LECTURE NOTES

ON

COST MANAGEMENT OF ENGINEERING PROJECTS

M.Tech III Sem (IARE-R18)

PREPARED BY

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UNIT-I
INTRODUCTION

INTRODUCTION:

In the contemporary business environment, cost management has become a critical survival skill for many organizations. But it is not sufficient to simply reduce costs; instead, costs must be managed strategically (Cooper and Slagmulder. Many authors stressed that the strategic importance of cost management has drastically increased in the recent years due to intense competition. According to Cooper and Slagmulder customers in highly competitive markets expect that each generation of products presents improvements. These improvements may include: improved quality, improved functionality or reduced prices. Any of these improvements alone or any combination of

THE CONCEPT OF STRAGIC COST MANAGEMENT

Strategic cost management is understood in different ways in literature. Cooper and Slagmulder.

argued that strategic cost management is "the application of cost management techniques so that they simultaneously improve the strategic position of a firm and reduce costs". They suggest three sorts of cost management initiative, based on whether the impact on the organization's competitive position is positive, negative or neutral. An example of a cost management initiative that strengthens an organization's position is illustrated as follows. A hospital redesigns its patient admission procedure so it becomes more efficient and easier for patients. The hospital will become known for its easy admission procedure so more people will come to that hospital if the patient has a choice. The strategic position of the hospital has just been increased over its competitors.

The second example of a cost management.

Initiative that will weaken the organization's competitive position is illustrated as follows. A large airline company only has two desks for administering and selling tickets. This set-up induces long lines for the airline customer which can ultimately result in high dissatisfaction and a bad reputation for the airline. This may reduce the amount of ticket sales when compared with the airline's competitors. Even though having only two desks available for customers may initially be cost effective, in the long run, it harms the company. As a general rule, an organization should never undertake any practices that are predicted to weaken the position of the organization. Furthermore, Cooper (1995a:89) argued that strategic cost management needs to include all aspects of production and delivering the product; the supply of purchased parts, the design of products and the manufacturing of these products. So, strategic cost management should be inherent to each stage of

a product's life cycle, i.e. during the development, manufacturing, distribution and during the service

lifetime of a product. According to Welfie and Keltyka (2000:33) strategic cost management is an area that holds exciting possibilities for accountants. They also emphasized that strategic cost management attempts to improve the strategic position of an organization and reduces costs at the same time and it is important because global competition means that firms must be constantly aware of their strategic position.

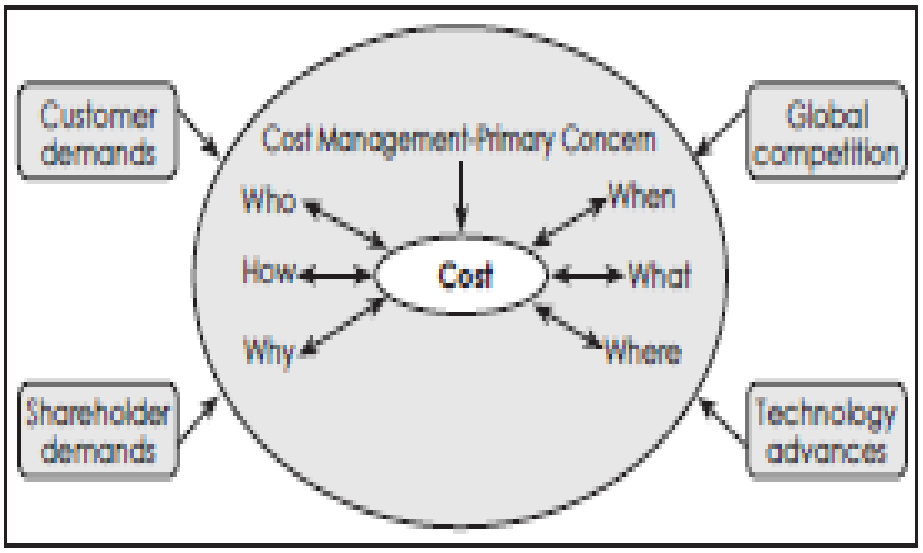
BUSINESS STRATEGY & STRATEGIC COST MANAGEMENT

Strategic Cost Management and Control flexibility with any cost reduction efforts contributing to an improved strategic position. A sophisticated understanding of an organization's cost structure can go a long way in the search for Sustainable competitive advantage, this point is emphasized by Shank and Govindarajan who define strategic cost management as "the managerial use of cost information explicitly directed at one or more of the four stages of strategic management:
(1) Formulating strategies,
(2) Communicating those strategies throughout the organization,
(3) Developing and carrying out tactics to implement the strategies,
(4) Developing and implementing controls to monitor the success of objectives".

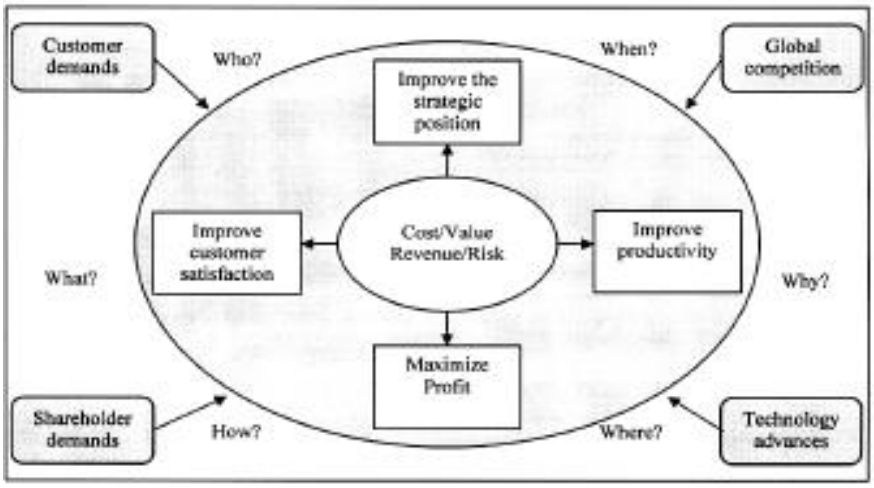
According to Horvath and Brokemper, strategic cost management has emerged as a key element to attain and sustain a strategic competitive advantage through long-term anticipation and formation of costs level, costs structure, and costs behavior pattern for products, processes, and recourses. For this purpose, strategic cost management must provide managers with different information. Strategic cost management sees products, processes, and resources themselves as creative objects for attaining a strategic competitive advantage. This goal may not be achieved based on traditional cost management. They also argue that strategic cost management must determine and analyze longterm cost determinants (economics of scale, experience, etc.) and their influence on costs level, costs structure, and costs behavior pattern. Finally, strategic cost management should begin with participation during R&D and design stages of the product in order to avoid the costs early in the product life cycle. Hence, the term strategic cost management has a broad focus, it is not confined to the continuous reduction of costs and controlling of costs and it is far more concerned with management's use of cost information for decision-making. Strategic cost management is also not confined to use of cost management techniques that reduce costs and improve the strategic position of a firm at the same time. When most authors talk about strategic cost management, they are really thinking about cost reduction. However, it is often difficult to demean the importance of cost factor for the success of company, but the challenge is to increase revenue, which can be facilitated by strategic cost management. Cost-management knowledge and information is critical to their organization's success. Strategic cost management is important to organizations because it is more than focusing on costs; in the successful companies of the 21st century costs will not be the only most important factor, but also value and revenue will be considered critical factors in the success of companies.

Concerns and Objectives of Strategic Cost Management

Change is an imprint of contemporary business environment that cannot be avoided. In the 21st century, strategic cost management is facing just such a challenge. Strategic cost management has both the opportunity and difficult task of defining and shaping its own future as well as the future of companies. Trends and changes in the business environment such as: increase of global competition, increasingly demanding customers and shareholders, and rapid advances in information and manufacturing technology - traditional cost management may be not adaptable to these events. In fact, there are many cost management systems, have been offered many solutions for companies, but their primary concern was cost reduction, as result, the late 20th century found organizations anxiously to, not deciding, their future.



Cost and revenue management is the present role of strategic cost management in the 21st century, strategic cost management primary concern will not only be cost management but also increase revenues, improve productivity and customer satisfaction, and the same time improve the strategic position of the company.



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Strategic Cost Management must bridge the gap between cost and value as well as between the language of the market and the language of the business. Traditional Cost Management during the 20th Century faced many criticism, however, Strategic Cost Management during 21st Century faces a future that will be unique and rewarding compared to its current realities. The difference between Traditional Cost Management and Strategic Cost Management is explained below :

	Traditional Cost Management	Strategic Cost Management
Focus	Internal	External
Perspective	Value-added	Value chain
Cost analysis-way	In term of: product, customer, and function With a strongly internal focus Value added is a key concept	In terms of the various stages of the overall value chain of which the firm is a part With a strongly external focus Value-added is seen as a dangerously narrow concept
Cost analysis-objective	Three objectives will apply, without regard to the strategic context: Score keeping, attention directing, and problem solving.	Although the three objectives are always present, the design of cost management system changes dramatically depending on the basic strategic positioning of the firm: either under a cost leadership strategy, or under a product differentiation strategy.
Cost driver concept	A single fundamental cost driver pervades literature - cost is a function of volume. Applied too often only at the overall firm level.	Multiple cost drivers such as: Structural drivers (e.g. scale, scope, experience, technology, complexity) Executional drivers (e.g. participative management, total quality management) Each value activity has a set of unique cost drivers.
Cost containment philosophy	Cost reduction approached via responsibility centers or product cost issues	Cost containment is a function of the cost driver(s) regulating each value activity.
Primary concern	Cost impact	Cost/Value/Revenue relationship
Key disciplines	Finance/Accounting	Marketing/Economies
Primary role	Scorekeeper	Analyst and consultant
Management responsibility	Follower/reactive Risk-averse	Leader/proactive Comfortable with ambiguity

The emergence of SCM results from a blending of three underlying themes, each taken from the strategic management literature:

1. Value chain analysis
2. Strategic positioning analysis
3. Cost driver analysis

Each of these three themes represents a stream of research and analysis in which cost information is cast in a light very different from that in which it is viewed in conventional management accounting.

Value Chain Analysis

The first theme that underlies the work in strategic cost management concerns the focus of cost management efforts. Stated in question form: How do we organize our thinking about cost management? In the SCM framework, managing costs effectively requires a broad focus, external to the firm. Porter (1985a) has called this focus the value chain. The value chain for any firm in any business is the linked set of value-creating activities all the way from basic raw material sources for component suppliers through to the ultimate end-use product delivered into the final consumers' hands. This focus is external to the firm, seeing each firm in the context of the overall chain of value-creating activities of which it is only a part, from basic raw material components to end-use consumers. In contrast, management accounting today often adopts a focus that is largely internal to the firm its purchases, its processes, its functions, its products, and its customers. Another way of saying this is that management accounting takes a value-added perspective, starting with payments to suppliers (purchases), and stopping with charges to customers (sales). The key theme is to maximize the difference (the value added) between purchases and sales. But the value chain concept is fundamentally different from the value-added concept. From a strategic perspective, the value-added concept has two big problems; it start too late and it stops too soon. Starting cost analysis with purchases misses all the

opportunities for exploiting linkages with the firm's suppliers. Such opportunities can be dramatically important to a firm.

Consider the following examples case

A few years ago, one of the major U.S. automobile companies began to implement Just in Time (JIT) management concepts in its assembly plants (Houliham. 1987). Manufacturing costs represented 30% of sales for the auto firm. It was believed that applying JIT concepts couId eliminate 20% of these costs because assembly costs in Japanese auto plants were known to be more than 20% below those in U.S. plants. As the firm began to manage its factories differently to eliminate waste and the need for inventory buffers, its assembly costs began to drop noticeably. But, at the same time, the firm experienced dramatic problems with its major suppliers. They began to demand price increases that more than offset the assembly plant costs savings. The auto firm's first response was to chide its suppliers that they, too, needed to embrace JIT concepts for their own operations.

A value chain perspective revealed a much different picture of the overall situation. Of the auto company's sales, 50% was purchases from parts suppliers; of this amount, 37% was purchases by the parts suppliers and 63% was suppliers' value added. Thus, suppliers were adding more manufacturing value to the auto than the assembly plants (63% x 50% - 31.5%, versus 30%). As the auto company reduced its need for buffer stocks, it placed major new strains on the manufacturing responsiveness of its suppliers. The suppliers' manufacturing costs went up more than the assembly plants' costs went down.The reason, once identified, was very simple. The assembly plants experienced huge and uncertain variability in their production schedules. One week ahead of actual production, the master schedule was more than 25% wrong 95% of the time. When the inventory buffers are stripped away from a highly unpredictable production process, the manufacturing activities of the suppliers become a nightmare. For every dollar of manufacturing cost the assembly plants saved by moving toward JIT management concepts, the suppliers' plants spent much more than one dollar extra because of schedule instability.

Because of its narrow value-added perspective, the auto company had overlooked the impact of its changes on its suppliers' costs. Management had ignored the idea that JIT involves a partnership with suppliers. Management did not realize that a major element in the success of JIT for a Japanese auto assembly plant is schedule stability for its supplier firms. In fact, hereas the U.S. plants regularly missed schedules only one week ahead by 25% or more, the Japanese plants varied 1% or less from schedules planned four weeks in advance (Jones & Udvare, 1986).! The failure to adopt a value chain perspective doomed this major effect by a leading U.S. firm. The lack of awareness of supply chain cost analysis concepts on the part of this company's management accountants proved to be a very costly oversight. Should those management accountants have been exposed to value chain concepts somewhere in their accounting education? In addition to starting too late, value-added analysis has another major flaw; is stops too soon. Stopping cost analysis at sales misses all the opportunities for exploiting linkages with the firm's customers. Customer linkages can be just as important as supplier linkages. Exploiting customer linkages is the key idea behind the concept of life cycle costing. Life cycle costing deals explicitly with the relationship between what a customer pays for a product and the total cost the customer incurs over the life cycle of using the product. Forbis and Mehta (1981) describe how a life cycle costing perspective on the customer linkage in the value chain can lead to increased profitability. Explicit attention to post purchase costs by the customer can lead to more effective market segmentationand product positioning. Or, designing a product to reduce post purchase costs of the customer can be a major weapon in capturing

competitive advantage. In many ways, the lower life cycle cost of imported Japanese autos helps to explain their success in the U.S. market. Just as many cost management problems are misunderstood because of failure to see the impact on the overall value chain, many cost management opportunities are missed in the same way.

The Strategic Positioning Concept

The second major theme underlying the work in strategic cost management concerns the perceived uses of management accounting information, stated, again, in question form: What role does cost management play in the firm? The theme of SCM can be stated very succinctly. In SCM, the role of cost analysis differs in important ways depending on how the firm is choosing to compete. Following Porter's (1980) delineation of basic strategic choices, a business can compete either by having lower costs (cost leadership) or by offering superior products (product differentiation). That these two approaches demand very different conceptual frameworks has been widely accepted in the strategy literature and, although strategic positioning does not involve simple either/or choices in practice, the implications for strategic management have been frequently amplified.! but the implications of strategic positioning for management accounting are not as well explored. Since differentiation and cost leadership involve different managerial mindsets, they also involve different cost analysis perspectives. As one example of how strategic positioning can significantly influence the role of cost analysis, consider the decision to invest in more carefully engineered product costs. For a firm, following a cost leadership strategy in a mature, commodity business, carefully attention to engineered target costs is likely to be a very important ongoing management tool. But for a firm following a product differentiation strategy in a market-drive, rapidly growing, fast-changing business, carefully engineered manufacturing costs may well be much less important.

The Cost Driver concept

In SCM it is acknowledged that cost is caused, or driven, by many factors that are interrelated in complex ways. Understanding means understanding the complex interplay of the set of cost drivers at work in any given situation. At this level of generality, the idea is almost tautological. It is hardly contentious or counterintuitive until one contrasts it with the prevailing theme in traditional management accounting today. In management accounting, cost is a function, primarily, of only one cost drive, output volume. Cost concepts related to output volume permeate the thinking and the writing about cost: fixed versus variable cost, average cost versus marginal cost, cost-volume-profit analysis, break even analysis, flexible budgets, and contribution margin, to name a few. In SCM, output volume as such is seen to capture very little of the richness of cost behavior. Management accounting, in this regard, tends to draw upon the simple models of basic microeconomics. SCM, on the other hand, tends to draw upon the richer models of the economics of industrial organization (Scherer, 1980).Strategic cost driver, cumulative experience, has also received some attention among management accountants over the years as a determinant of unit costs. Reference to the learning curve also appears in much managerial accounting text. However, rather than seeing experience as one of many cost drivers, the accounting literature sees it more narrowly as an explanation of how the relationship between cost and output volume changes over time as cumulative output increases for one particular product of process. That is, even in the learning curve literature in accounting, output volume is still the preeminent cost driver. Experience is seen as a phenomenon that can help explain the changing relationship between output volume and costs over time. If output volume is a poor way to explain cost behavior, what is a better way? Porter (1985a) presents one attempt to create a comprehensive list of cost drivers, but his attempt is more important than his

particular list. In the strategic management is more important than this particular list. In the strategic management literature, better lists exist (Riley, 1987). Following Riley, the following list of cost drivers is broken into two categories. The first category comprises "structural" cost drivers, drawing upon the industrial organization literature (Scherer, 1980). From this perspective there are at least five strategic choices by the firm regarding its underlying economic structure that drive cost position for any given product group:

(i) Scale: How big an investment to make in manufacturing, in R&D, and in marketing resources.
(ii) Scope: Degree of vertical integration. Horizontal integration is more related to scale.
(iii) Experience: How many times in the past the firm has already done what it is doing again.
(iv) Technology: What process technologies are used at each step of the firm's value chain.
(v) Complexity: How wide a line or products or services to offer to customers.

Each structural driver involves choices by the firm that drive product cost. Given certain assumptions,
the cost calculus of each structural driver can be specified. Of the structural drivers, scale, scope, and experience have received a large amount of attention from economists and strategists over the years. Of these three, only experience has drawn much interest from management accountants, as noted previously. Complexity, as a structural variable, has received the most attention among accountants recently. Some examples of the potential importance of complexity as a cost determinant are in the work on activity based costing by Kaplan (1987), Cooper (1986), or Shank and Govindarajan (1988d). We consider this work as a useful strategic analysis tool, but not as the primary tool. The second category of cost drivers, executional drivers (Riley, 1987), are those determinants of a firm's cost position that hinge on its ability to execute successfully. Whereas structural cost drivers are not monotonically scaled with performance, executional drivers are. That it for each of the structural drivers, more is not always better. There are diseconomies of scale, or scope, as well as economics. A more complex line, too much experience can be as bad as too little in a dynamic environment. For example, Texas Instruments emphasized the learning curve and became the world's lowest-cost producer of microchips that were no longer state of the art. Technological leadership versus followership is a legitimate choice for most firms. In contrast, for each of the executional drivers, more is always better. The list of basic executional drivers includes at least the following: Work force involvement (participation) - the concept of work force commitment to continual improvement. Total quality management (beliefs and achievement regarding product and process quality). Capacity utilization (given the scale choices on plant construction).Plant layout efficiency. (How efficient, against current norms, is the layout) Product configuration. (Is the design or formulation effective?) Exploiting linkages with suppliers and/or customers, per the firm's value chain. While it may not always be true that a higher level of these executional factors improves cost position, examples of diseconomies are much less frequent. Operationalizing each of these drivers also involves specific cost analysis issues. Many strategy consultants maintain that the strategic cost analysis field is moving very quickly toward executional drivers because the insights from analysis based on structural drivers are too often old fashioned. It is somewhat ironic that the cost drivers concept is moving from one revolution to a second one before the accounting world has caught up with the first one.

Whatever cost drivers are on the list, the key ideas are as follows:

• For strategic analysis, volume is usually not the most useful way to explain cost behavior.
• In a strategic sense, it is more useful to explain cost position in terms of the structural choices

and executional skills that shape the firm's competitive position.
• Not all the strategic drivers are equally important all the time, but some (more than one) of them are very probably very important in every case.
• For each cost driver there is a particular cost analysis frame work that is critical to understanding the positioning of a firm. Being a well-trained cost analysis requires knowledge of these various frameworks.

Strategic Cost Analysis – Target Costing, Life Cycle Costing and Kaizen Costing

In every business, the owners and managers need to know what their product or service costs to deliver and what they can sell it for. They want to make strategic decisions that maximize their profits, and they require information to do this. Even not-for-profit businesses have a service or product that they wish to offer but are constrained by the funding they receive from grants, donations and bequests. The simple truth is that you can not decide what to do unless you know the cost. This link between cost information and strategy has always been present, possible in an unsophisticated and informal manner. Increasing competitiveness and the contributions made by academics, consultants, and practicing business people have made that link explicit. The conclusion is that strategic decisions cannot be successfully made unless you understand cost information. Strategic Cost Analysis explains the tools that managers need. It examines the different methods of calculating cost, techniques for controlling and monitoring costs, and ways to integrate cost data and strategy into every aspect of the organization. It helps companies identify, analyze and use strategically important resources for continuing success.
Strategic Cost Analysis (SCA) focuses on an organization's various activities, identifies the reasons for their costs, and financially evaluates strategies for creating a sustainable competitive advantage. The technique provides organizations with the total costs and revenues of strategic decisions. This requires creative thinking, and managers need to identify and solve problems from an integrative and cross functional viewpoint.

