend above or below the mean and the process is said to be “out of control”. The seven run rule says that any time seven data points in a row are all above or below the mean, or are all increasing or decreasing it is likely a non-random event is occurring and the process will run out of control if corrective action is not taken.

6. The meaning of acceptance decisions, rework, and process adjustments are:

- Acceptance decisions – decisions that determine if the products or services produced as part of the project will be accepted or rejected
- Rework – actions taken to bring rejected items into compliance with product requirements or specifications or other stakeholder expectations
- Process adjustments – adjustments made to correct or prevent further quality problems based on quality control measurements.