Example of SCA include the following :
• Deciding on product mixes and production volumes
• Outsourcing decisions
• Cost reductions
• Investment and profit growth in different markets
• Responses to suppliers' and competitors' activities
• Changes in consumer demand

Target Costing and Life Cycle Costing

Target costing and lifecycle costing can be regarded as relatively modern advances in engagement accounting, so it is worth first looking at the approach taken by conventional costing. Typically, conventional costing attempts to work out the cost of producing an item incorporating the costs of resources that are currently used or consumed. Therefore, for each unit made the classical
variable costs of material, direct labour and variable overheads are included (the total of these is the marginal cost of production), together with a share of the fixed production costs. The fixed production costs can be included using a conventional overhead absorption rate or they can be accounted for using activity-based costing (ABC). ABC is more complex but almost certainly more accurate. However, whether conventional overhead treatment or ABC is used the overheads incorporated are usually based on the budgeted overheads for the current period.
Once the total absorption cost of units has been calculated, a mark-up (or gross profit percentage) is used to determine the selling price and the profit per unit. The mark-up is chosen so that if the budgeted sales are achieved, the organization should make a profit.

There are two flaws in this approach

1. The product's price is based on its cost, but no one might want to buy at that price. The product might incorporate features which customers do not value and therefore do not want to pay for, and competitors' products might be cheaper, or at least offer better value for money.

This flaw is addressed by target costing

2. The costs incorporated are the current costs only. They are the marginal costs plus a share of the fixed costs for the current accounting period. There may be other important costs which are not part of these categories, but without which the goods could not have been made. Examples include the research and development costs and any close down costs incurred at the end of the product's life. Why have these costs been excluded, particularly when selling prices have to be high enough to ensure that the product makes a profit. To make a profit, total revenue must exceed total costs in the long term.

This flaw is addressed by lifecycle costing and Target costing

Target costing is very much a marketing approach to costing. The Chartered Institute of Marketing defines marketing as:

'The management process responsible for identifying, anticipating and satisfying customer requirements profitably.'

In marketing, customers rule, and marketing departments attempt to find answers to the following questions:

• Are customers homogeneous or can we identify different segments within the market?
• What features does each market segment want in the product?
• What price are customers willing to pay?
• To which competitor products or services are customers comparing ours?
• How will we advertise and distribute our products? (There are costs associated with those activities too.)

Marketing says that there is no point in management, engineers and accountants sitting in darkened rooms dreaming up products, putting them into production, adding on, say 50% for mark-up then hoping those products sell. At best this is corporate arrogance; at worst it is corporate suicide. Note that marketing is not a passive approach, and management cannot simply rely on customers volunteering their ideas. Management should anticipate customer requirements, perhaps by developing prototypes and using other market research techniques.

The really important information relating to a new product is:

Of course, there will probably be a range of products and prices, but the company cannot dictate the market, customers or competitors. There are powerful constraints on the product and its price and the company has to make the required product, sell it at an acceptable and competitive

price and, at the same time, make a profit. If the profit is going to be adequate, the costs have to be sufficiently low. Therefore, instead of starting with the cost and working to the selling price by adding on the expected margin, target costing will start with the selling price of a particular product and work back to the cost by removing the profit element. This means that the company has to find ways of not exceeding that cost.

Lifecycle costing

As mentioned above, target costing places great emphasis on controlling costs by good product design and production planning, but those up-front activities also cause costs. There might be other costs incurred after a product is sold such as warranty costs and plant decommissioning. When seeking to make a profit on a product it is essential that the total revenue arising from the product exceeds total costs, whether these costs are incurred before, during or after the product is produced. This is the concept of life cycle costing, and it is important to realize that target costs can be driven down by attacking any of the costs that relate to any part of a product's life.

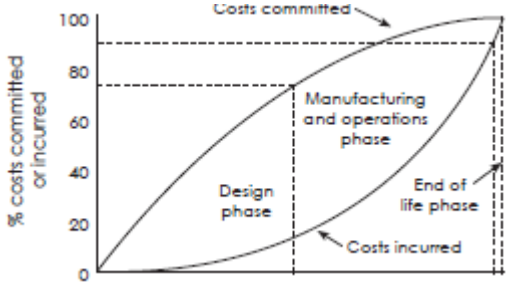
The cost phases of a product can be identified as:

Examples of types of cost

Design Research, development, design and tooling Manufacture Material, labour , overheads, machine set up, inventory, training, production machine maintenance and depreciation Operation Distribution, advertising and warranty claims End of life Environmental clean-up, disposal and decommissioning There are four principal lessons to be learned from lifecycle costing:

• All costs should be taken into account when working out the cost of a unit and its profitability.
• Attention to all costs will help to reduce the cost per unit and will help an organization achieve its target cost.
• Many costs will be linked. For example, more attention to design can reduce manufacturing and warranty costs. More attention to training can reduce machine maintenance costs. More attention to waste disposal during manufacturing can reduce end-of life costs.
• Costs are committed and incurred at very different times. A committed cost is a cost that will be incurred in the future because of decisions that have already been made. Costs are incurred only when a resource is used.

Typically the following pattern of costs committed and costs incurred is observed:



The diagram shows that by the end of the design phase approximately 80% of costs are committed. For example, the design will largely dictate material, labour and machine costs. The company can try to haggle with suppliers over the cost of components but if, for example, the design specifies 10 units of a certain component, negotiating with suppliers is likely to have

only a small overall effect on costs. A bigger cost decrease would be obtained if the design had specified only eight units of the component.

The design phase locks the company in to most future costs and it this phase which gives the company its greatest opportunities to reduce those costs. Conventional costing records costs only as they are incurred, but recording those costs is different to controlling those costs and performance management depends on cost control, not cost measurement.

Kaizen Costing

Yashihuro Modern defines kaizen costing as "the maintenance of present cost levels for products currently being manufactured via systematic efforts to achieve the desired cost level." The word *kaizen* is a Japanese word meaning *continuous improvement*.

Modern has described two types of kaizen costing:

- Asset and organization specific kaizen costing activities planned according to the exigencies of each deal
- Product model specific **costing** activities carried out in special projects with added emphasis on

value analysis

Kaizen costing is applied to products that are already in production phase. Prior to kaizen costing, when the products are under development phase, target costing is applied.

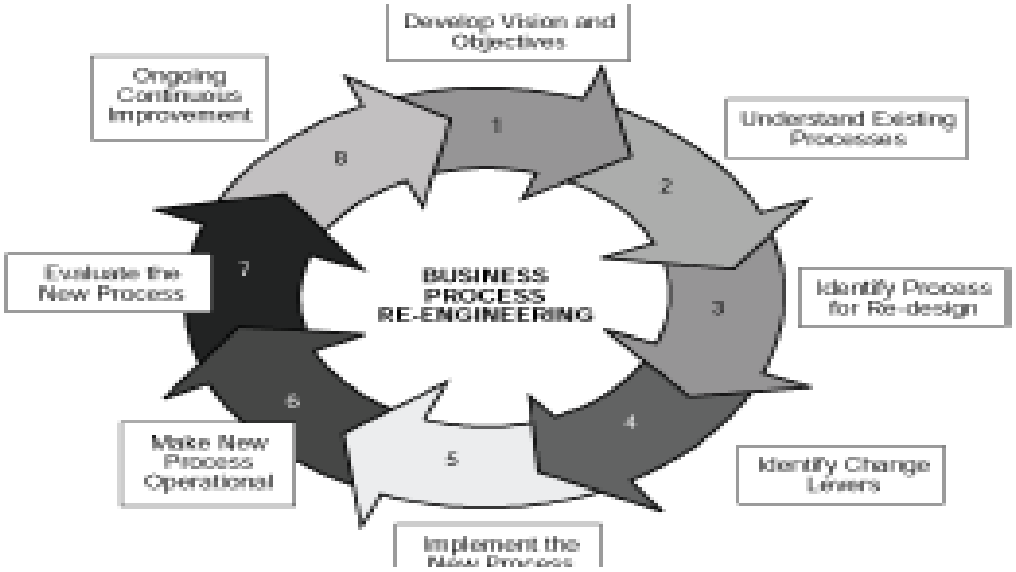
'Kaizen costing is based on the belief that nothing is ever perfect, so improvements and reductions in the variable costs are always possible'

The cost-plus method is one of the most traditional and common pricing techniques. In fact, virtually all companies in the UK used cost-plus pricing until they started to realize that they were operating in price-competitive markets. Until then, they had naively assumed that consumers would be willing to pay whatever price they arrived at by adding a percentage to the estimated cost of the product or service. This cost-plus approach has gradually been replaced by target costing. This addresses the pricing issue from the other direction. It must be accepted that in a competitive market a company has little influence over the selling price of its product.

Organizations use market research to establish the number of units they are likely to sell and the unit price that customers are willing to pay for the product. From this selling price, a company subtracts the profit required to meet its profit objective, arriving at a target cost. In most cases this cost will be lower than the current cost, especially if the product is subject to the learning-curve phenomenon, which would result I n a "cost gap". The firm's objective is to bridge this gap – i.e., to cut the cost by using tools such as value analysis and functional analysis. Achieving the target cost requires a concerted effort from the whole company. Some firms choose a team of managers from all the main departments, whose main aim is to examine every aspect of the product and the manufacturing process to remove unnecessary costs and anything that does not add value, while maintaining quality and functionality. In some cases this may lead to a complete product redesign. Once the design has been approved, production can begin, which is where Kaizen costing starts. The method can be defined as a focus on obtaining small, incremental cost reductions (rather than big changes at longer intervals) during the production phase of the product's life cycle. Kaizen costing is based on the belief that nothing is ever perfect, so improvements and reductions in the variable costs are always possible. Like its big brother TQM, it becomes part of the culture, involving all members of the organization. Everyone is encouraged to offer ideas that, however small, could lead to a reduction in variable costs, which could in turn lead to a reduction in the selling price and, hopefully, a growth in

sales. Alternatively, the price could be maintained and the resulting increase in profits could be used to reward the shareholders or be reinvested in other projects. It's easy to see how Kaizen costing is aligned closely with lean manufacturing, whose main aim is to cut waste through continuous improvement. This is achieved by identifying the best resources and most efficient processes to remove waste from production.

Business process re-engineering (BPR) is a business management strategy, originally pioneered in the early 1990s, focusing on the analysis and design of workflows and processes within an organization. BPR aimed to help organizations fundamentally rethink how they do their work in order to dramatically improve customer service, cut operational costs, and become world-class competitors. In the mid-1990s, as many as 60% of the Fortune 500 companies claimed to either have initiated reengineering efforts, or to have plans to do so. seeks to help companies radically restructure their organizations by focusing on the BPR ground-up design of their business processes. According to Davenport (1990) a business process is a set of logically related tasks performed to achieve a defined business outcome. Re-engineering emphasized a holistic focus on business objectives and how processes related to them, encouraging full-scale recreation of processes rather than iterative optimization of sub processes. Business process re-engineering is also known as business process redesign, business transformation, or business process change management.



The globalization of the economy and the liberalization of the trade markets have formulated new conditions in the market place which are characterized by instability and intensive competition in the business environment. Competition is continuously increasing with respect to price, quality and selection, service and promptness of delivery. Removal of barriers, international cooperation, technological innovations cause competition to intensify. All these changes impose the need for organizational transformation, where the entire processes, organization climate and organization structure are changed.

Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision Making.

UNIT-II
COST CONCEPTS

WHAT IS COST MANAGEMENT IN PROJECT MANAGEMENT?

Cost management is the process of estimating, allocating, and controlling the costs in a project. It allows a business to predict coming expenses in order to reduce the chances of it going over budget. Projected costs are calculated during the planning phase of a project and must be approved before work begins. As the project plan is executed, expenses are documented and tracked so things stay within the cost management plan. Once the project is completed, predicted costs vs. actual costs are compared, providing benchmarks for future cost management plans and project budgets.

Cost concepts in decision making

Many business decisions require a firm knowledge of several cost concepts. Different types of costs have differing characteristics. Consequently, when reviewing a business case to determine which path to take, it is useful to understand the following cost concepts:

- ***Fixed, variable, and mixed costs***. A fixed cost, such as rent, does not change in lock step with the level of activity. Conversely, a variable cost, such as direct materials, will change as the level of activity changes. Those few costs that change somewhat with activity are considered mixed costs. It is important to understand the distinction, since a decision to alter an activity may or may not alter costs. For example, shuttering a facility may not terminate the associated building lease payments, which are fixed for the duration of the lease.

- ***By-product costs***. A product may be an incidental by-product of a production process (such as sawdust at a lumber mill). If so, it does not really have any cost, since its cost would have been incurred anyways as a result of the production of the main product. Thus, selling a by-product at any price is profitable; no price is too low.

- ***Allocated costs***. Overhead costs are allocated to manufactured goods only because it is required by the accounting standards (for the production of financial statements). There is no cause-and-effect between the creation of one additional unit of production and the incurrence of additional overhead. Thus, there is no reason to include allocated overhead in the decision to set a price for one additional unit.

- ***Discretionary costs*.** Only a few costs can actually be dropped without causing any short-term harm to an organization. Examples are employee training and maintenance. Over the long-term, delaying these expenditures will eventually have a negative effect. Thus, managers need to understand the impact of their decisions over a period of time when determining which costs to cut back.

- ***Step costs*.** Though some costs are essentially fixed, it may be necessary to make a large investment in them when the activity level increases past a certain point. Adding a

production shift is an example of a step cost. Management should understand the activity volumes at which step costs can be incurred, so that it can manage around them - perhaps delaying sales or outsourcing work, rather than incurring step costs.

What Is Relevant Cost?

Relevant cost is a managerial accounting term that describes avoidable costs that are incurred only when making specific business decisions. The concept of relevant cost is used to eliminate unnecessary data that could complicate the decision-making process. As an example, relevant cost is used to determine whether to sell or keep a business unit. The opposite of a relevant cost is a sunk cost, which has already been incurred regardless of the outcome of the current decision.

Types of Relevant Cost Decisions

Continue Operating vs. Closing Business Units

A big decision for a manager is whether to close a business unit or continue to operate it, and relevant costs are the basis for the decision. Assume, for example, a chain of retail sporting goods stores is considering closing a group of stores catering to the outdoor sports market. The relevant costs are the costs that can be eliminated due to the closure, as well as the revenue lost when the stores are closed. If the costs to be eliminated are greater than the revenue lost, the outdoor stores should be closed.

Make vs. Buy

Make vs. buy decisions are often an issue for a company that requires component parts to create a finished product. For example, a furniture manufacturer is considering an outside vendor to assemble and stain wood cabinets, which would then be finished in-house by adding handles and other details. The relevant costs in this decision are the variable costs incurred by the manufacturer to make the wood cabinets and the price paid to the outside vendor. If the vendor can provide the component part at a lower cost, the furniture manufacturer outsources the work.

Factoring in a Special Order

A special order occurs when a customer places an order near the end of the month, and prior sales have already covered the fixed cost of production for the month. If a client wants a price quote for a special order, management only considers the variable costs to produce the goods, specifically material and labor costs. Fixed costs, such as a factory lease or manager salaries are irrelevant, because the firm has already paid for those costs with prior sales.

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CLASSIFICATION

Costs may be classified as **differential cost**, **opportunity cost** and **sunk cost**. This classification is made for decision making purposes. Explanation and examples of differential, opportunity and sunk costs are given below:

Differential cost:

The work of managers includes comparison of costs and revenues of different lternatives. **Differential cost** (also known as **incremental cost**) is the difference in cost of two alternatives. For example, if the cost of alternative A is $10,000 per year and the cost of alternative B is $8,000 per year. The difference of $2,000 would be differential cost. The differential cost can be a fixed cost or variable cost.

Similarly the difference in revenue of two alternatives is known as differential revenue. For example, if alternative A's revenue is $15,000 and alternative B's revenue is $10,000. The difference of $5,000 would be differential revenue.

When different revenue generating alternatives are compared, the differential cost as well as differential revenues associated with each alternative is taken into account.

The terms "differential cost" and "differential revenue" used in managerial accounting are similar to the terms "marginal cost" and "marginal revenue" used in economics.

Example – computation of differential cost, differential revenues and differential net operating income:

The management of Galaxy company has two alternatives to choose from. Compute differential revenue, differential cost and differential net operating income from the information of two alternatives given below:

Revenues and Costs	Alternative 1	Alternative 2
Revenues	1,400,000	1,600,000
Cost of goods sold	700,000	800,000
Advertising expenses	160,000	90,000
Sales commission	30,000	80,000
Depreciation expenses	100,000	160,000
Other expenses	120,000	110,000

Solution:

Revenues and Costs	Alternative 1	Alternative 2	Differential Costs & Revenues
Revenues	$1,400,000	$1,600,000	$200,000
Cost of goods sold	$700,000	$800,000	$100,000
Advertising expenses	160,000	90,000	(70,000)
Sales commission	30,000	80,000	50,000
Depreciation expenses	100,000	160,000	60,000
Other expenses	120,000	110,000	(10,000)
Total	$1,110,000	$1,240,000	$130,000
Net operating income	$290,000	$360,000	$70,000

In the above example, total differential revenue is $200,000 (1,600,000 – 1,400,000), differential cost is $130,000 (1,240,000 – 1,110,000) and differential net operating income is $70,000 ($360,000 – $290,000).

If a decision is made on the basis of above computations, alternative 2 would be selected because it promises to generate more net operating income.

Opportunity cost:

Unlike other types of cost, opportunity cost does not require the payment of cash or its equivalent. It is a potential benefit or income that is given up as a result of selecting an alternative over another. For example, You have a job in a company that pays you $25,000 per year. For a better future, you want to get a Master's degree but cannot continue your job while studying. If you decide to give up your job and return to school to earn a Master's degree, you would not receive $25,000. Your opportunity cost would be $25,000.

Almost every alternative has an opportunity cost. It is not entered in the accounting records but must be considered while making decisions.

Sunk cost:

The costs that have already been incurred and cannot be changed by any decision are known as **sunk costs**. For example, a company purchased a machine several years ago. Due to change in fashion in several years, the products produced by the machine cannot be sold to customers. Therefore the machine is now useless or obsolete. The price originally paid to purchase the machine cannot be recovered by any action and is therefore a sunk cost.

These costs should not be taken into account while making any decision because no action can revers them.

A **costing system** is designed to monitor the costs incurred by a business. The system is comprised of a set of forms, processes, controls, and reports that are designed to aggregate and report to management about revenues, costs, and profitability. The areas reported upon can be any part of a company, including:

- Customers
- Departments
- Facilities
- Processes
- Products and services
- Research and development
- Sales regions

The information issued by a costing system is used by management for a variety of purposes, including:

- Fine-tuning operations to generate higher profitability
- Deciding where to cut costs in the event of a business downturn
- Matching actual costs incurred against budgeted cost levels for control purposes
- Creating strategic and tactical plans for future operations

The reports of a costing system are intended for internal use, and so are not subject to the reporting requirements of any of the accounting frameworks, such as GAAP or IFRS. Instead, management can decide what types of information it prefers to see, which information to ignore, and how the results are to be formatted and distributed for its consumption. Typical reports created by a costing system include:

- Budget-versus-actual reports for costs incurred
- Profitability reports for customers, sales regions, stores, products, and/or product lines
- Expense trend reports that show expenses incurred by month for many consecutive months

These reports may be accompanied by additional information assembled by the accounting department, which provide details regarding how certain costs were incurred and who authorized them.

There are two main types of costing systems. A business can accumulate information based on either one of these systems, or adopt a hybrid approach that mixes and matches systems to best meet its needs. The primary costing systems are:

- *Job costing system*. Materials, labor, and overhead costs are compiled for an individual unit or job. This approach works best for unique products, such as custom-designed machines or consulting projects. The cost accumulation process is highly detailed and labor-intensive.
- *Process costing system*. Materials, labor and overhead costs are compiled in aggregate for an entire production process, and are then allocated to individual production units. This approach works well for large production runs of identical items, such as a production run of 100,000 cell phones. The cost accumulation process is highly efficient and portions of it can possibly be automated.

Another costing system option is activity based costing (ABC). ABC was developed in response to concerns that overhead costs are rarely allocated in an appropriate manner, and involves a finer degree of differentiation in determining how overhead costs are assigned to different cost pools, and then how the costs in those pools are allocated to cost objects. An ABC system can be difficult to set up and operate, and so works best when designed for very specific cost allocation projects that have clearly defined boundaries.

Objectives of a Costing System

1. To ascertain the cost per unit of the different products manufactured by a business concern;

2. To provide a correct analysis of cost both by process or operations and by different elements of cost;

3. To disclose sources of wastage whether of material, time or expense or in the use of machinery, equipment and tools and to prepare such reports which may be necessary to control such wastage;

4. To provide requisite data and serve as a guide for fixing prices of products manufactured or services rendered;

5. To ascertain the profitability of each of the products and advise management as to how these profits can be maximised;

6. To exercise effective control if stocks of raw materials, work-**in-progress, consumable stores and finished goods in** order to minimise the capital locked up in these stocks;

7. To reveal sources of economy by installing and implementing a system of cost control for materials, labour and overheads;

8. To advise management on future expansion policies and proposed capital projects;

9. To present and interpret data for management planning, evaluation of performance and control;

10. To help in the preparation of budgets and implementation of budgetary control;

11. To organise an effective information system so that different levels of management may get the required information at the right time in right form for carrying out their individual responsibilities in an efficient manner;

12. To guide management in the formulation and implementation of incentive bonus plans based on productivity and cost savings;

13. To supply useful data to management for taking various financial decisions such as introduction of new products, replacement of labour by machine etc.;

14. To help in supervising the working of punched card accounting or data processing through computers;

15. To organise the internal audit system to ensure effective working of different departments;

16. . To organise cost reduction programmes with the help of different departmental managers;

17. To provide specialised services of cost audit in order to prevent the errors and frauds and to facilitate prompt and reliable information to management; and

18. To find out costing profit or loss by identifying with revenues the costs of those products or services by selling which the revenues have resulted.

Inventory Valuation

Inventory or stock is the resourceful but idle assets lying with the company at the end of the accounting period. It is one of the most significant assets of a company on its balance sheet. So inventory valuation is a very important factor in the accounting of a company. Let us learn more about it.

Significance of Inventory Valuation

When we talk about inventory we usually refer to the stock-in-trade with a company of raw materials, semi-finished goods, finished goods, and spare parts. So at the end of the year inventory has to be counted to get to the closing stock.

However only counting inventory is not enough, it also has to be valued. The process of inventory valuation helps determine the value at which we will record the inventories in the final accounting statements of the company. The correct inventory valuation is essential to have a fair representation of the company's finances. Let us take a look at the reasons inventory valuation is so important for a company.

1] Helps Determine Income

To calculate the gross profit or loss for the year we match the cost of goods sold to the direct revenue of an accounting period. The formulae for calculating the cost of goods sold is as follows,

COGS = Opening Inventory + Purchases + Direct Expenses – Closing Inventory

Inventory valuation will have a major impact on income determination if valuations are over or understated, this can be explained as:

a. When closing inventory is overstated, net income for the accounting period will be overstated.

b. When opening inventory is overstated, net income for the accounting period will be understated.

c. When closing inventory is understated, net income for the accounting period will be understated.

d. When opening inventory is understated, net income for the accounting period will be overstated.

So as you can see inventory valuation (closing inventory) has a direct impact on income determination of a firm. The misstatement or miscalculation of inventory can overstate or understate the profits of the firm.

2] Helps Determine Financial Position

Inventory is not only a part of the Profit and Loss statement but also of the Balance Sheet, Inventories are considered as Current Assets of a firm. So it is very important to have precise and correct inventory valuation. If the calculated value of the inventory is wrong it will represent a wrong financial position on the date of the balance sheet.

3] Liquidity Analysis

Inventory is a current asset because the firm is not expected to hold it for a long period of time. There is a lot of turnovers when it comes to stock. So inventory actually is a significant portion of the working capital of a company. It is important to value it correctly so the current ratio and liquid ratios can be calculated accurately. These ratios are important to check for the liquidity of a company.

4] Statutory Compliance

Inventory valuation is not statutory compliance under the Companies Act 2013. In accordance with the Accounting Standard (AS2), all firms now have to disclose the valuation of each class of inventory. The disclosure must include

- Accounting policies adopted for the inventory valuation
- The total amount of the inventories along with the classifications (raw materials, WIP, finished goods etc.)

Project Management Concepts

Your startup IT company has just landed its first real contract to install your new human resources software for a local organization. Since you are a startup, you are limited on staff, and the staff all wear multiple hats. This project is important to the company's owner, and he's asked you to fill the role of project manager.

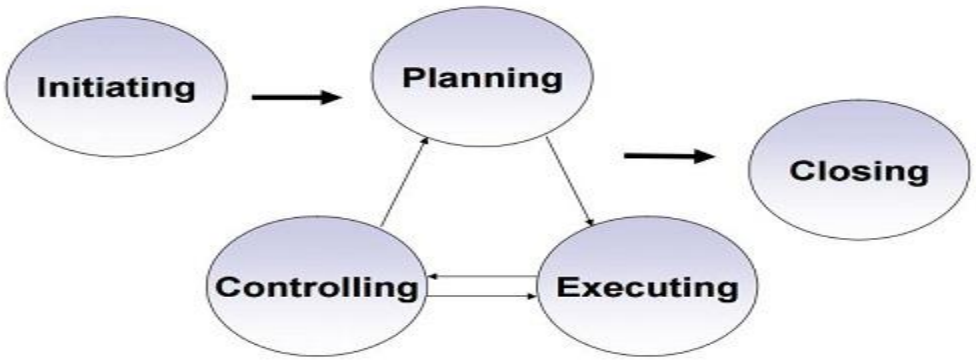
Before trying to understand the project management process, it's important to understand what a project is. A **project** is a temporary endeavor to create a specific product, service or result. Installing software in a client's environment meets this definition because the effort has a defined beginning and end and will result in the customer's purchase of new products and services to install the software.

Project management is using specific knowledge, skills, tools and techniques to ensure project activities meet the project goals. Deciding you need to understand more about project

management before this contract gets off the ground, you decide to do a little research on basic project management concepts, including the skills a project manager should have.

Five Phases of Project Management

You find that project management is broken into 5 basic phases.



Let's take a closer look at each phase.

Conception and Initiation

Project conception and initiation is where the project starts.This is where someone determines if the project can be realistically completed and if the benefits of doing it make it worth the effort to move forward with the project. The concept and initiation phase is also where you determine what you are going to do to meet an objective and how you are going to do it.

For the software project, you realize this is already in the contract the customer signed, and you simply have to understand it.

Definition and Planning

The concept and initiation phase is very broad, leaving many details unplanned. To further define it, the **definition and planning** phase digs into project specifics. A project team defines the tasks, calculates a budget and schedule, determines what resources are necessary, and defines acceptance and testing criteria. All of this information is put into a project plan, which is reviewed and approved by the customer. The definition and planning stage ensures everybody has the same expectations, preventing unexpected and often costly mistakes.

For your software project, you realize that the definition and planning phase is where project management will add true value to the success of the contract because the overall concept in the contract is refined into a working plan that lays out, in detail, project expectations. Any concerns can be worked through at this stage before any tasks have been started.

Execution

The **execution** of the project is where tasks are assigned and completed. This is the phase where you build the product or deliver the services for the customer. In most projects, this is the phase that lasts the longest and takes up most of the project team's energy.

Performance and Control

While a project is in execution, **performance and control** ensure that the deliverables are produced as specified, at the cost estimated, and on schedule. During this phase, project managers compare 'what is' to 'what should be' and adjust the plan if needed. If the project isn't monitored, the costs could exceed profit and the company would not make money, the schedule could get off track without anyone realizing it, or the product could fail to meet agreed upon criteria.

In looking at this phase as it relates to your software project, you realize that this is an important phase to both the customer and the company because it ensures the customer is happy with the results and the company makes a profit.

Closing

Closing is the phase where the customer formally accepts the project deliverables. By accepting the deliverables, the customer is saying that the product meets the criteria and expectations and work on this project is over.

Closing isn't just for the customer, however. The project team should learn from the project's successes and problems, taking the time to document the lessons learned for future reference.

Basic Principle of Inventory Valuation

So the principle basically states that we must value the inventory either at the cost of the inventory or at its net realizable value. We will record it at the lower amount amongst the two in accordance with the conservative cost approach. Now let us understand the terms cost and net realizable value.

- ***Cost:*** Cost of the inventory includes the cost of purchase of the materials. To this, we will add the cost of conversion. These will be the direct expenses of the manufacturing process like direct material and direct labor etc. Any other costs to bring the inventory to its current condition will form a part of this cost. Abnormal losses, storage, distribution and selling costs will be avoided.
- ***Net Realizable Value:*** This is the estimated price of a finished good after deducting the costs to make the sale. In the case of raw materials, it will be the replacement cost of the raw materials, i.e. their market price. And for WIP it will be the selling price minus the cost of conversion

Operational control

Command authority that may be exercised by commanders at any echelon at or below the level of combatant command. Operational control is inherent in combatant command (command authority) and may be delegated within the command. When forces are transferred between combatant commands, the command relationship the gaining commander will exercise (and the losing commander will relinquish) over these forces must be specified by the Secretary of Defense. Operational control is the authority to perform those functions of command over subordinate forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction necessary to accomplish the mission. Operational control includes authoritative direction over all aspects of military operations and joint training necessary to accomplish missions assigned to the command. Operational control should be exercised through the commanders of subordinate organizations. Normally this

authority is exercised through subordinate joint force commanders and Service and/or functional component commanders. Operational control normally provides full authority to organize commands and forces and to employ those forces as the commander in operational control considers necessary to accomplish assigned missions; it does not, in and of itself, include authoritative direction for logistics or matters of administration, discipline, internal organization, or unit training. Also called OPCON. See also combatant command; combatant command (command authority); tactical control.

Provision of data for Decision Making

Provision of data for Decision Making Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents. Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Data is increasingly under the spotlight as regulators and clients demand more from financial institutions. In order to address this issue, this paper puts forward a framework for improving the accuracy and overall quality of data that is used to inform decision-making. Drivers for adopting a more systematic approach to improving data quality are explained in terms of the current regulatory and business context. The paper describes 'fitness for use' in terms of various aspects of quality that will be important to the various consumers in an organisation. The importance of data governance as an appropriate control mechanism is emphasised and a framework of necessary components is put forward. An overarching approach to corporate internal controls is vital to provide the strategic context and management backing for a data governance initiative and the various components are explained in detail. This then sets the scene for the specific data components of the framework. The paper describes how to catalogue data inventory and put meaning and relevance at the heart of explaining the data requirements of the business. Analysis of how the data is used in frontto- back processes provides the link to data lineage and describes accountability and ownership for data quality, so implementing governance within the day-to-day business. Ongoing monitoring of data quality and the types of metrics that should be used is discussed and an example of their use in a buy-side value chain adds real-world context. Finally, the meaning of data accuracy in relation to future trends in the world of 'Big Data' and analytics leads to the conclusion that organisations should be aiming for 'good enough' for a given situation. This, and future business success and profitability, however, is predicated on a fundamental understanding of the nature of the data that the business requires.how to Become More Data-Driven in 5 Steps

With all this in mind, let's become more data-driven, shall we?

Step 1: Strategy

Data-driven decision making starts with the all-important strategy. This helps focus your attention by weeding out all the data that's not helpful for your business. First, identify your goals — what can data do for you? Perhaps you're looking for new leads, or you want to know which processes are working and which aren't. Look at your business objectives, then build a strategy around them — that way you won't be dazzled by all the possibilities big data has to offer.

Step 2: Identify key areas

Data is flowing into your organization from all directions, from customer interactions to the machines used by your workforce. It's essential to manage the multiple sources of data and identify which areas will bring the most benefit. Which area is key to achieving your overarching business strategy? This could be finance or operations, for example.

Targeting data according to your business objectives will help keep the costs of data storage down, not to mention ensuring that you're gaining the most useful insights. Keep an eye on costs, and keep the board happy, by focusing only on the data you really need.

Step 4: Collecting and analyzing data

Identify the key players who will be managing the data. This will usually be heads of departments. That said, the most useful data will be collected at all levels and will come from both external and internal sources, so you have a well-rounded view of what's going on across the business.

To analyze the data effectively, you may need integrated systems to connect all the different data sources. The level of skills you need will vary according to what you need to analyze. The more complex the query, the more specialized skills you'll need. On the other hand, simple analytics may require no more than a working knowledge of Excel, for example. Some analytics platforms offer accessibility so that everyone can access data, which can help connect the entire workforce and make for a more joined-up organization.

The more accessible the data, the more potential there is for people to spot insights from it.

Step 5: Turning insights into action

The way you present the insights you've gleaned from the data will determine how much you stand to gain from them.

There are multiple business intelligence tools that can pull together even complex sets of data and present it in a way that makes your insights more digestible for decision makers.

Of course, it's not about presenting pretty pictures but about visualizing the insights in a way that's relatable, making it easier to see what actions needs to be taken and ultimately how this information can be used in the business.

See an example:

Creation of a Database for operational control;

Operational database management systems (also referred to as OLTP On Line Transaction Processing databases), are used to update data in real-time. These types of databases allow users to do more than simply view archived data. Operational databases allow you to modify that data (add, change or delete data), doing it in real-time.[1] OLTP databases provide transactions as main abstraction to guarantee data consistency that guarantee the so-called ACID properties. Basically, the consistency of the data is guaranteed in the case of failures and/or concurrent access to the data.

Since the early 90's, the operational database software market has been largely taken over by SQL engines. Today, the operational DBMS market (formerly OLTP) is evolving dramatically, with new, innovative entrants and incumbents supporting the growing use of unstructured data and NoSQL DBMS engines, as well as XML databases and NewSQL databases. NoSQL databases typically have focused on scalability and have renounced to data consistency by not providing transactions as OLTP system do. Operational databases are

increasingly supporting distributed database [2] architecture that can leverage distribution to provide high availability and fault tolerance through replication and scale out ability.

The growing role of operational databases in the IT industry is moving fast from legacy databases to real-time operational databases capable to handle distributed web and mobile demand and to address Big data challenges. Recognizing this, Gartner started to publish the Magic Quadrant for Operational Database Management Systems in October 2013.[3]

Use in business

perational databases are used to store, manage and track real-time business information. For example, a company might have an operational database used to track warehouse/stock quantities. As customers order products from an online web store, an operational database can be used to keep track of how many items have been sold and when the company will need to reorder stock. An **operational database** stores information about the activities of an organization, for example customer relationship management transactions or financial operations, in a computer database.

Operational databases allow a business to enter, gather, and retrieve large quantities of specific information, such as company legal data, financial data, call data records, personal employee information, sales data, customer data, data on assets and many other information. An important feature of storing information in an operational database is the ability to share information across the company and over the Internet. Operational databases can be used to manage mission-critical business data, to monitor activities, to audit suspicious transactions, or to review the history of dealings with a particular customer. They can also be part of the actual process of making and fulfilling a purchase, for example in e-commerce.

Data warehouse terminology [edit]

In data warehousing, the term is even more specific: the operational database is the one which is accessed by an operational system (for example a customer-facing website or the application used by the customer service department) to carry out regular operations of an organization. Operational databases usually use an online transaction processing database which is optimized for faster transaction processing (create, read, update and delete operations). An operational database is the source for a data warehouse.[1]

TYPES

- HTAP databases
- Document-oriented databases
- NewSQL databases
- NoSQL databases
- XML databases
- SQL databases
- Distributed databases

Hybrid transaction/analytical processing (HTAP) is an emerging application architecture that "breaks the wall" between transaction processing and analytics. It enables more informed and "in business real time" decision making.

A **document-oriented database**, or **document store**, is a computer program designed for storing, retrieving and managing document-oriented information, also known as semi-structured data.[1]

Document-oriented databases are one of the main categories of NoSQL databases, and the popularity of the term "document-oriented database" has grown[2] with the use of the term NoSQL itself. XML databases are a subclass of document-oriented databases that are optimized to work with XML documents. Graph databases are similar, but add another layer, the *relationship*, which allows them to link documents for rapid traversal.

Document-oriented databases are inherently a subclass of the key-value store, another NoSQL database concept. The difference lies in the way the data is processed; in a key-value store, the data is considered to be inherently opaque to the database, whereas a document-oriented system relies on internal structure in the *document* in order to extract metadata that the database engine uses for further optimization. Although the difference is often moot due to tools in the systems,[a] conceptually the document-store is designed to offer a richer experience with modern programming techniques.

Document databases[b] contrast strongly with the traditional relational database (RDB). Relational databases generally store data in separate *tables* that are defined by the programmer, and a single object may be spread across several tables. Document databases store all information for a given object in a single instance in the database, and every stored object can be different from every other. This eliminates the need for object-relational mapping while loading data into the database.

NewSQL is a class of relational database management systems that seek to provide the scalability of NoSQL systems for online transaction processing (OLTP) workloads while maintaining the ACID guarantees of a traditional database system.[1][2][3][4]

Many enterprise systems that handle high-profile data (e.g., financial and order processing systems) are too large for conventional relational databases, but have transactional and consistency requirements that are not practical for NoSQL systems.[5][6] The only options previously available for these organizations were to either purchase more powerful computers or to develop custom middleware that distributes requests over conventional DBMS. Both approaches feature high costs and/or development costs. NewSQL systems attempt to reconcile the conflicts.

A **NoSQL** (originally referring to "non SQL" or "non relational")[1] database provides a mechanism for storage and retrieval of data that is modeled in means other than the tabular relations used in relational databases. Such databases have existed since the late 1960s, but did not obtain the "NoSQL" moniker until a surge of popularity in the early 21st century,[2] triggered by the needs of Web 2.0 companies.[3][4][5] NoSQL databases are increasingly used in big data and real-time web applications.[6] NoSQL systems are also sometimes called "Not only SQL" to emphasize that they may support SQL-like query languages, or sit alongside SQL databases in polyglot persistent architectures.[7][8]

Motivations for this approach include: simplicity of design, simpler "horizontal" scaling to clusters of machines (which is a problem for relational databases),[2] finer control over availability and limiting the object-relational impedance mismatch.[9] The data structures used by NoSQL databases (e.g. key-value, wide column, graph, or document) are different from those used by default in relational databases, making some operations faster in NoSQL. The

particular suitability of a given NoSQL database depends on the problem it must solve. Sometimes the data structures used by NoSQL databases are also viewed as "more flexible" than relational database tables.[10]

Many NoSQL stores compromise consistency (in the sense of the CAP theorem) in favor of availability, partition tolerance, and speed. Barriers to the greater adoption of NoSQL stores include the use of low-level query languages (instead of SQL, for instance the lack of ability to perform ad-hoc joins across tables), lack of standardized interfaces, and huge previous investments in existing relational databases.[11] Most NoSQL stores lack true ACID transactions, although a few databases have made them central to their designs.

Instead, most NoSQL databases offer a concept of "eventual consistency" in which database changes are propagated to all nodes "eventually" (typically within milliseconds) so queries for data might not return updated data immediately or might result in reading data that is not accurate, a problem known as stale reads.[12] Additionally, some NoSQL systems may exhibit lost writes and other forms of data loss.[13] Some NoSQL systems provide concepts such as write-ahead logging to avoid data loss.[14] For distributed transaction processing across multiple databases, data consistency is an even bigger challenge that is difficult for both NoSQL and relational databases. Relational databases "do not allow referential integrity constraints to span databases".[15] Few systems maintain both ACID transactions and X/Open XA standards for distributed transaction processing.

Extensible Markup Language (**XML**) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. The World Wide Web Consortium's XML 1.0 Specification[2] and several other related specifications[3]—all of them free open standards—define XML.[4]

The design goals of XML emphasize simplicity, generality, and usability across the Internet.[5] It is a textual data format with strong support via Unicode for different human languages. Although the design of XML focuses on documents, the language is widely used for the representation of arbitrary data structures[6] such as those used in web services.

Several schema systems exist to aid in the definition of XML-based languages, while programmers have developed many application programming interfaces (APIs) to aid the processing of XML data.

Structured Query Language)[5][6][7] is a domain-specific language used in programming and designed for managing data held in a relational database management system (RDBMS), or for stream processing in a relational data stream management system (RDSMS). It is particularly useful in handling structured data, i.e. data incorporating relations among entities and variables.

SQL offers two main advantages over older read–write APIs such as ISAM or VSAM. Firstly, it introduced the concept of accessing many records with one single command. Secondly, it eliminates the need to specify *how* to reach a record, e.g. with or without an index.

Originally based upon relational algebra and tuple relational calculus, SQL consists of many types of statements,[8] which may be informally classed as sublanguages, commonly: a data query language (DQL),[a] a data definition language (DDL),[b] a data control language (DCL), and a data manipulation language (DML).[c][9] The scope of SQL includes data query, data manipulation (insert, update and delete), data definition (schema creation and modification), and data access control. Although SQL is essentially a declarative language (4GL), it includes also procedural elements.

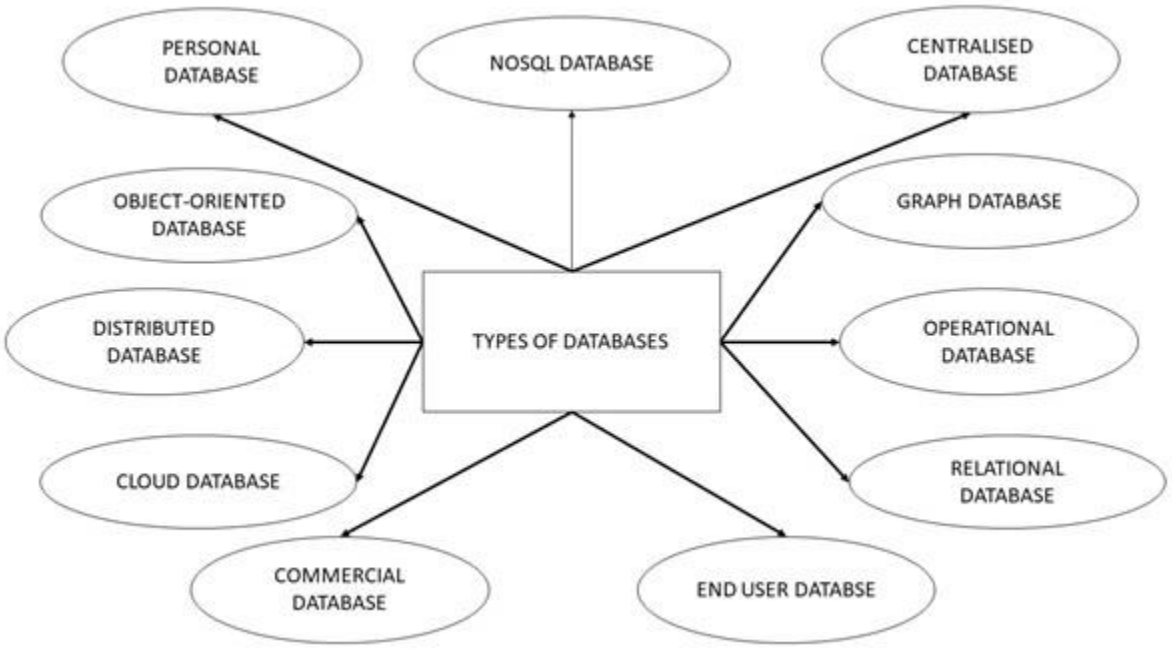
SQL was one of the first commercial languages to utilize Edgar F. Codd's relational model. The model was described in his influential 1970 paper, "A Relational Model of Data for Large Shared Data Banks".[10] Despite not entirely adhering to the relational model as described by Codd, it became the most widely used database language.[11][12]

SQL became a standard of the American National Standards Institute (ANSI) in 1986, and of the International Organization for Standardization (ISO) in 1987.[13] Since then, the standard has been revised to include a larger set of features. Despite the existence of such standards, most SQL code is not completely portable among different database systems without adjustments.

Types of databases

Depending upon the usage requirements, there are following types of databases available in the market:

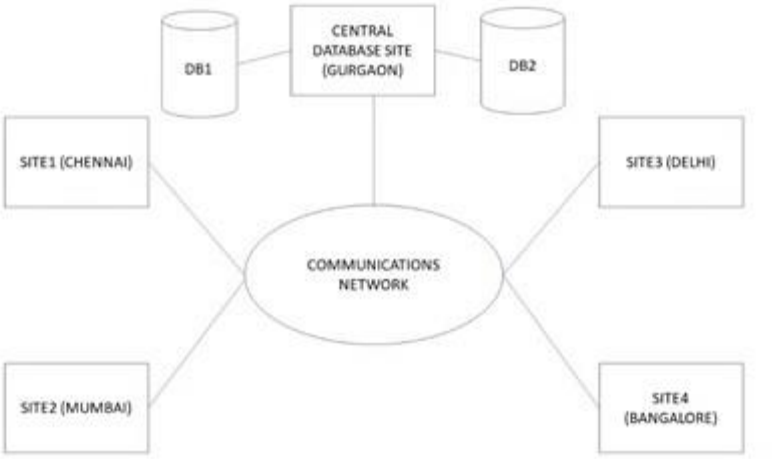
1. Centralised database.
2. Distributed database.
3. Personal database.
4. End-user database.
5. Commercial database.
6. NoSQL database.
7. Operational database.
8. Relational database.
9. Cloud database.
10. Object-oriented database.
11. Graph database.



1. Centralised Database

The information(data) is stored at a centralized location and the users from different locations can access this data. This type of database contains application procedures that help the users to access the data even from a remote location.

Various kinds of authentication procedures are applied for the verification and validation of end users, likewise, a registration number is provided by the application procedures which keeps a track and record of data usage. The local area office handles this thing.

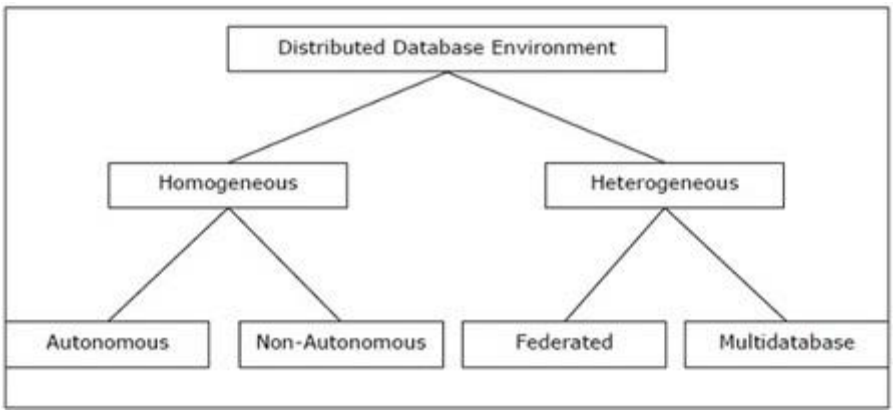


2. Distributed Database

Just opposite of the centralized database concept, the distributed database has contributions from the common database as well as the information captured by local computers also. The data is not at one place and is distributed at various sites of an organization. These sites are connected to each other with the help of communication links which helps them to access the distributed data easily.

You can imagine a distributed database as a one in which various portions of a database are stored in multiple different locations(physical) along with the application procedures which are replicated and distributed among various points in a network.

There are two kinds of distributed database, viz. homogenous and heterogeneous. The databases which have same underlying hardware and run over same operating systems and application procedures are known as homogeneous DDB, for eg. All physical locations in a DDB. Whereas, the operating systems, underlying hardware as well as application procedures can be different at various sites of a DDB which is known as heterogeneous DDB.



3.Personal Database

Data is collected and stored on personal computers which is small and easily manageable. The data is generally used by the same department of an organization and is accessed by a small group of people.

4.End User Database

The end user is usually not concerned about the transaction or operations done at various levels and is only aware of the product which may be a software or an application. Therefore, this is a shared database which is specifically designed for the end user, just like different levels' managers. Summary of whole information is collected in this database.

5.Commercial Database

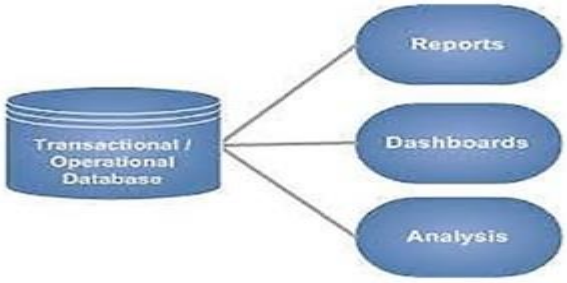
These are the paid versions of the huge databases designed uniquely for the users who want to access the information for help. These databases are subject specific, and one cannot afford to maintain such a huge information. Access to such databases is provided through commercial links.

6.NoSQL Database

These are used for large sets of distributed data. There are some big data performance issues which are effectively handled by relational databases, such kind of issues are easily managed by NoSQL databases. There are very efficient in analyzing large size unstructured data that may be stored at multiple virtual servers of the cloud.

7.Operational Database

Information related to operations of an enterprise is stored inside this database. Functional lines like marketing, employee relations, customer service etc. require such kind of databases.

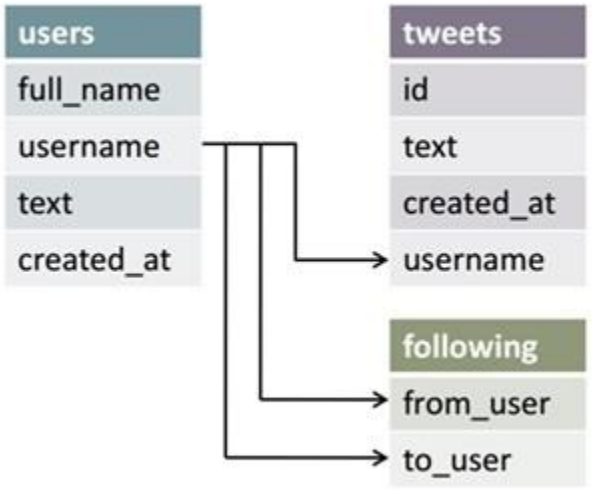


8.Relational Databases

These databases are categorized by a set of tables where data gets fit into a pre-defined category. The table consists of rows and columns where the column has an entry for data for a

specific category and rows contains instance for that data defined according to the category. The Structured Query Language (SQL) is the standard user and application program interface for a relational database.

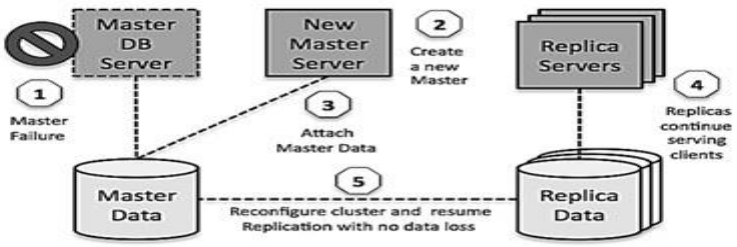
There are various simple operations that can be applied over the table which makes these databases easier to extend, join two databases with a common relation and modify all existing applications.



9.Cloud Databases

Now a day, data has been specifically getting stored over clouds also known as a virtual environment, either in a hybrid cloud, public or private cloud. A cloud database is a database that has been optimized or built for such a virtualized environment. There are various benefits of a cloud database, some of which are the ability to pay for storage capacity and bandwidth on a per-user basis, and they provide scalability on demand, along with high availability.

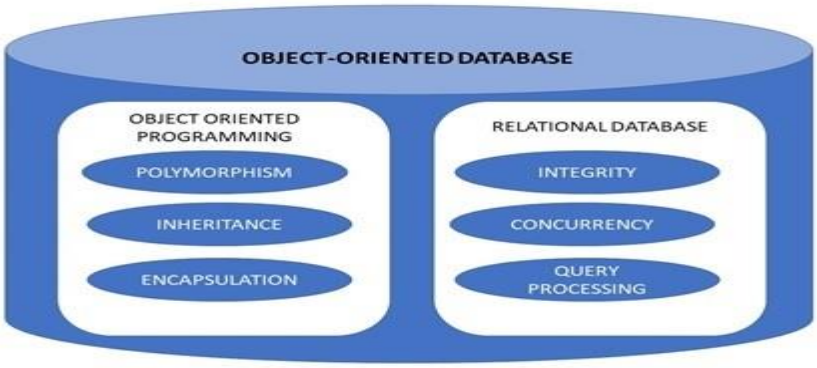
A cloud database also gives enterprises the opportunity to support business applications in a software-as-a-service deployment.



10. Object-Oriented Databases

An object-oriented database is a collection of object-oriented programming and relational database. There are various items which are created using object-oriented programming languages like C++, Java which can be stored in relational databases, but object-oriented databases are well-suited for those items.

An object-oriented database is organized around objects rather than actions, and data rather than logic. For example, a multimedia record in a relational database can be a definable data object, as opposed to an alphanumeric value.



11.Graph Databases

The graph is a collection of nodes and edges where each node is used to represent an entity and each edge describes the relationship between entities. A graph-oriented database, or graph database, is a type of NoSQL database that uses graph theory to store, map and query relationships.

Graph databases are basically used for analyzing interconnections. For example, companies might use a graph database to mine data about customers from social media.

UNIT-III

PROJECT MANAGEMENT

Project management is the practice of initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria at the specified time.The primary challenge of project management is to achieve all of the project goals within the given constraints.[1] This information is usually described in project documentation, created at the beginning of the development process. The primary constraints are scope, time, quality and budget.[2] The secondary—and more ambitious—challenge is to optimize the allocation of necessary inputs and apply them to meet pre-defined objectives.

The object of project management is to produce a complete project which complies with the client's objectives. In many cases the object of project management is also to shape or reform the client's brief in order to feasibly be able to address the client's objectives. Once the client's objectives are clearly established they should influence all decisions made by other people involved in the project – for example project managers, designers, contractors and sub-contractors. Ill-defined or too tightly prescribed project management objectives are detrimental to decision making.

A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end (usually time-constrained, and often constrained by funding or staffing) undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value.[3][4] The temporary nature of projects stands in contrast with business as usual (or operations),[5] which are repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of such distinct production approaches requires the development of distinct technical skills and management strategies

A project is **temporary** in that it has a defined beginning and end in time, and therefore defined scope and resources.

And a project is **unique** in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. So a project team often includes people who don't usually work together – sometimes from different organizations and across multiple geographies.

The development of software for an improved business process, the construction of a building or bridge, the relief effort after a natural disaster, the expansion of sales into a new geographic market — all are projects.

And all must be expertly managed to deliver the on-time, on-budget results, learning and integration that organizations need.

Project management, then, is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

It has always been practiced informally, but began to emerge as a distinct profession in the mid-20th century. PMI's *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* identifies its recurring elements:

Project management processes fall into five groups:

1. Initiating
2. Planning
3. Executing
4. Monitoring and Controlling
5. Closing

Project management knowledge draws on ten areas:

1. Integration
2. Scope
3. Time
4. Cost
5. Quality
6. Procurement
7. Human resources
8. Communications
9. Risk management
10. Stakeholder management

All management is concerned with these, of course. But project management brings a unique focus shaped by the goals, resources and schedule of each project. The value of that focus is proved by the rapid, worldwide growth of project management:

- as a recognized and strategic organizational competence
- as a subject for training and education
- as a career path

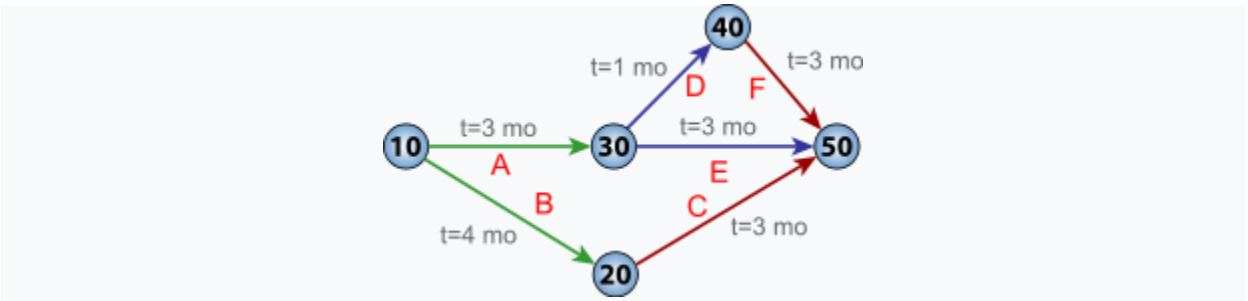
Until 1900, civil engineering projects were generally managed by creative architects, engineers, and master builders themselves.
In the 1950s organizations started to systematically apply project-management tools and techniques to complex engineering projects

As a discipline, project management developed from several fields of application including civil construction, engineering, and heavy defense activity.[9] Two forefathers of project management are Henry Gantt, called the father of planning and control techniques,[10] who is famous for his use of the Gantt chart as a project management tool (alternatively *Harmonogram* first proposed by Karol Adamiecki[11]); and Henri Fayol for his creation of the five management functions that form the foundation of the body of knowledge associated with project and program management.[12] Both Gantt and Fayol were students of Frederick Winslow Taylor's theories of scientific management. His work is the forerunner to modern project management tools including work breakdown structure (WBS) and resource allocation.

The 1950s marked the beginning of the modern project management era where core engineering fields come together to work as one. Project management became recognized as a distinct discipline arising from the management discipline with engineering model.[13] In the United States, prior to the 1950s, projects were managed on an ad-hoc basis, using mostly Gantt charts and informal techniques and tools. At that time, two mathematical project-scheduling models were developed. The "critical path method" (CPM) was developed as a joint venture between DuPont Corporation and Remington Rand Corporation for managing plant

maintenance projects. The "program evaluation and review technique" (PERT), was developed by the U.S. Navy Special Projects Office in conjunction with the Lockheed Corporation and Booz Allen Hamilton as part of the Polaris missile submarine program.[14]

PERT and CPM are very similar in their approach but still present some differences. CPM is used for projects that assume deterministic activity times; the times at which each activity will be carried out are known. PERT, on the other hand, allows for stochastic activity times; the times at which each activity will be carried out are uncertain or varied. Because of this core difference, CPM and PERT are used in different contexts. These mathematical techniques quickly spread into many private enterprises.



PERT network chart for a seven-month project with five milestones

At the same time, as project-scheduling models were being developed, technology for project cost estimating, cost management and engineering economics was evolving, with pioneering work by Hans Lang and others. In 1956, the American Association of Cost Engineers (now AACE International; the Association for the Advancement of Cost Engineering) was formed by early practitioners of project management and the associated specialties of planning and scheduling, cost estimating, and cost/schedule control (project control). AACE continued its pioneering work and in 2006 released the first integrated process for portfolio, program and project management (total cost management framework).

In 1969, the Project Management Institute (PMI) was formed in the USA.[15] PMI publishes *A Guide to the Project Management Body of Knowledge* (PMBOK Guide), which describes project management practices that are common to "most projects, most of the time." PMI also offers a range of certifications.

Project management types[edit]

Project management methods can be applied to any project. It is often tailored to a specific type of projects based on project size, nature and industry. For example, the construction industry, which focuses on the delivery of things like buildings, roads, and bridges, has developed its own specialized form of project management that it refers to as *construction project management* and in which project managers can become trained and certified.[16] The information technology industry has also evolved to develop its own form of project management that is referred to as *IT project management* and which specializes in the delivery of technical assets and services that are required to pass through various lifecycle phases such as planning, design, development, testing, and deployment. *Biotechnology project management* focuses on the intricacies of biotechnology research and development.[17] *Localization project management* includes many standard project management practices even though many consider this type of management to be a very different discipline. It focuses on three important goals: time, quality and budget. Successful projects are completed on schedule, within budget, and according to previously agreed quality standards.[18]

For each type of project management, project managers develop and utilize repeatable templates that are specific to the industry they're dealing with. This allows project plans to become very

thorough and highly repeatable, with the specific intent to increase quality, lower delivery costs, and lower time to deliver project results.

Approaches[edit]

A 2017 study suggested that the success of any project depends on how well four key aspects are aligned with the contextual dynamics affecting the project, these are referred to as the *four P's*.[19]

- *Plan*: The planning and forecasting activities.
- *Process:* The overall approach to all activities and project governance.
- *People:* Including dynamics of how they collaborate and communicate.
- *Power:* Lines of authority, decision-makers, organograms, policies for implementation and the like.

There are a number of approaches to organizing and completing project activities, including: phased, lean, iterative, and incremental. There are also several extensions to project planning, for example based on outcomes (product-based) or activities (process-based).

Regardless of the methodology employed, careful consideration must be given to the overall project objectives, timeline, and cost, as well as the roles and responsibilities of all participants and stakeholders.[20]

Benefits realization management[edit]

Main article: Benefits realisation management

Benefits realization management (BRM) enhances normal project management techniques through a focus on outcomes (benefits) of a project rather than products or outputs, and then measuring the degree to which that is happening to keep a project on track. This can help to reduce the risk of a completed project being a failure by delivering agreed upon requirements/outputs but failing to deliver the ***benefits*** of those requirements.

In addition, BRM practices aim to ensure the alignment between project outcomes and business strategies. The effectiveness of these practices is supported by recent research evidencing BRM practices influencing project success from a strategic perspective across different countries and industries.[21]

An example of delivering a project to requirements might be agreeing to deliver a computer system that will process staff data and manage payroll, holiday and staff personnel records. Under BRM the agreement might be to achieve a specified reduction in staff hours required to process and maintain staff data.

Critical chain project management[edit]

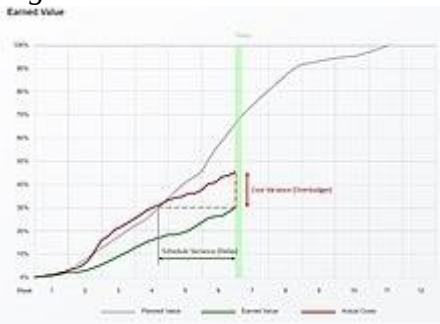
Main article: Critical chain project management

Critical chain project management (CCPM) is an application of the theory of constraints (TOC) to planning and managing projects, and is designed to deal with the uncertainties inherent in managing projects, while taking into consideration limited availability of resources (physical, human skills, as well as management & support capacity) needed to execute projects.

The goal is to increase the flow of projects in an organization (throughput). Applying the first three of the five focusing steps of TOC, the system constraint for all projects, as well as the resources, are identified. To exploit the constraint, tasks on the critical chain are given priority over all other activities. Finally, projects are planned and managed to ensure that the resources are ready when the critical chain tasks must start, subordinating all other resources to the critical chain.

Earned value management[edit]

Main article: Earned value management



Earned Value chart shows Planned Value, Earned Value, Actual Cost, and their variances in percent. The approach is used in project management simulation SimulTrain.

Earned value management (EVM) extends project management with techniques to improve project monitoring. It illustrates project progress towards completion in terms of work and value (cost). Earned Schedule is an extension to the theory and practice of EVM. This theory was introduced in 2019. [22]

Iterative and incremental project management[edit]

See also: Iterative and incremental development

In critical studies of project management, it has been noted that phased approaches are not well suited for projects which are large-scale and multi-company,[23] with undefined, ambiguous, or fast-changing requirements,[24] or those with high degrees of risk, dependency, and fast-changing technologies.[25] The cone of uncertainty explains some of this as the planning made on the initial phase of the project suffers from a high degree of uncertainty. This becomes especially true as software development is often the realization of a new or novel product.

These complexities are better handled with a more exploratory or iterative and incremental approach.[26] Several models of iterative and incremental project management have evolved, including agile project management, dynamic systems development method, extreme project management, and Innovation Engineering®.[27]

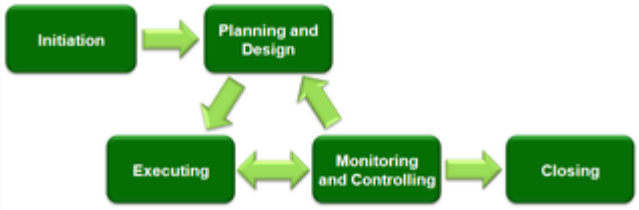
Lean project management[edit]

Main article: Lean project management

Lean project management uses the principles from lean manufacturing to focus on delivering value with less waste and reduced time

Phased approach[edit]

The phased (or staged) approach breaks down and manages the work through a series of distinct steps to be completed, and is often referred to as "traditional"[28] or "waterfall".[29] Although it can vary, it typically consists of five process areas, four phases plus control:



Typical development phases of an engineering project

1. initiation
2. planning and design
3. construction
4. monitoring and controlling
5. completion or closing

Many industries use variations of these project stages and it is not uncommon for the stages to be renamed in order to better suit the organization. For example, when working on a brick-and-mortar design and construction, projects will typically progress through stages like pre-planning, conceptual design, schematic design, design development, construction drawings (or contract documents), and construction administration.

While the phased approach works well for small, well-defined projects, it often results in challenge or failure on larger projects, or those that are more complex or have more ambiguities, issues and risk.[30]

Process-based management[edit]
Main article: Process-based management

The incorporation of process-based management has been driven by the use of maturity models such as the OPM3 and the CMMI (capability maturity model integration; see this example of a predecessor) and ISO/IEC 15504 (SPICE – software process improvement and capability estimation). Unlike SEI's CMM, the OPM3 maturity model describes how to make project management processes capable of performing successfully, consistently, and predictably in order to enact the strategies of an organization.

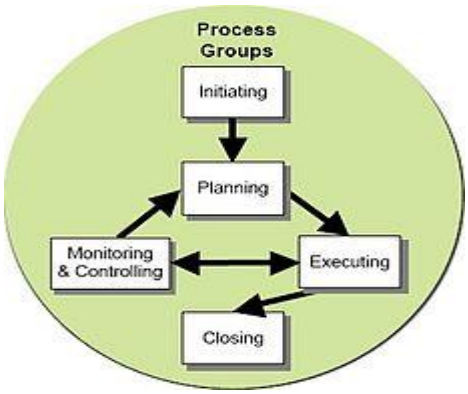
Project production management[edit]
Main article: Project production management

Project production management is the application of operations management to the delivery of capital projects. The Project production management framework is based on a project as a production system view, in which a project transforms inputs (raw materials, information, labor, plant & machinery) into outputs (goods and services).[31]

Product-based planning[edit]
Main article: Product-based planning

Product-based planning is a structured approach to project management, based on identifying all of the products (project deliverables) that contribute to achieving the project objectives. As such, it defines a successful project as output-oriented rather than activity- or task-oriented.[32] The most common implementation of this approach is PRINCE2.[33]

Process groups



The project development stages

Traditionally (depending on what project management methodology is being used), project management includes a number of elements: four to five project management process groups, and a control system. Regardless of the methodology or terminology used, the same basic project management processes or stages of development will be used. Major process groups generally include:[2]

- Initiation
- Planning
- Production or execution
- Monitoring and controlling
- Closing

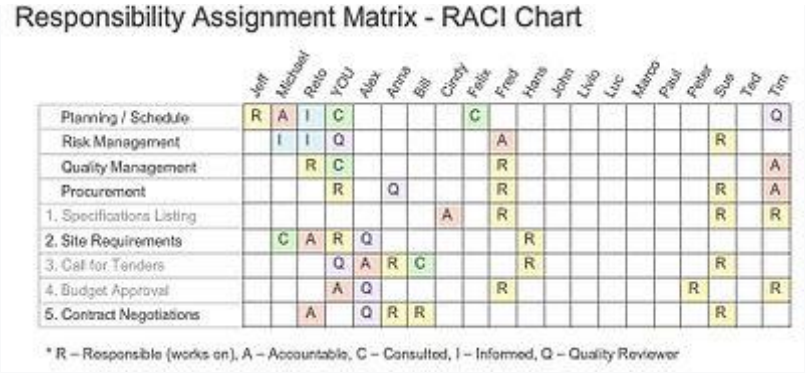
In project environments with a significant exploratory element (e.g., research and development), these stages may be supplemented with decision points (go/no go decisions) at which the project's continuation is debated and decided. An example is the Phase–gate model.

Initiating

Initiating process group processes[34]

The initiating processes determine the nature and scope of the project.[35] If this stage is not performed well, it is unlikely that the project will be successful in meeting the business' needs. The key project controls needed here are an understanding of the business environment and making sure that all necessary controls are incorporated into the project. Any deficiencies should be reported and a recommendation should be made to fix them.

The initiating stage should include a plan that encompasses the following areas. These areas can be recorded in a series of documents called Project Initiation documents. Project Initiation documents are a series of planned documents used to create order for the duration of the project. These tend to include:



RACI(Q) chart. At least one *Responsible* and exactly one *Accountable* person are designated for each project and planning activity.

- project proposal (idea behind project, overall goal, duration)
- project scope (project direction and track)

- product breakdown structure (PBS) (a hierarchy of deliverables / outcomes and components thereof)
- work breakdown structure (WBS) (a hierarchy of the work to be done, down to daily tasks)
- responsibility assignment matrix (RACI) (roles and responsibilities aligned to deliverables / outcomes)
- tentative project schedule (milestones, important dates, deadlines)
- analysis of business needs and requirements against measurable goals
- review of the current operations
- financial analysis of the costs and benefits, including a budget
- stakeholder analysis, including users and support personnel for the project
- project charter including costs, tasks, deliverables, and schedules
- SWOT analysis: strengths, weaknesses, opportunities, and threats to the business

Planning

After the initiation stage, the project is planned to an appropriate level of detail (see example of a flow-chart).[34] The main purpose is to plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution. As with the Initiation process group, a failure to adequately plan greatly reduces the project's chances of successfully accomplishing its goals.

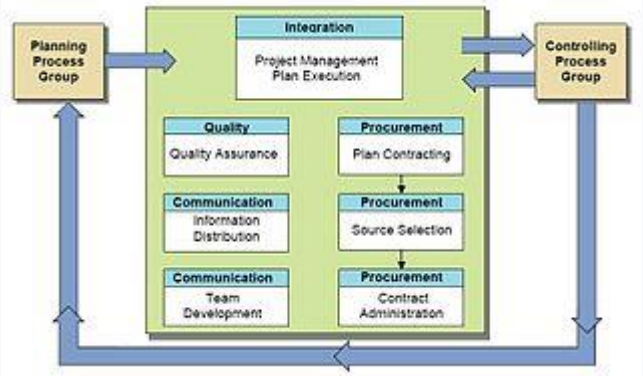
Project planning generally consists of[36]

- determining the project management methodology to follow (e.g. whether the plan will be defined wholly up front, iteratively, or in rolling waves);
- developing the scope statement;
- selecting the planning team;
- identifying deliverables and creating the product and work breakdown structures;
- identifying the activities needed to complete those deliverables and networking the activities in their logical sequence;
- estimating the resource requirements for the activities;
- estimating time and cost for activities;
- developing the schedule;
- developing the budget;
- risk planning;
- developing quality assurance measures;
- gaining formal approval to begin work.

Additional processes, such as planning for communications and for scope management, identifying roles and responsibilities, determining what to purchase for the project and holding a kick-off meeting are also generally advisable.

For new product development projects, conceptual design of the operation of the final product may be performed concurrent with the project planning activities, and may help to inform the planning team when identifying deliverables and planning activities.

Executing



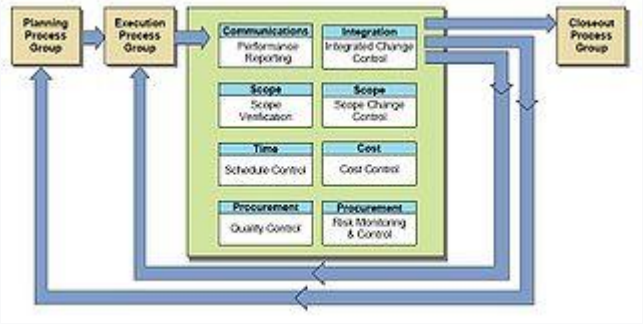
Executing process group processes

While executing we must know what are the planned terms that need to be executed. The execution/implementation phase ensures that the project management plan's deliverables are executed accordingly. This phase involves proper allocation, co-ordination and management of human resources and any other resources such as material and budgets. The output of this phase is the project deliverables.

Project Documentation

Documenting everything within a project is key to being successful. In order to maintain budget, scope, effectiveness and pace a project must have physical documents pertaining to each specific task. With correct documentation, it is easy to see whether or not a project's requirement has been met. To go along with that, documentation provides information regarding what has already been completed for that project. Documentation throughout a project provides a paper trail for anyone who needs to go back and reference the work in the past. In most cases, documentation is the most successful way to monitor and control the specific phases of a project. With the correct documentation, a project's success can be tracked and observed as the project goes on. If performed correctly documentation can be the backbone to a project's success.

Monitoring and controlling



Monitoring and controlling process group processes

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan.

Monitoring and controlling includes:

- Measuring the ongoing project activities ('where we are');

- Monitoring the project variables (cost, effort, scope, etc.) against the project management plan and the project performance baseline (*where we should be*);
- Identifying corrective actions to address issues and risks properly (*How can we get on track again*);
- Influencing the factors that could circumvent integrated change control so only approved changes are implemented.

In multi-phase projects, the monitoring and control process also provides feedback between project phases, in order to implement corrective or preventive actions to bring the project into compliance with the project management plan.

Project maintenance is an ongoing process, and it includes:

- Continuing support of end-users
- Correction of errors
- Updates to the product over time

Monitoring and controlling cycle

In this stage, auditors should pay attention to how effectively and quickly user problems are resolved.

Over the course of any construction project, the work scope may change. Change is a normal and expected part of the construction process. Changes can be the result of necessary design modifications, differing site conditions, material availability, contractor-requested changes, value engineering and impacts from third parties, to name a few. Beyond executing the change in the field, the change normally needs to be documented to show what was actually constructed. This is referred to as change management. Hence, the owner usually requires a final record to show all changes or, more specifically, any change that modifies the tangible portions of the finished work. The record is made on the contract documents – usually, but not necessarily limited to, the design drawings. The end product of this effort is what the industry terms as-built drawings, or more simply, "as built." The requirement for providing them is a norm in construction contracts. Construction document management is a highly important task undertaken with the aid of an online or desktop software system, or maintained through physical documentation. The increasing legality pertaining to the construction industry's maintenance of correct documentation has caused the increase in the need for document management systems.

When changes are introduced to the project, the viability of the project has to be re-assessed. It is important not to lose sight of the initial goals and targets of the projects. When the changes accumulate, the forecasted result may not justify the original proposed investment in the project. Successful project management identifies these components, and tracks and monitors progress so as to stay within time and budget frames already outlined at the commencement of the project.

Closing

Closing process group processes.

Closing includes the formal acceptance of the project and the ending thereof. Administrative activities include the archiving of the files and documenting lessons learned.

This phase consists of

- **Contract closure**: Complete and settle each contract (including the resolution of any open items) and close each contract applicable to the project or project phase.
- **Project close**: Finalize all activities across all of the process groups to formally close the project or a project phase

Also included in this phase is the Post Implementation Review. This is a vital phase of the project for the project team to learn from experiences and apply to future projects. Normally a Post Implementation Review consists of looking at things that went well and analyzing things that went badly on the project to come up with lessons learned.

Project controlling and project control systems

Project controlling (also known as Cost Engineering) should be established as an independent function in project management. It implements verification and controlling function during the processing of a project in order to reinforce the defined performance and formal goals.[38] The tasks of project controlling are also:

- the creation of infrastructure for the supply of the right information and its update
- the establishment of a way to communicate disparities of project parameters
- the development of project information technology based on an intranet or the determination of a project key performance indicator system (KPI)
- divergence analyses and generation of proposals for potential project regulations[39]
- the establishment of methods to accomplish an appropriate project structure, project workflow organization, project control and governance
- creation of transparency among the project parameters[40]

Fulfillment and implementation of these tasks can be achieved by applying specific methods and instruments of project controlling. The following methods of project controlling can be applied:

- investment analysis
- cost–benefit analysis
- value benefit analysis
- expert surveys
- simulation calculations
- risk-profile analysis
- surcharge calculations
- milestone trend analysis
- cost trend analysis
- target/actual-comparison[41]

Project control is that element of a project that keeps it on track, on-time and within budget.[37] Project control begins early in the project with planning and ends late in the project with post-implementation review, having a thorough involvement of each step in the process. Projects may be audited or reviewed while the project is in progress. Formal audits are generally risk or compliance-based and management will direct the objectives of the audit. An examination may include a comparison of approved project management processes with how the project is actually being managed.[42] Each project should be assessed for the appropriate level of control needed: too much control is too time consuming, too little control is very risky. If project control is not implemented correctly, the cost to the business should be clarified in terms of errors and fixes.

Control systems are needed for cost, risk, quality, communication, time, change, procurement, and human resources. In addition, auditors should consider how important the projects are to the financial statements, how reliant the stakeholders are on controls, and how many controls exist. Auditors should review the development process and procedures for how they are implemented. The process of development and the quality of the final product may also be assessed if needed or requested. A business may want the auditing firm to be involved throughout the process to catch problems earlier on so that they can be fixed more easily. An auditor can serve as a controls consultant as part of the development team or as an independent auditor as part of an audit.

Businesses sometimes use formal systems development processes. These help assure systems are developed successfully. A formal process is more effective in creating strong controls, and auditors should review this process to confirm that it is well designed and is followed in practice. A good formal systems development plan outlines:

- A strategy to align development with the organization's broader objectives
- Standards for new systems
- Project management policies for timing and budgeting
- Procedures describing the process
- Evaluation of quality of change

Characteristics of projects

There are five important characteristics of a project. (i) It should always have a specific start and end dates. (ii) They are performed and completed by a group of people. (iii) The output is delivery on unique product or service. (iv) They are temporary in nature. (v) It is progressively elaborated. example: Designing a new car, writing a book.

Project Complexity

Complexity and its nature plays an important role in the area of project management. Despite having number of debates on this subject matter, studies suggest lack of definition and reasonable understanding of complexity in relation to management of complex projects.[43] As it is considered that project complexity and project performance are closely related, it is important to define and measure complexity of the project for project management to be effective.[44]

By applying the discovery in measuring work complexity described in Requisite Organization and Stratified Systems Theory, Dr Elliott Jaques classifies projects and project work (stages, tasks) into basic 7 levels of project complexity based on such criteria as time-span of discretion and complexity of a project's output:[45][46]

- Level 1 Project – improve the direct output of an activity (quantity, quality, time) within a business process with targeted completion time up to 3 months.
- Level 2 Project – develop and improve compliance to a business process with targeted completion time from 3 months to 1 year.
- Level 3 Project – develop, change and improve a business process with targeted completion time from 1 to 2 years.
- Level 4 Project – develop, change and improve a functional system with targeted completion time from 2 to 5 years.
- Level 5 Project – develop, change and improve a group of functional systems / business function with targeted completion time from 5 to 10 years.
- Level 6 Project – develop, change and improve a whole single value chain of a company with targeted completion time from 10 to 20 years.
- Level 7 Project – develop, change and improve multiple value chains of a company with target completion time from 20 to 50 years.[47]

Benefits from measuring Project Complexity is to improve project people feasibility by:[48]

- Match the level of a project's complexity with effective targeted completion time of a project
- Match the level of a project's complexity with the respective capability level of the project manager
- Match the level of a project task's complexity with the respective capability of the project members

Project managers

A project manager is a professional in the field of project management. Project managers are in charge of the people in a project. People are the key to any successful project. Without the correct people in the right place and at the right time a project cannot be successful. Project managers can have the responsibility of the planning, execution, controlling, and closing of any project typically relating to the construction industry, engineering, architecture, computing, and telecommunications. Many other fields of production engineering, design engineering, and heavy industrial have project managers.

A project manager needs to understand the order of execution of a project to schedule the project correctly as well as the time necessary to accomplish each individual task within the project. A project manager is the person accountable for accomplishing the stated project objectives. Project Managers tend to have multiple years' experience in their field. A project manager is required to know the project in and out while supervising the workers along with the project. Typically in most construction, engineering, architecture and industrial projects, a project manager has another manager working alongside of them who is typically responsible for the execution of task on a daily basis. This position in some cases is known as a superintendent. A superintendent and project manager work hand in hand in completing daily project task. Key project management responsibilities include creating clear and attainable project objectives, building the project requirements, and managing the triple constraint (now including more constraints and calling it competing constraints) for projects, which is cost, time, and scope for the first three but about three additional ones in current project management. A typical project is composed of a team of workers who work under the project manager to complete the assignment. A project manager normally reports directly to someone of higher stature on the completion and success of the project.

A project manager is often a client representative and has to determine and implement the exact needs of the client, based on knowledge of the firm they are representing. The ability to adapt to the various internal procedures of the contracting party, and to form close links with the nominated representatives, is essential in ensuring that the key issues of cost, time, quality and above all, client satisfaction, can be realized.

Project management success criteria

There is a tendency to confuse the project success with project management success. They are two different things. Project management success criteria is different from project success criteria. The project management is said to be successful if the given project is completed within the agreed upon time, met the agreed upon scope and within the agreed upon budget. Meanwhile, a project is said to be successful, when it succeeds in achieving the expected business case.

Risk management

Main article: Project risk management

An example of the Risk Register that includes 4 steps: Identify, Analyze, Plan Response, Monitor and Control.

The United States Department of Defense states; "Cost, Schedule, Performance, and Risk" are the four elements through which Department of Defense acquisition professionals make trade-offs and track program status. There are also international standards. Risk management applies proactive identification (see tools) of future problems and understanding of their consequences allowing predictive decisions about projects.

Work breakdown structure

The work breakdown structure (WBS) is a tree structure that shows a subdivision of the activities required to achieve an objective – for example a program, project, and contract. The WBS may be hardware-, product-, service-, or process-oriented (see an example in a NASA reporting structure (2001)).

A WBS can be developed by starting with the end objective and successively subdividing it into manageable components in terms of size, duration, and responsibility (e.g., systems, subsystems, components, tasks, sub-tasks, and work packages), which include all steps necessary to achieve the objective.

The work breakdown structure provides a common framework for the natural development of the overall planning and control of a contract and is the basis for dividing work into definable increments from which the statement of work can be developed and technical, schedule, cost, and labor hour reporting can be established.[51] The work breakdown structure can be displayed in two forms, as a table with subdivision of tasks or as an organisational chart whose lowest nodes are referred to as "work packages".

It is an essential element in assessing the quality of a plan, and an initial element used during the planning of the project. For example, a WBS is used when the project is scheduled, so that the use of work packages can be recorded and tracked.

International standards

There are several project management standards, including:

- The ISO standards ISO 9000, a family of standards for quality management systems, and the ISO 10006:2003, for Quality management systems and guidelines for quality management in projects.
- ISO 21500:2012 – *Guidance on project management*. This is the first International Standard related to project management published by ISO. Other standards in the 21500 family include 21503:2017 *Guidance on programme management*; 21504:2015 *Guidance on portfolio management*; 21505:2017 *Guidance on governance*; 21506:2018 *Vocabulary*; 21508:2018 *Earned value management in project and programme management*; and 21511:2018 *Work breakdown structures for project and programme management.*
- ISO 31000:2009 – Risk management.
- ISO/IEC/IEEE 16326:2009 – Systems and Software Engineering—Life Cycle Processes—Project Management[52]

- Association for Project Management Body of Knowledge[53]
- Australian Institute of Project Management (AIPM) has 4 levels of certification; CPPP, CPPM, CPPD & CPPE for Certified Practicing Project ... Partner, Manager, Director and Executive.
- Capability Maturity Model from the Software Engineering Institute.
- A Guide to the Project Management Body of Knowledge (*PMBOK Guide*) from the Project Management Institute (PMI)
- GAPPS, Global Alliance for Project Performance Standards – an open source standard describing COMPETENCIES for project and program managers.
- HERMES method, Swiss general project management method, selected for use in Luxembourg and international organizations.
- International Project Management Association Individual Competence Baseline[54]
- The logical framework approach, which is popular in international development organizations.
- PRINCE2 (Projects in Controlled Environments).
- Team Software Process (TSP) from the Software Engineering Institute.
- Total Cost Management Framework, AACE International's Methodology for Integrated Portfolio, Program and Project Management.
- V-Model, an original systems development method.

Project portfolio management

Main article: Project portfolio management

An increasing number of organizations are using what is referred to as project portfolio management (PPM) as a means of selecting the right projects and then using project management techniques[55] as the means for delivering the outcomes in the form of benefits to the performing private or not-for-profit organization. PPM is usually performed by a dedicated team of managers organized by within a Project Management Office (PMO), usually based within the organization.

Project management software

Main articles: Project management software and Project management information system

Project management software is software used to help plan, organize, and manage resource pools, develop resource estimates and implement plans. Depending on the sophistication of the

software, functionality may include estimation and planning, scheduling, cost control and budget management, resource allocation, collaboration software, communication, decision-making, workflow, risk, quality, documentation and/or administration systems.[56][57]

Virtual project management

Main article: Virtual team

Virtual program management (VPM) is management of a project done by a virtual team, though it rarely may refer to a project implementing a virtual environment[58] It is noted that managing a virtual project is fundamentally different from managing traditional projects,[59] combining concerns of telecommuting and global collaboration (culture, timezones, language).[60]

The Role of Project Managers

In the project life cycle, the most influential factors affecting the outcome of the project often reside at the early stages. At this point, decisions should be based on competent economic evaluation with due consideration for adequate financing, the prevalent social and regulatory environment, and technological considerations. Architects and engineers might specialize in planning, in construction field management, or in operation, but as project managers, they must have some familiarity with all such aspects in order to understand properly their role and be able to make competent decisions.

Since the 1970's, many large-scale projects have run into serious problems of management, such as cost overruns and long schedule delays. Actually, the management of megaprojects or superprojects is not a practice peculiar to our time. Witness the construction of transcontinental railroads in the Civil War era and the construction of the Panama Canal at the turn of this century. Although the megaprojects of this generation may appear in greater frequency and present a new set of challenge, the problems are organizational rather than technical. As noted by Hardy Cross.

It is customary to think of engineering as a part of a trilogy, pure science, applied science and engineering. It needs emphasis that this trilogy is only one of a triad of trilogies into which engineering fits. This first is pure science, applied science and engineering; the second is economic theory, finance and engineering; and the third is social relations, industrial relations and engineering. Many engineering problems are as closely allied to social problems as they are to pure science.

As engineers advance professionally, they often spend as much or more time on planning, management and other economic or social problems as on the traditional engineering design and analysis problems which form the core of most educational programs. It is upon the ability of engineers to tackle all such problems that their performance will ultimately be judged.

The greatest stumbling block to effective management in construction is the inertia and historic divisions among planners, designers and constructors. While technical competence in design and innovation remains the foundation of engineering practice, the social, economic and organizational factors that are pervasive in influencing the success and failure of construction projects must also be dealt with effectively by design and construction organizations. Of course, engineers are not expected to know every detail of management techniques, but they must be knowledgeable enough to anticipate the problems of management so that they can work harmoniously with professionals in related fields to overcome the inertia and historic divisions.

Paradoxically, engineers who are creative in engineering design are often innovative in planning and management since both types of activities involve problem solving. In fact, they can reinforce each other if both are included in the education process, provided that creativity and innovation instead of routine practice are emphasized. A project manager who is well educated

in the fundamental principles of engineering design and management can usefully apply such principles once he or she has acquired basic understanding of a new application area. A project manager who has been trained by rote learning for a specific type of project may merely gain one year of experience repeated twenty times even if he or she has been in the field for twenty years. A broadly educated project manager can reasonably hope to become a leader in the profession; a narrowly trained project manager is often relegated to the role of his or her first job level permanently.

The owners have much at stake in selecting a competent project manager and in providing her or him with the authority to assume responsibility at various stages of the project regardless of the types of contractual agreements for implementing the project. Of course, the project manager must also possess the leadership quality and the ability to handle effectively intricate interpersonal relationships within an organization. The ultimate test of the education and experience of a project manager for construction lies in her or his ability to apply fundamental principles to solving problems in the new and unfamiliar situations which have become the hallmarks of the changing environment in the construction industry.

A project is an activity to meet the creation of a unique product or service and thus activities that are undertaken to accomplish routine activities cannot be considered projects. For instance, if your project is less than three months old and has fewer than 20 people working on it, you may not be working in what is called a project according to the definition of the term.

It has to be remembered that the term temporary does not apply to the result or service that is generated by the project. The project may be finite but not the result. For instance, a project to build a monument would be of fixed duration whereas the result that is the monument may be for an indefinite period in time.

A project is an activity to create something unique. Of course, many of the office buildings that are built are similar in many respects but each individual facility is unique in its own way.

Finally, a project must be progressively elaborated. This means that the project progresses in steps and continues by increments. This also means that the definition of the project is refined at each step and ultimately the purpose of the progress is enunciated. This means that a project is first defined initially and then as the project progresses, the definition is revisited and more clarity is added to the scope of the project as well as the underlying assumptions about the project.

What are the basic phases of a project and their purposes ?

The phases of a project make up the project life cycle. It is convenient for the project managers to divide the project into phases for control and tracking purposes. Each milestone at each stage is then elaborated and tracked for completion. The basic phases of a project are dependent on the kind of project that is being carried out. For instance, a software project may have requirement, design, build, test, implementation phases whereas a project to build a metro or a building may have different names for each phase.

Thus, the naming of the phases of a project depends on the kind of deliverables that is sought at each phase. For the purpose of definition, the phases may be divided into initial charter, scope statement, plan, baseline, progress, acceptance, approval and handover. This classification is according to the PMBOK. Thus, the phases of a project are closely correlated with that of the project cycle.

The purpose of each phase of the project is a set of deliverables that are agreed upon before the project starts. For instance, in a software project, the requirement phase needs to generate the requirement documents, the design phase the design document etc. The build phase in a project delivers the completed code whereas the test phase is about the completed testing for the deliverables.

Each phase of the project is associated with a certain milestone and the set of deliverables that each phase is expected to deliver is then tracked for compliance and closure. The Project Life Cycle consists of the initiating, executing, controlling and closing processes of the framework as described in the PMBOK. Each of these processes is necessary to ensure that the project stays on track and is completed according to the specifications.

Importance of Project Management for Organizations

Project management includes: identifying requirements, establishing clear and achievable objectives, balancing the competing demands from the different stakeholders and ensuring that a commonality of purpose is achieved. It is clear that unless there is a structured and scientific approach to the practice of management, organizations would find themselves adrift in the Ocean called organizational development and hence would be unable to meet the myriad challenges that the modern era throws at them. Hence, the importance of project management to organizations cannot be emphasized more and the succeeding paragraphs provide some reasons why organizations must take the practice of project management seriously.

Without a scientific approach to the task of managing the projects and achieving objectives, it would be very difficult for the organizations to successfully execute the projects within the constraints of time, scope and quality and deliver the required result. In other words, there has to be a framework and a defined way of doing things to ensure that there is a structure to the art of project management.

Thus, project management is about creating structure and managing the project commitments and the delivery of agreed upon results. By using the methods of project management as described in the PMBOK and allied technical journals, organizations can seek to achieve control over the project environment and ensure that the project deliverables are being managed. Managers face what is known as the “triple constraint”. This is the competing demands of time, scope and quality upon the project manager’s list of things to do and how well the project manager manages these constraints goes a long way in determining the success of the project. Without the use of Project Management, managers and organizations would find themselves facing an unpredictable and chaotic environment over which they have little control. Thus, Project Management is both necessary and essential to the success of the project.

Project Management is too big an area to be covered in a few pages and the attempt is to provide concise and lucid definitions of the various terms and terminologies associated with a project. It is important to note that project management provides a framework within which subsequent actions by the organization can be taken and in this way, it is essential for organizations to adopt the framework provided by the practice of project management.

The major reasons for schedule and cost overruns across major sector's infrastructure projects. While some projects are impacted due to external factors which are beyond the control of the implementing agencies such as land acquisition, regulatory approvals, etc., majority of projects are delayed by factors which can be controlled at the project level through proper planning and project management. The study also highlights the severe skill shortage and the growing ,professionals affecting the infrastructure sector in India. Project owners feel this is a longterm issue which not only makes the projects more expensive and risky, but also results in compromise on quality as well as timelines.

Reasons for project time overruns across project lifecycle

Stages	**External issues**	**Internal issues**
Pre-planning	• Delay in regulatory approvals • Unavailability/delayed availability of funds • Land/site handover	• Lack of project managers/commercial managers with adequate planning skills • Lack of Liaoning 0fĕcer /Planning engineer • Lack of cost managers • Lack of safety officers/ environmental practitioners
Planning and design	• Lack of strong policies • Ineffective procurement planning • Design/scope change • Delay in regulatory approvals • Delay in decision making	• Lack Of planning engineer/commercial managers • Lack of liaison officer or planning engineer • Lack of .&P engineers
Execution and monitoring	• Weak/ineffective project planning & monitoring • Contractual disputes • Unavailability/delayed availability of funds • Lack of strong R&R policies • Delay land/site handover	• Lack of project managers/site managers/planning engineers/quantity supervisors • Lack of awareness modern equipment & technology • Lack of liaison officer and commercial officers
Closure and handover	• Pre-commissioning teething troubles y • Contractual disputes	• Lack of commissioning project and site managers audit and total quality management professionals

various stages of project execution

At the start of a project, the amount of planning and work required can seem overwhelming. There may be dozens, or even hundreds of tasks that need to be completed at just the right time and in just the right sequence.

Seasoned project managers know it is often easier to handle the details of a project and take steps in the right order when you break the project down into phases. Dividing your project management efforts into these five phases can help give your efforts structure and simplify them into a series of logical and manageable steps.

1. Project Initiation

Initiation is the first phase of the project lifecycle. This is where the project's value and feasibility are measured. Project managers typically use two evaluation tools to decide whether or not to pursue a project:

- **Business Case Document** – This document justifies the need for the project, and it includes an estimate of potential financial benefits.
- **Feasibility Study** – This is an evaluation of the project's goals, timeline and costs to determine if the project should be executed. It balances the requirements of the project with available resources to see if pursuing the project makes sense.

Teams abandon proposed projects that are labeled unprofitable and/or unfeasible. However, projects that pass these two tests can be assigned to a project team or designated project office.

2. Project Planning

Once the project receives the green light, it needs a solid plan to guide the team, as well as keep them on time and on budget. A well-written project plan gives guidance for obtaining resources, acquiring financing and procuring required materials. The project plan gives the team direction for producing quality outputs, handling risk, creating acceptance, communicating benefits to stakeholders and managing suppliers.

The project plan also prepares teams for the obstacles they might encounter over the course of the project, and helps them understand the cost, scope and timeframe of the project.

3. Project Execution

This is the phase that is most commonly associated with project management. Execution is all about building deliverables that satisfy the customer. Team leaders make this happen by allocating resources and keeping team members focused on their assigned tasks.

Execution relies heavily on the planning phase. The work and efforts of the team during the execution phase are derived from the project plan.

4. Project Monitoring and Control

Monitoring and control are sometimes combined with execution because they often occur at the same time. As teams execute their project plan, they must constantly monitor their own progress.

To guarantee delivery of what was promised, teams must monitor tasks to prevent scope creep, calculate key performance indicators and track variations from allotted cost and time. This constant vigilance helps keep the project moving ahead smoothly.

5. Project Closure

Teams close a project when they deliver the finished project to the customer, communicating completion to stakeholders and releasing resources to other projects. This vital step in the project lifecycle allows the team to evaluate and document the project and move on the next

one, using previous project mistakes and successes to build stronger processes and more successful teams.

Although project management may seem overwhelming at times, breaking it down into these five distinct cycles can help your team manage even the most complex projects and use time and resources more wisely.

Detailed engineering are studies which creates a full definition of every aspect of a project development. It includes all the studies to be performed before project construction starts. Detail engineering studies are a key component for every project development across mining, infrastructure, energy, pharmaceuticals, chemicals, and oil and gas sectors.

Detailed engineering is a service which is delivered for example by global engineering companies such as Outotec, Hatch, Amec Foster Wheeler, Ausenco, SNC-Lavalin, Techint and Jacobs Engineering.[1]

Detailed engineering follows Front End Engineering Design (FEED) and Basic Engineering previous steps on the engineering process for a project development, it contains in detail diagrams and drawings for construction, civil works, instrumentation, control system, electrical facilities, management of suppliers, schedule of activities, costs, procurement of equipment, economic evaluation and also environmental impacts before starting of construction of a project.

Detailed engineering is used for different stages and purposes in project development worldwide, whether it is a water treatment plant at OceanaGold Didipo gold-copper mine in the Philippines,[2] a processing plant at Hochschild Mining Inmaculada silver mine in Peru,[3] a molybdenum flotation plant at KGHM Sierra Gorda copper project in Chile,[4] detailed engineering is a key component for every project development.

Project team: Role of each member.

Successful projects are usually the result of careful planning and the talent and collaboration of a project's team members. Projects can't move forward without each of its key team members, but it's not always clear who those members are, or what roles they play. Here, we'll describe five roles – project manager, project team member, project sponsor, executive sponsor and business analyst – and describe their associated duties.

Project Manager

The project manager plays a primary role in the project, and is responsible for its successful completion. The manager's job is to ensure that the project proceeds within the specified time frame and under the established budget, while achieving its objectives. Project managers make sure that projects are given sufficient resources, while managing relationships with contributors and stakeholders.

Project manager duties:

- Develop a project plan
- Manage deliverables according to the plan
- Recruit project staff

- Lead and manage the project team
- Determine the methodology used on the project
- Establish a project schedule and determine each phase
- Assign tasks to project team members
- Provide regular updates to upper management

Project Team Member

Project team members are the individuals who actively work on one or more phases of the project. They may be in-house staff or external consultants, working on the project on a full-time or part-time basis. Team member roles can vary according to each project.

Project team member duties may include:

- Contributing to overall project objectives
- Completing individual deliverables
- Providing expertise
- Working with users to establish and meet business needs
- Documenting the process

Project Sponsor

The project sponsor is the driver and in-house champion of the project. They are typically members of senior management – those with a stake in the project's outcome. Project sponsors work closely with the project manager. They legitimize the project's objectives and participate in high-level project planning. In addition, they often help resolve conflicts and remove obstacles that occur throughout the project, and they sign off on approvals needed to advance each phase.

Project sponsor duties:

- Make key business decisions for the project
- Approve the project budget
- Ensure availability of resources
- Communicate the project's goals througout the organization

Executive Sponsor

The executive sponsor is ideally a high-ranking member of management. He or she is the visible champion of the project with the management team and is the ultimate decision-maker, with final approval on all phases, deliverables and scope changes.

Executive sponsor duties typically include:

- Carry ultimate responsibility for the project
- Approve all changes to the project scope
- Provide additional funds for scope changes
- Approve project deliverables

Business Analyst

The business analyst defines needs and recommends solutions to make an organization better. When part of a project team, they ensure that the project's objectives solve existing problems or

enhance performance, and add value to the organization. They can also help maximize the value of the project deliverables.

Business analyst duties:

- Assist in defining the project
- Gather requirements from business units or users
- Document technical and business requirements
- Verify that project deliverables meet the requirements
- Test solutions to validate objectives

Boost Project Management Skills and Expand Career Options

Just as a successful project usually takes careful planning and preparation, so does a successful project management career. Today's competitive business environment means that employers may look for project managers with proven skills – and they may seek out candidates with credentials such as the industry-respected Project Management Professional (PMP)® certification from the Project Management Institute.

Villanova University offers a Certificate in Applied Project Management online, so project management professionals can gain in-demand skills and prepare for the PMP® certification. When you're planning your project management education, consider Villanova's convenient and highly regarded certificate program, available 100% online.

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Standard Project Roles and Responsibilities

This describes typical roles and responsibilities for projects and programs. Roles may be assigned to one or more individuals. Conversely, individuals may play one or more roles.

Executive Sponsor

• Has ultimate authority and responsibility for a project or program
• Approves changes to scope
• Provides additional funds for scope changes
• Approves deliverables

Executive Committee (Class 4/5 Project)

• Allocates resources to support project implementation
• Advises on issues escalated by Steering Committee
• Exemplifies rapid analysis and decision-making characteristics imperative of all project team members
• Prioritizes project to demonstrate its importance and timeliness across other UCSC objectives
• Recommends a communication plan within the UCSC community
• Provides information and expert advice about campus plans for other projects or system developments that impact project timelines, deliverables, or resources
• Recommends resolution of scope related matters
• Advises on strategic partnerships

Steering Committee

• Provides campus wide leadership in support of the project
• Resolves issues escalated by the project manager or project team leads
• Resolves or forwards policy issues to appropriate decision-making bodies

Program/Project Sponsor

• Makes the business decisions for the program/project
• Participates day-to-day in one or more programs/projects
• Makes user resources available
• Approves work products
• Disposes of issues and project scope change requests

Program/Project Manager

• Reports to and receives direction from Executive Sponsor
• Participates in and approves project plan and deliverables*
• Manages, reviews, and prioritizes the project work plans with objective to stay on time and on budget
• Provides status and progress reviews to Executive Sponsor and Steering Committee
• May manage and supervise the following resources:
o Senior technical staff
o Technical project managers
o Team leads
o Team members
• Manages project resources
• Reports status to and receive feedback from Steering Committee
• Collaborates with project managers to resolve issues within individual projects or within portfolios*
• Brings issues to the Steering Committee as needed
• Recommends resource and policy changes to the Steering Committee
• Identifies required project team members and constructs project teams
• Meets with project managers to regularly review issues and monitor progress*
• Motivates and coaches project managers* and team members
• Monitors contract compliance
• Approves job orders and change orders*
• Conducts risk management analysis
• Meets facility and resource requirements
• Reviews and approves deliverables*

* Program Manager more likely to take this role.

Project Team Lead / ScrumMaster

• Assigned full or part time to participate in project team activities
• Responsible for contributing to overall project objectives and specific team deliverables
• Manages specific project plan activities and contributes to project plan development in collaboration with project manager
• Coordinates documentation, testing, and training efforts related to project plan
• If the project adopts an Agile development approach, the ScrumMaster is responsible for managing each development sprint, the daily Scrum and ensuring that the team properly applies Agile development principles.

Project Team Member

• Assigned full or part time to participate in project team activities
• Responsible for contributing to overall project objectives and specific team deliverables
• Escalates policy issues to team lead for referral to appropriate policy making bodies
• This role includes all various resources necessary to execute the project plan.

Technology Support

• This role is comprised of various team members who perform technology support for the project.
• Membership includes DBA, App Admin, App Dev, Business Analyst, etc.
• Establishes project support technology standards
• Assists team members in the use of project support technology
• Maintains project support technology
• Ensures that the technical environment is in place and operational throughout the project
• Establishes and maintains target environment for new applications

Stakeholders

• Community member affected by or participating in the project

Key User

• Provides source information to the team
• Provides expert business understanding of the organization
• Represents the users area in identifying current or future procedures
• Reviews and confirms major SDLC work products for the project
• Participates as required in User Acceptance Testing Activities

**** Application Developer**

• Designs systems from a user perspective
• Designs human factors (windowing, ease-of-use)
• Designs externals (screens, reports, forms)
• Designs usability of the application
• Designs application software components, including programs, modules, and run units
• Prototypes, develops, and unit tests application software components or fragments
• Typically knowledgeable in one or more development environments
• Develops against accepted institutional development standards using systemwide business policies (Business and Finance Bulletins IS-3 and IS-10)
• Participates with Business Analysts in application documentation

**** Business Analyst**

• Assesses current systems
• Develops and maintains models of business requirements
• Designs business transactions
• Designs and organizes procedures
• Documents and analyzes business processes using value-added/non-value added, process modeling tools, cost-time charts, and root cause analysis or other tools as appropriate
• Documents “ability to” functional requirements for use by application designers and developers
• Is an active participant in unit testing, system testing, and regression testing

Project execution

Project Execution

Posted on 14th December 2015 by ThePD

Execution is the implementation processes that is the act of doing or performing the works and activities in accordance with agreed plans and procedures to satisfy the specifications and contractual requirements. The Project Execution is the performing the project scope of works and activities in accordance with the project baselines, plans and procedures with the resource, interface, change, schedule, cost, risk, quality, safety and environment management, and other contractual requirements. The key success factors for the project execution is well defined project definitions, and roles and responsibilities, organised and building the team works, and accurate status reporting including forecast, timely decision making under the project manager’s

leadership within internal and external organisations. (Refer to the Key Words for Successful Project Execution)

What is Cost Control in Project Management?
It is the task of overseeing and managing project expenses as well as preparing for potential financial risks. This job is typically the project manager's responsibility. Cost control involves not only managing the budget, but also planning, and preparing for potential risks. Risks can set projects back and sometimes even require unexpected expenses. Preparation for these setbacks can save your team time and potentially, money.

Further Reading:

- Three Ways to Minimize Your Project Budget Exposure
- Top 5 Reasons for Project Failure and How to Avert Disaster
- Project Management Basics: 6 Steps to a Foolproof Project Plan

- Three Ways to Minimize Your Project Budget Exposure

Keeping the project budget in line is one of the most difficult things in project management – and yet it is a huge factor in determining the overall success of the project when the engagement winds down.

The goal is to keep it in line throughout and avoid falling into emergency mode at any point with a huge budget overrun that you have to either fix or find yourself at the brink of project shutdown.

Through my experience, I've found that the following three processes are extremely helpful to me as I try to keep my project budgets in check on the multiple projects I'm usually managing at any given point in time. Project managers are busy with many things beyond managing the budget on our plate.

Developing good processes and habits will help you significantly reduce the likelihood that your project budget will turn into a catastrophe. Let's review each of the three ways to minimize your project budget exposure more closely….
Review and revise the project budget at least weekly

The first thing you can do to protect your project budget is probably the easiest thing you can do and it is definitely the least invasive thing you can do. All it requires is you – and the proper information provided to you on a weekly basis.

- Top 5 Reasons for Project Failure and How to Avert Disaster

As a vendor of project management and collaboration software, we talk to a lot of project managers. And we've heard all too often that despite every obvious intention for a project to be successful, the reality is that sometimes things fall apart.

My belief is that the more you are prepared to fail, the better suited you are to prevent it from occurring at all. So I asked project managers to share their stories on project failure and the reasons behind the big flop. Now I'm sharing their lessons with you, so that we're all clearly aware of what we're up against each time a new project begins.

1. Poor communication

Everyone knows how vital it is to proactively share information and knowledge during a project if you want to succeed; yet poor communication continues to trip teams up time and time again. If you and your team haven't set aside any time to focus on improving your communication skills recently, don't wait until the next project disaster to convince you that it's necessary.

2. Underestimated timelines

When you underestimate the timeline for a project, the result is more than just a missed deadline on the calendar. Workers have to be paid for more time, so your estimated budget goes over. Sales teams were relying on your timely product release, and now they've lost big deals. It's important to accurately predict your timeline — and Jazmin Truesdale does that with excellent risk management.

3. Failure to hammer out the nitty gritty details

Are you a big-picture thinker, or do you have a detail-oriented mind? Usually we only excel at one or the other, but if you want your projects to be successful, you need both. (I know, not your favorite answer.) If you're still missing part of the picture, then start reviewing past projects to see where your common oversights have been, and take those lessons learned to plan more accurately in the future.

If the idea of recording lessons learned during your projects sounds daunting, use these tips and templates to help you get started: Why You Need to Record Your Project Management Lessons Learned: Tips & Templates

4.Unhelpful teams and technology just complicate things

We're talking about teams and tools that cannot deliver on the expectations. Stop the madness! Fix your broken processes quickly — even if you eat the cost from ending a contract early. Trevor Ewen told me about a client project gone wrong when his consulting firm was charged with breathing life into a failing project:

"In an effort to preserve an existing vendor relationship, we were forced to work with that vendor. In reality, we would've been much better off telling [the client] to pay the vendor to walk away. It was a win-lose. They delivered a broken product: we were required to fix it." — Trevor Ewen, Senior Software Engineer, Neosavvy

Keeping yourself locked in with teams that create more problems means you're going to spend extra time and money hiring additional teams to fix their mistakes. Bail early, before they create more problems than they're worth.

And the same goes with technology. If the tools you're using to run your team and projects are making work harder, then find a new solution immediately. There are many types of tools your team can use to make work easier: project management, document management, content management, portfolio management, client relationship management... the list goes on.

5. Management not paying enough attention

As the project manager, you are the symbolic parent and champion of progress. And just like

a child, projects need regular health checkups to make sure everything is growing as it should be. It's important to check in frequently with your team and offer your assistance when things are slowing down. Trevor Ewen's unfortunate failed project struggled without proper support from the project manager:

Cost Control Techniques

Following are some of the valuable and essential techniques used for efficient project cost control:

1 - Planning the Project Budget

You would need to ideally make a budget at the beginning of the planning session with regard to the project at hand. It is this budget that you would have to help you for all payments that need to be made and costs that you will incur during the project life cycle. The making of this budget therefore entails a lot of research and critical thinking.

Like any other budget, you would always have to leave room for adjustments as the costs may not remain the same right through the period of the project. Adhering to the project budget at all times is key to the profit from project.

2 - Keeping a Track of Costs

Keeping track of all actual costs is also equally important as any other technique. Here, it is best to prepare a budget that is time-based. This will help you keep track of the budget of a project in each of its phases. The actual costs will have to be tracked against the periodic targets that have been set out in the budget. These targets could be on a monthly or weekly basis or even yearly if the project will go on for long.

This is much easier to work with rather than having one complete budget for the entire period of the project. If any new work is required to be carried out, you would need to make estimations for this and see if it can be accommodated with the final amount in the budget. If not, you may have to work on necessary arrangements for 'Change Requests', where the client will pay for the new work or the changes.

3 - Effective Time Management

Another effective technique would be effective time management. Although this technique does apply to various management areas, it is very important with regard to project cost control.

The reason for this is that the cost of your project could keep rising if you are unable to meet the project deadlines; the longer the project is dragged on for, the higher the costs incurred which effectively means that the budget will be exceeded.

The project manager would need to constantly remind his/her team of the important deadlines of the project in order to ensure that work is completed on time.

4 - Project Change Control

Project change control is yet another vital technique. Change control systems are essential to take into account any potential changes that could occur during the course of the project.

This is due to the fact that each change to the scope of the project will have an impact on the deadlines of the deliverables, so the changes may increase project cost by increasing the effort needed for the project.

5 - Use of Earned Value

Similarly, in order to identify the value of the work that has been carried out thus far, it is very helpful to use the accounting technique commonly known as 'Earned Value'.

This is particularly helpful for large projects and will help you make any quick changes that are absolutely essential for the success of the project.

The Additional Steps for Project Cost Control

It is advisable to constantly review the budget as well as the trends and other financial information. Providing reports on project financials at regular intervals will also help keep track of the progress of the project.

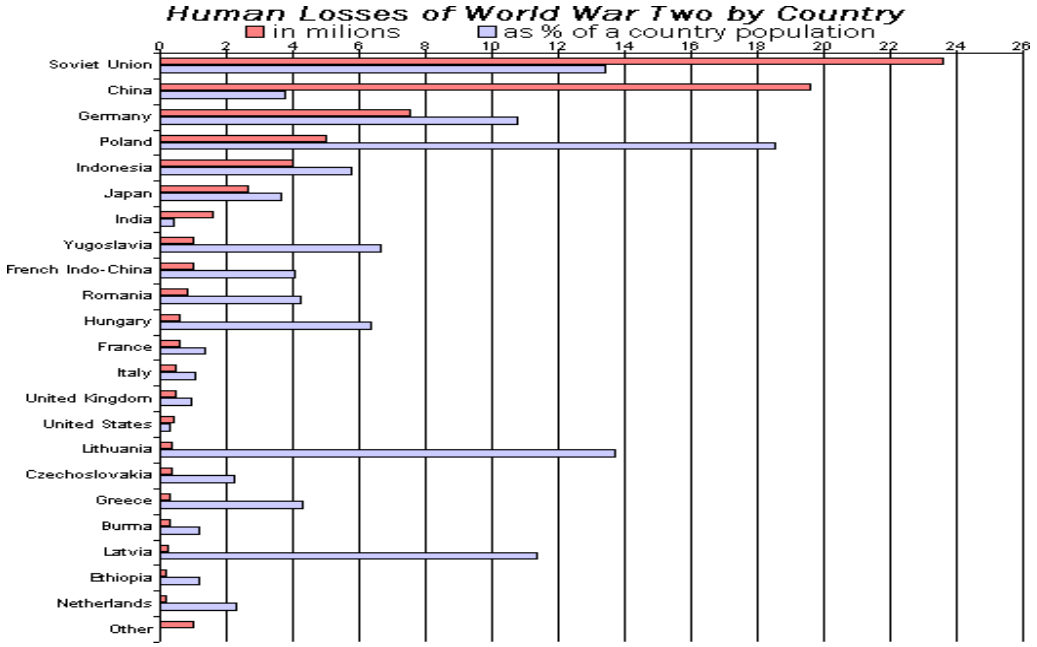
This will ensure that overspending does not take place, as you would not want to find out when it is too late. The earlier the problem is found, the more easily and quickly it could be remedied.

All documents should also be provided at regular intervals to auditors, who would also be able to point out to you any potential cost risks.

Bar charts and Network diagram. Project commissioning: mechanical and process.

A **bar chart** or **bar graph** is a chart or graph that presents categorical data with rectangular bars with heights or lengths proportional to the values that they represent. The bars can be plotted vertically or horizontally. A vertical bar chart is sometimes called a **line graph**.

A bar graph shows comparisons among discrete categories. One axis of the chart shows the specific categories being compared, and the other axis represents a measured value. Some bar graphs present bars clustered in groups of more than one, showing the values of more than one measured variable.



Usage

Bar charts have a discrete domain of categories, and are usually scaled so that all the data can fit on the chart. When there is no natural ordering of the categories being compared, bars on the chart may be arranged in any order. Bar charts arranged from highest to lowest incidence are called Pareto charts. Bar graphs/charts provide a visual presentation of categorical data.[2] Categorical data is a grouping of data into discrete groups, such as months of the year, age group, shoe sizes, and animals. These categories are usually qualitative. In a column bar chart, the categories appear along the horizontal axis; the height of the bar corresponds to the value of each category.

Grouped and Stacked[edit]

Bar graphs can also be used for more complex comparisons of data with grouped bar charts and stacked bar charts.[2] In a **grouped bar chart**, for each categorical group there are two or more bars. These bars are color-coded to represent a particular grouping. For example, a business owner with two stores might make a grouped bar chart with different colored bars to represent each store: the horizontal axis would show the months of the year and the vertical axis would show the revenue. Alternatively, a **stacked bar chart** could be used. The stacked bar chart stacks bars that represent different groups on top of each other. The height of the resulting bar shows the combined result of the groups. However, stacked bar charts are not suited to data sets where some groups have negative values. In such cases, grouped bar chart are preferable.

Grouped bar graphs usually present the information in the same order in each grouping. Stacked bar graphs present the information in the same sequence on each bar.

What are Network Diagrams?

A Network Diagram is a visual representation of a project's schedule. Well known complements to network diagrams include the PERT and Gantt charts.A network diagram in project management is useful for planning and tracking the project from beginning to finish.It represents a project's critical path as well as the scope for the project.

Two types of network diagrams

There are two main types of network diagrams in project management: the arrow diagramming method (ADM), also known as "arrow network" or "activity on arrow"; and the precedence diagramming method (PDM), also known as "node network" or "activity on node."

Arrow diagram method (ADM)

The arrow diagramming method uses arrows to represent activities associated with the project. In ADM:

- The tail of the arrow represents the start of the activity and the head represents the finish.
- The length of the arrow typically denotes the duration of the activity.
- Each arrow connects two boxes, known as "nodes." The nodes are used to represent the start or end of an activity in a sequence. The starting node of an activity is sometimes called the "i-node," with the final node of a sequence sometimes called the "j-node."
- The only relationship between the nodes an activity in an ADM chart can represent is that of "finish to start" or FS.

Occasionally, "dummy activities"—arrows that do not represent a direct relationship—need to be included in ADM network diagrams. In the diagram above, activity C can only occur once activities A and B are complete; in the network diagram, you've connected activity A to activity C. Perhaps we're talking about tiling a floor (activity C): It can only begin once the concrete is poured (activity A) and the permits are obtained (activity B). Since activities A and B are not directly related—A doesn't lead to B, and B doesn't lead to A—you'll need to draw a dummy activity between B and C to show that C is dependent on B being completed.An ADM chart also does not have a way to encapsulate lead and lag times without introducing new nodes and activities, and it's important to note ADM is not widely used anymore due to its representational limitations.

Precedence diagram method (PDM)

In the precedence diagramming method for creating network diagrams, each box, or node, represents an activity—with the arrows representing relationships between the different activities. The arrows can therefore represent all four possible relationships:

- "finish to start" (FS): This is used when an activity cannot start before another activity finishes.
- "start to start" (SS): This is used to illustrate when two activities are able to start simultaneously.
- "finish to finish" (FF): This is used when to tasks need to finish together

- "start to finish" (SF): This is an uncommon dependency and only used when one activity cannot finish until another activity starts.

In PDM, lead times and lag times can be written in alongside the arrows. If a particular activity is going to require 10 days to elapse until the next activity can occur, for example, you can simply write "10 days" over the arrow representing the relationship between the connected nodes.

PDM network diagrams are frequently used in project management today.

Critical path method (CPM) is a resource-utilization algorithm for scheduling a set of project activities. The essential technique for using CPM is to construct a model of the project that includes the following:

- A list of all tasks required to complete the project
- The dependencies between the tasks
- The estimate of time (duration) that each activity will take to complete

With this information, you can determine the critical path by identifying the longest stretch of dependent activities and measuring them from start to finish.
Once you've identified which activities are on the longest, or critical path, you can more easily discern which have total float, or can be delayed without making the project longer.
Using the Critical Path Method in a Project
Now we'll try to demonstrate the concept of the critical path method with a simple, real-life example: planning a killer party. How should you plan and execute on this project?

critical path

critical path in project management as a project modeling technique. It's a sequence of stages where you figure out what the least amount of time is necessary to complete a task with the least amount of slack. So, the critical path is really the longest length of time it will take to complete the project tasks.
Since that time, the critical path method has been used in a variety of projects, from construction, aerospace and defense to software and product development, engineering, plant maintenance and more. Projects with interdependent activities can benefit from this. While the original critical path program isn't used anymore, the approach remains the same.

Except today's critical path is calculated automatically by project scheduling software. That makes the whole method, a whole lot easier.

Critical Path – Definition of Terms

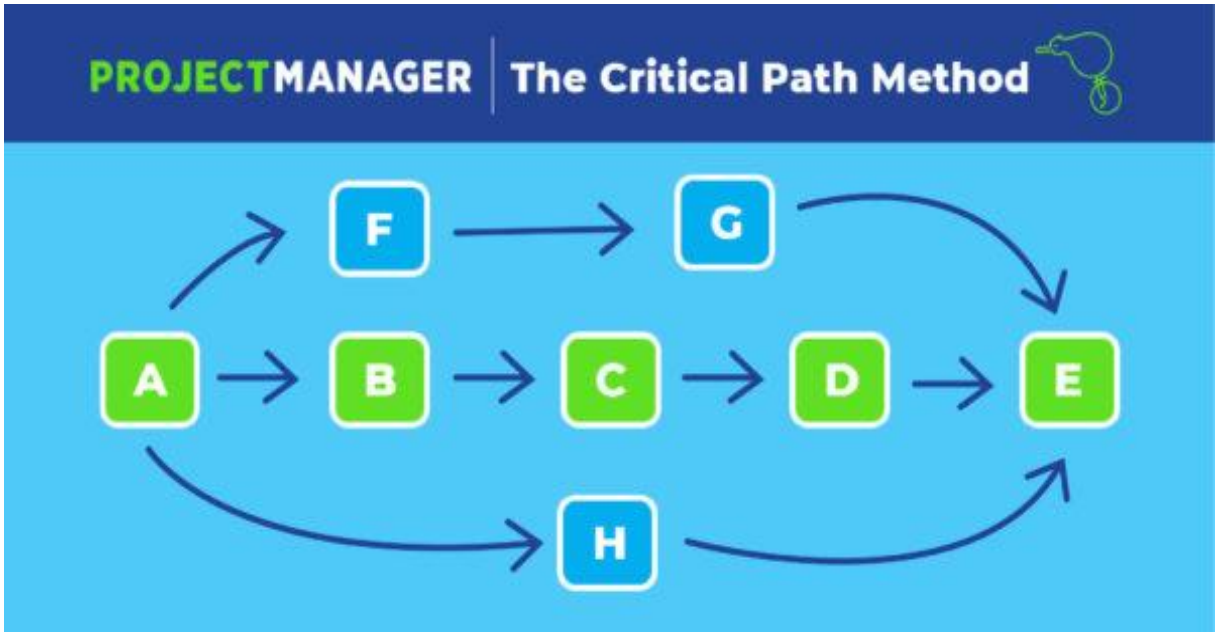
The critical path is the longest distance between the start and the finish of your project, including all the tasks, their duration, which gives you a clear picture of the project's actual schedule.

Another term in the critical path method is *earliest start date*. This is simply the earliest date that a task can be started in your project. You cannot determine this without first knowing if any tasks are dependent on this one task, or figuring out other constraint that might impact the start of this task. Next is the *earliest finish date*. This being the earliest date your task can be completed.

Along those lines, you need to figure out what the *latest start date* is. This is the very last minute in which you can start a task before it threatens to upset your project schedule. And you need to calculate what the *latest finish date* is for the same reason. By having a clear picture of this timeframe, you can better schedule the project to meet its deadline.

Float, also known as slack, is a term that describes how long you can delay a task before it impacts the planned schedule and threatens the project's deadline. When you are collecting tasks for the critical path, they must have zero float. But if the tasks do have some float, then they go on the non-critical path, which means if this task is delayed the project can still finish on time.

Crash duration is a term that describes the shortest amount of time that a task can be scheduled. You can get there by moving around resources, adding more towards the end of the task, to decrease the time needed to complete the task. This often means a reduction in quality, but is based on a relationship between cost and time



Critical Path: Basic Steps

The technique for figuring out the critical path in your project can be boiled down to four essential steps.

1. List all the tasks needed to complete the project. You can use a work breakdown structure, which is a hierarchical decomposition of the project, noting every deliverable.

2. Note the duration of each of those tasks, such as how long each one is going to take to complete it and move onto the next one.

3. If there are any task dependencies, you want to collect them, too. A task dependency is when one task cannot start until another one has been finished. It's a key element of good task management.

4. What are the milestones in the project? That being the major phases. Also, what are the deliverables? Create a list of these.

   When you have this data collected, you're able to calculate the longest path your planned tasks will take to reach the end of the project, as well as the earliest and latest that each task can start and finish without impacting the project schedule.

   Therefore, you're determining what tasks are critical and which can float, meaning they can be delayed without negatively impacting the project by making it longer. Now you have the information you need to plan the schedule more accurately and have more of a guarantee you'll meet your project deadline.

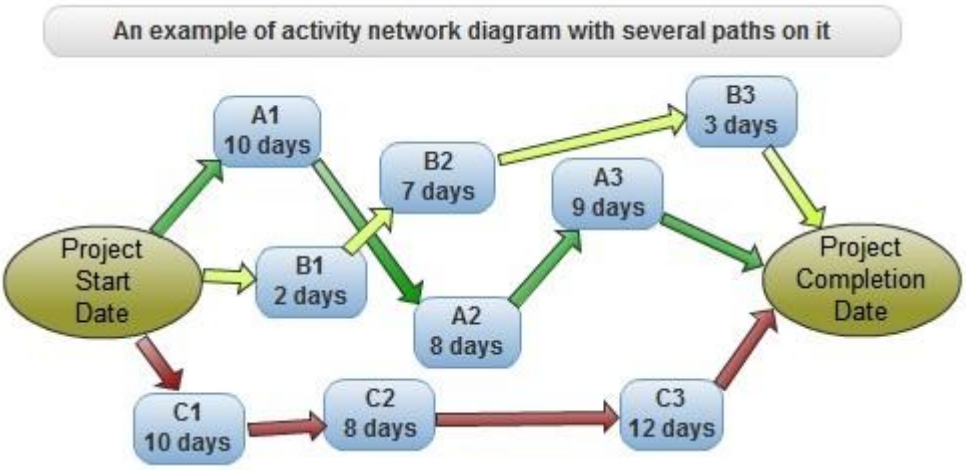
   You also need to consider other constraints that might change the project schedule. The more you can account for these issues, the more accurate your critical path method will be. If time is added to the project because of these constraints, that is called a critical path drag, which is how much longer a project with take because of the task and constraint.

Llimitations of Critical Path Method?

It is believed that the methodology was developed for routine and complex projects with the possibility of a minimum change in the completion time of tasks. CPM loses its usefulness in more chaotic projects.

There are alternatives, for example, PERT-diagrams, which allow changing the duration of each activity.

A critical path imitates events and activities in a project, presenting them in an interconnected network. Activities are rendered as "nodes," and the beginning and end of the activities look like arches and lines between nodes.



The **Critical Path Method** (CPM) can help you keep your projects on track.

Critical path schedules will...

- Help you identify the activities that must be completed on time in order to complete the whole project on time.
- Show you which tasks can be delayed and for how long without impacting the overall project schedule.
- Calculate the minimum amount of time it will take to complete the project.
- Tell you the earliest and latest dates each activity can start on in order to maintain the schedule.

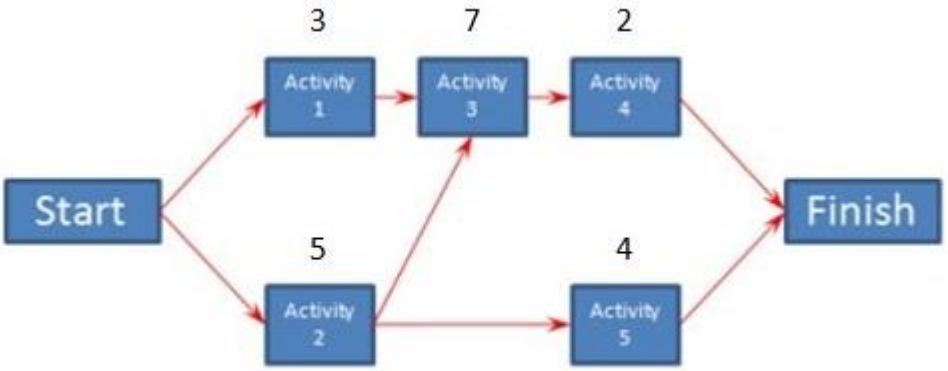
The Critical Path Method has four key elements...

- Critical Path Analysis
- Float Determination
- Early Start & Early Finish Calculation
- Late Start & Late Finish Calculation

Critical Path Analysis

The critical path is the sequence of activities with the longest duration. A delay in any of these activities will result in a delay for the whole project. Below are some *critical path*

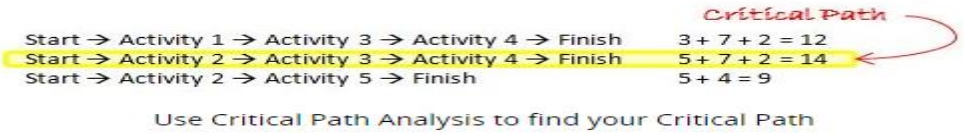
examples to help you understand the key elements...



Using the Critical Path Method (CPM)

Using the Critical Path Method (CPM)

The duration of each activity is listed above each node in the diagram. For each path, add the duration of each node to determine it's total duration. The critical path is the one with the longest duration.



Use Critical Path Analysis to find your Critical Path

There are three paths through this project...

Use Critical Path Analysis to find your Critical Path

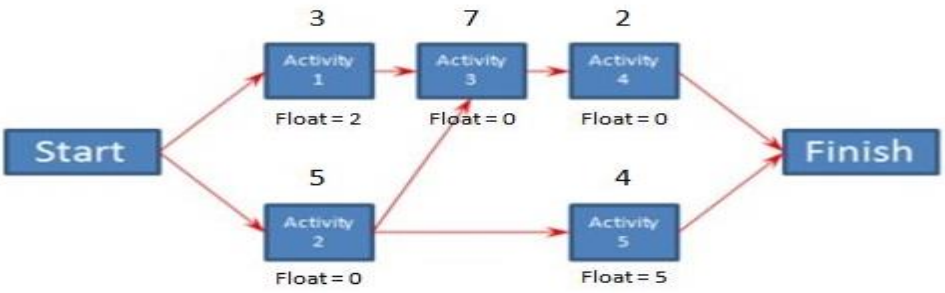
Float Determination

Once you've identified the critical path for the project, you can determine the float for each activity. *Float is the amount of time an activity can slip before it causes your project to be delayed.* Float is sometimes referred to as *slack*.

Figuring out the float using the Critical Path Method is fairly easy. You will start with the activities on the critical path. Each of those activities has a float of zero. If any of those activities slips, the project will be delayed.

Then you take the next longest path. Subtract it's duration from the duration of the critical path. That's the float for each of the activities on that path.

You will continue doing the same for each subsequent longest path until each activities float has been determined. If an activity is on two paths, it's float will be based on the longer path that it belongs to.



Determining Float

Using the critical path diagram from the previous section, Activities 2, 3, and 4 are on the critical path so they have a float of zero.

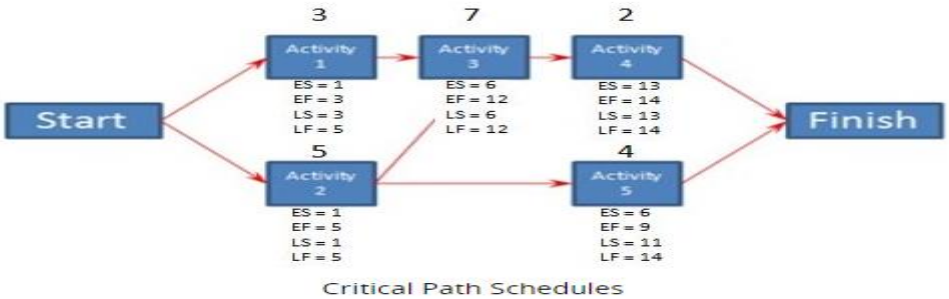
The next longest path is Activities 1, 3, and 4. Since Activities 3 and 4 are also on the critical path, their float will remain as zero. For any remaining activities, in this case Activity 1, the float will be the duration of the critical path minus the duration of this path. 14 - 12 = 2. So Activity 1 has a float of 2.

The next longest path is Activities 2 and 5. Activity 2 is on the critical path so it will have a float of zero. Activity 5 has a float of 14 - 9, which is 5. So as long as Activity 5 doesn't slip more than 5 days, it won't cause a delay to the project.

Early Start & Early Finish Calculation

The Critical Path Method includes a technique called the **Forward Pass** which is used to determine the earliest date an activity can start and the earliest date it can finish. These dates are valid as long as all prior activities in that path started on their earliest start date and didn't slip.

Starting with the critical path, the **Early Start (ES)** of the first activity is one. The **Early Finish (EF)** of an activity is its ES plus its duration minus one. Using our earlier example, Activity 2 is the first activity on the critical path: ES = 1, EF = 1 + 5 -1 = 5.



Critical Path Schedules

You then move to the next activity in the path, in this case Activity 3. Its ES is the previous activity's EF + 1. Activity 3 ES = 5 + 1 = 6. Its EF is calculated the same as before: EF = 6 + 7 - 1 = 12.

If an activity has more than one predecessor, to calculate its ES you will use the activity with the latest EF.

Late Start & Late Finish Calculation

The **Backward Pass** is a Critical Path Method techique you can use to determine the latest date an activity can start and the latest date it can finish before it delays the project.

You'll start once again with the critical path, but this time you'l begin from the last activity in the path. The **Late Finish (LF)** for the last activity in every path is the same as the last activity's EF in the critical path. The **Late Start (LS)** is the LF - duration + 1.

In our example, Activity 4 is the last activity on the critical path. Its LF is the same as its EF, which is 14. To calculate the LS, subtract its duration from its LF and add one. LS = 14 - 2 + 1 = 13.

You then move on to the next activity in the path. Its LF is determined by subtracting one from the previous activity's LS. In our example, the next Activity in the critical path is Activity 3. Its LF is equal to Activity 4 LS - 1. Activity 3 LF = 13 -1 = 12. It's LS is calculated the same as before by subtracting its duration from the LF and adding one. Activity 3 LS = 12 - 7 + 1 = 6.

You will continue in this manner moving along each path filling in LF and LS for activities that don't have it already filled in.

Manage Your Schedule with the Critical Path Method

The *Critical Path Method* is an important tool for managing your project's schedule. As you can see, it's not very difficult to determine it's key elements. However, once your project has more than a few activities, **critical path scheduling** can become tedious.

Luckily, today's project management software provides this information for you. So take a few minutes and learn how to access this information from your software and you'll soon be on top of your schedule and performing *critical path analysis* like a seasoned pro.

UNIT-IV

COST BEHAVIOR AND PROFIT PLANNING

Profit planning is the set of actions taken to achieve a targeted **profit** level. These actions involve the development of an interlocking set of budgets that roll up into a master budget.
After **planning profit** successfully, an organization needs to **control profit**. **Profit control** involves measuring the gap between the estimated level and actual level of **profit** achieved by an organization. If there is any deviation, the necessary actions are taken by the organization.
Profit planning is a vital part of any business plan structure for a small or medium business. The goals of small business owners include ensuring that the business makes profits year-over-year, and that it is sustained over a period of time for growth. The business plan includes a forecast that tries to anticipate the business growth and determine the revenue that could be generated in that particular year. Here's a look at the basics of profit planning for your business:

1. Evaluate your business operations: Profit planning and forecasting enables a comparison between projected costs and spends, and the actual costs that your business is incurring. This can help your team decide on improving cost efficiency and closing up the gaps. It also enables better decision-making like which resources to invest in or cut costs from. Proper profit planning will ensure that the business does not spend more than is necessary or end up not investing enough in resources that are required.
2. Forecast marketing strategies: Marketing is one of the highest areas of expense for small businesses because marketing efforts are directly related to getting leads for the business. The company's marketing efforts are categorized into various areas, and each of these need to be evaluated for the employees and resources required to fulfill them. If the marketing costs are not estimated properly it could affect profits, and the company will unnecessarily spend more on marketing. Profit planning helps avoid this scenario.
3. Anticipate financial planning: Planning funds to allocate across departments and procedures needs to begin well in advance. Profit planning anticipates the company's financial ability to make the maximum use of resources, with efficiency in costs and finally high profit-making potential.
4. Carve out hiring requirements: After the entire financial projection is made and the business plan structure is ready, the company needs to evaluate if they have enough staff to carry out all the operations. Profit planning also estimates the number of personnel required, vis-à-vis the work they generate which has a bearing on the company's revenue and profits. Planning costs for hiring requirements is also an important part of this. Profit planning is a crucial business activity that prepares the company for the coming year, helps spread out company resources efficiently and motivates the major stakeholders of the company to strive towards year-on-year growth. Profit planning needs to be an activity that is carried out every year. After the end of the year, there also needs to be an audit that compares the projection to the actual profits. This can guarantee that the company is prepared and has a well thought-out strategy to improve every time and maximize profits and performance.

Net Profit

Net Profit is a measure of profitability of a company usually referred to as 'the bottom line' of the income statement. It refers to the profit that remains after deducting expenses from gross profit. These expenses include all operating expenses, non-operating expenses, taxes and preferred stock dividends of a business.
Therefore, net profit is an important component of trading and profit and loss account of a business. The trading account represents the results from the manufacturing activities of a business. That is, the activities that involve manufacturing, purchasing and the ones that help in bringing goods to the point of sale. Thus, purchases is one of the constituents of such activities. The other constituents of the activities directly related to the production are direct expenses. These expenses include carriage inwards, freight inwards, wages, factory lighting, coal, water and fuel, royalty on production, etc

Consolidated Results	FY 2017	FY 2018
Revenue	550,402	544,871
Cost of Revenue	(391,544)	(385,575)
Gross Profit	158,858	159,296
Selling and Marketing Expenses	(40,817)	(42,349)
General and Administrative Expenses	(32,021)	(34,141)
Foreign Exchange Losses/Gains	3,777	1,488
Other Operating Income	4,082	-
Operating Income	93,879	84,294
Finance Expenses	(5,942)	(5,830)
Finance and Other Income	22,419	23,999
Share of Profit/Loss of Equity Accounted Investee	-	11
Profit Before Taxes	110,356	102,474
Income Taxes	(25,213)	(22,390)
Profit Attributable to Equity Holders	85,143	80,084

.

On the other hand, the profit and loss account represents the Gross Profit on the credit side. Furthermore, the expenses related to normal operations of a business are represented on the debit side. These expenses include operating, non-operating and indirect expenses.

Net Profit Example

We considered Wipro's Annual Report for 2017 – 2018 in our previous article on Gross Profit. The idea was to understand the concept of Gross, Gross Profit formula and important ratios concerning

Gross Profit. So let's consider the annual report once again to understand:

- what is net profit
- why it matters to your business and
- what is the difference between gross and net profit

The Net Profit of Wipro Limited for the year ended March 31, 2018 was Rs 80,084 million. This was reasonably less as compared to the previous year's Net Profit that stood at Rs 85,143

million. Net Profit was calculated as the difference between gross profit earned and expenses incurred at the end of the accounting period. The following table showcases the consolidated financial highlights of Wipro Limited for the year ended March 31, 2018:

It is clear from the above table that first operating profit is calculated to calculate Net Profit. Then, operating Profit is ascertained as the difference between Gross Profit and sum of following expenses:

- Selling and Marketing Expenses
- General and Administrative Expenses
- Foreign Exchange Losses/Gains
- Other Operating Income

Then, the following expenses or incomes are adjusted to operating income to calculate Net Profit of Wipro:

- Finance Expenses
- Finance and Other Income
- Income Taxes

Now, all expenses deducted from Gross Profit and Operating Income are indirect expenses. These expenses are not directly related with the manufacturing activity. That is, it is difficult to trace how each of them individually contributes to the production of goods.

Therefore, let's understand some basic terms associated with the calculation of Net Profit to understand the concept clearly.

You May Also Read
How to Calculate Gross Profit?

Direct Expenses
These are the expenses that are specifically caused by the product, project, organizational unit or any other purpose for which costs are measured. Thus, direct expenses are the expenses related to the manufacture of a product or rendering of a service linked to the cost object.

A cost object includes a:

- product
- service
- cost center
- activity
- sub-activity
- project
- contract

- customer or distribution channel or any other unit in relation to which costs are ascertained.

For instance, cloth used in manufacturing a piece of garment is a direct cost to the batch of garments under manufacture. Furthermore, the wages of the employees working directly in manufacturing the garments are a part of the direct expenditure.

Following are the expenses that are considered direct:

Opening Stock

It is the stock of goods or inventory that is in hand at the beginning of the year. Such a stock is carried forward from the previous year and does not change during the accounting period. This item appears on the debit side of the trading account as it forms part of the cost of goods sold during the year.

Purchases less returns

Goods bought for reselling after adding value are considered purchases. These appear on the debit side of the trading account of your business. Further, these include both cash and credit purchases. On the other hand, goods returned are the goods that are sent back to the supplier. These goods are deducted from the purchases and appear as net purchases in the trading account.

Wages

Wages refer to the earnings of the workers who worked directly on the cost project. It is a remuneration given to the employees engaged in factory for loading, unloading and production of goods. These appear on the debit side of the trading account.

Carriage Inwards/Freight Inwards

These are the transport expenses incurred while bringing raw materials or goods purchased to the place of business. These expenses are borne with regards to the purchases made during the year. Furthermore, these expenses appear on the debit side of the trading account.

Fuel/Water/Power/Gas

These expenses are incurred during the manufacturing process and are hence considered direct.

Packaging Material and Packaging Charges

Packaging charges refer to the cost of the packaging material used in the product. It is a direct expense for your business. This expense is considered direct as the containers or any other packaging material used to contain the goods form a part of the goods to be sold. However, the packing material refers to the containers that are used for transporting the goods. It is regarded as an indirect expense. Such an expense is debited to the profit and loss account of your business.

Indirect Expenses

These are the expenses associated with two or more cost projects jointly. The indirect expenses cannot be traced directly to each of the cost projects. That is, it is not possible to figure out how much of the cost is attributable to a single cost project.

Thus, indirect expenses are the expenses not directly attributable to a particular cost object. These expenses include: Selling and Distribution overheads, Administrative Overheads and other expenses such as finance expenses. And Selling and Distribution Overheads and Distribution Overheads combined together are referred to as Marketing Overheads.

Let’s consider each of them individually

Overheads

Overheads include costs of indirect materials, indirect employees and indirect expenses. These expenses are not directly identifiable to a cost object in an economically feasible manner.

Distribution Overheads

Next, Distribution Overheads are the costs incurred in handling a product or service from the time it is ready for delivery until it reaches the ultimate consumer. For instance, cost of packing, repacking, labeling, etc.is a part of the distribution cost. Following expenses come under distribution cost:

- Packing, repacking or labeling
- Transportation cost
- Cost of warehousing

Selling Overheads

Then, Selling Overheads are the expenses related to the sale of products. These include all Indirect Expenses incurred in managing sales of an organization. Following costs are a part of selling overheads of a business:

- Salaries of sales personnel
- Travelling expenses of sales personnel
- Commission to sales agents
- Sales and brand promotion expenses including advertisements, publicity, sponsorship, endorsements and similar other expenses.
- **Receivables** Collection costs
- After sales service costs
- Warranty costs

Administrative Overheads

Administrative Overheads are the costs of all the activities related to the general management and administration of an organization. These overheads do not include production overheads, marketing overheads and finance costs.

Production Overheads

Production overheads include administration expenses that relate with production, factory, works or manufacturing.

Finance Costs

- Finance costs are the costs incurred by a business in relation to borrowing funds. These expenses include:Interest and commitment charges on bank borrowings
- Amortization of discounts or premium related to borrowings
- Interest and commitment charges on short-term and long-term borrowings
- Amortization of ancillary costs incurred in connection with the arrangement of borrowings

- Finance charges in respect of finance leases
- Exchange differences arising out of foreign current borrowings to the extent they are regarded as an adjustment to the interest costs.

Cost of Sales or Cost of Goods Sold

Cost of goods sold refers to the direct costs incurred to produce goods or render services with the purpose of selling them. These costs include the cost of materials and direct labor costs incurred in producing goods. However, cost of goods sold does not include indirect expenses, like selling and distribution costs. Hence we can say:

Cost of Goods Sold = Opening Stock + Purchases + Direct Expenses – Closing Stock

Operating Profit

Operating Profit refers to the profit earned through the normal operations and activities of your business. It is the excess of operating revenue over operating expenses. Thus, the Operating Income for the year ended March 31, 2018 stood at Rs 84,294 million. This figure is calculated after considering operating expenses and revenues but before accounting financial incomes and expenses.

Therefore, while calculating operating profit, the income and expenses of a purely financial nature are not taken into account. Hence, we can say that operating profit is profit before interest and tax (EBIT). Similarly, abnormal items such as loss by fire, etc. are also not taken into account while calculating Operating Profit.

Operating Profit of a company is calculated as follows:

Operating profit = Net Profit + Non Operating Expenses – Non Operating Incomes
Or
Operating Profit = Gross Profit – Operating Expenses + Operating Incomes

Net Profit Formula

Let’s try to understand how Net Profit is calculated after having a fair idea about various components of Net Profit, . Generally, the formula for Net Profit stands at:

Net Profit = Gross Profit + Other Incomes – Indirect Expenses

So let’s consider the consolidated Income Statement of Wipro Limited as of March 31, 2018 to understand how Net Profit is calculated.

Wipro Limited and Subsidiaries Consolidated Statement of Income for the Year Ended March 31, 2018 (in Rs million unless otherwise stated)			
Particulars	FY 2016	FY 2017	FY 2018
Revenue	512,440	550,402	544,871
Cost of Revenue	(356,724)	(391,544)	(385,575)
Gross Profit	155,716	158,858	159,296
Selling and Marketing Expenses	(34,097)	(40,817)	(42,349)
General and Administrative Expenses	(28,626)	(32,021)	(34,141)
Foreign Exchange Losses/Gains	3,867	3,777	1,488
Other Operating Income	-	4,082	-
Operating Income	96,860	93,879	84,294
Finance Expenses	(5,378)	(5,942)	(5,830)
Finance and Other Income	23,451	22,419	23,999
Share of Profit/Loss of Equity Accounted Investee	-	-	11
Profit Before Taxes	114,933	110,356	102,474
Income Taxes	(25,366)	(25,213)	(22,390)
Profit for the Year	89,567	85,143	80,084

As it is apparent from the statement above, Gross Profit stands at Rs 155,716 million for the year ended March 31, 2018. This is calculated using the following formula:

Gross Profit = Revenues – Cost of Sales

In calculating Gross Profit, all direct expenses of manufacturing goods are considered in the cost of sales. Once Gross Profit is calculated, the operating income of Wipro is calculated. In calculating operating income, all the expenses incurred or income gained in operating and managing Wipro's business are deducted from Gross Profit.

The operating expenses include Selling and Marketing Expenses, General and Administrative Expenses and Foreign Exchange Losses. These expenses totaled Rs 76,490 million (42,349 + 34,141) for Wipro for the year ended March 31, 2018. However, Wipro did not have a foreign exchange fluctuation loss. Instead, there was a gain amounting to Rs 1,488 million against foreign exchange. This is operating income for Wipro. Thus, after considering operating expenses and incomes, total operating income for Wipro in the current year was Rs 84,294 million.

Then to calculate net profit, all non-operating expenses and taxes are deducted from and non-operating incomes are added to the operating profit. Thus, the net profit for Wipro for the current year comes to Rs 80,084 million.

Why is Net Profit Important?

How much profit your business generates depends upon the efficiency of its operations. Such levels of profit are determined after considering both long-term and short-term goals of your business. In the short-run, the level of profitability showcases your business' capability to sustain its operations. Whereas, in the long-run, the pattern of profitability helps in taking managerial decisions such as expansion of business.

Apart from this, even the stakeholders of your business analyse profits generated by your business over a period of time. Each stakeholder examines the level of profitability from a different perspective. For an internal stakeholder like the top management, it is important to analyze profits as it helps them to measure the efficiency of the business. Such information helps the financial expert in guiding the management on its operational aspects.

Similarly, the owners of the business analyze its profitability to measure their return on investment. While the employees are more bothered about their salary, incentives and other fringe benefits. Lastly, the creditors of your business analyze profits to know whether their investment is a safe investment or not.

Net Profit Ratios

The **accounting ratios** are an important tool in analyzing the financial statements of a business. The profitability ratios, also known as performance ratios, help in determining the earning capacity of your business. These ratios let you know the efficiency with which the resources of your business are utilized.
The important ratios based on Net Profit are Net Profit Ratio and Net Profit Margin.

Net Profit Ratio

Net profit ratio is based on all inclusive concept of profit. This ratio showcases relationship between revenue from business operations and net profit after operational as well as non-operational expenses and incomes. The Net Profit ratio is calculated as under:

Net Profit Ratio = Net profit/Revenue from Operations × 100

Generally, net profit refers to profit after tax (PAT).

This ratio gives you a fair idea about the profitability of your business. Furthermore, it gives insights about the overall efficiency of your business. This is an important measure from the point of view of investors.

Net Margin Ratio

Net profit margin is the amount of profit realized by your organization as a percentage of the total sales generated during an accounting period. The objective of calculating such a ratio is to figure out the earning trends of your business over a period of time. Thus, the Net Margin Ratio is calculated as under:

Net Profit Margin = Net Income/Net Sales (Revenue)

This ratio gives investors a fair idea about the income and expense elements that determine Net Profit Margin of your business. It gives investors an opportunity to have a comprehensive view of the Net Profit margin of your business.

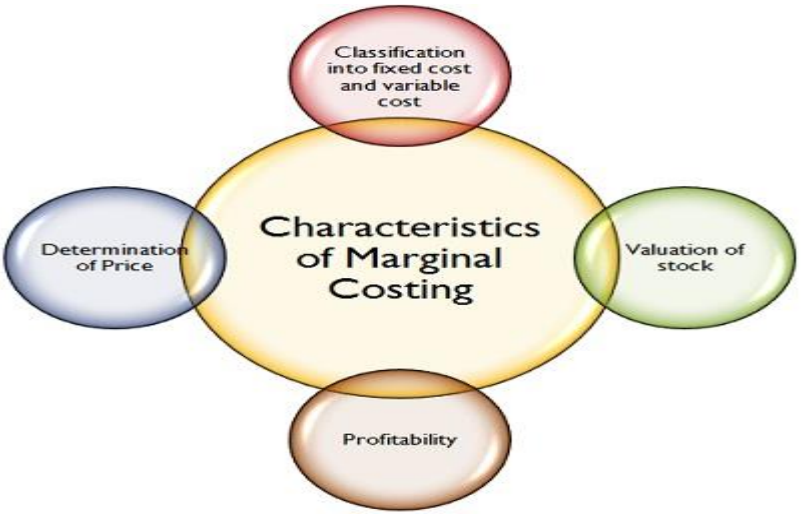
Thus, we can say that Net Profit or the bottom line of your business is the most important number to consider. This measure gives a fair view of the profitability of your business and its financial performance.

Marginal cost is the **cost** of one additional unit of output. The concept is used to determine the optimum production quantity for a company, where it **costs** the least amount to produce additional units. If a company operates within this "sweet spot," it can maximize its profits.

The term **marginal cost implies the additional cost involved in producing an extra unit of output**, which can be reckoned by total variable cost assigned to one unit. It can be calculated as:

Marginal Cost = Direct Material + Direct Labor + Direct Expenses + Variable Overheads

Characteristics of Marginal Costing

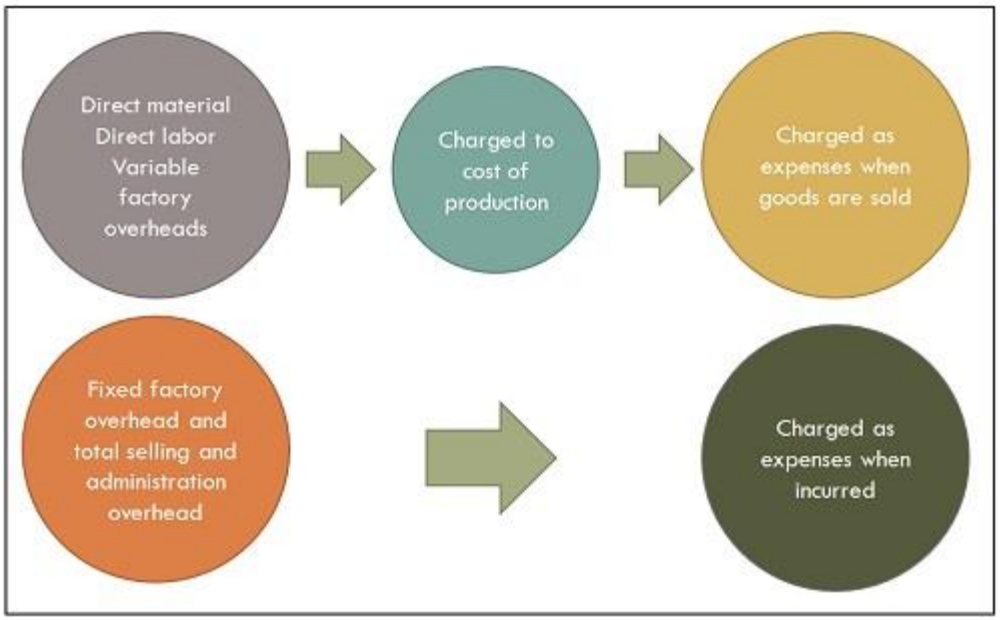


- **Classification into Fixed and Variable Cost**: Costs are bifurcated, on the basis of variability into fixed cost and variable costs. In the same way, semi variable cost is separated.
- **Valuation of Stock**: While valuing the finished goods and work in progress, only variable cost are taken into account. However, the variable selling and distribution overheads are not included in the valuation of inventory.

- **Determination of Price**: The prices are determined on the basis of marginal cost and marginal contribution.
- **Profitability**: The ascertainment of departmental and product's profitability is based on the contribution margin.

In addition to the above characteristics, marginal costing system brings together the techniques of cost recording and reporting.

Marginal Costing Approach



The difference between product costs and period costs forms a basis for marginal costing technique, wherein only **variable cost is considered as the product cost while the fixed cost is deemed as a period cost**, which incurs during the period, irrespective of the level of activity.

Facts Concerning Marginal Costing

- **Cost Ascertainment**: The basis for ascertaining cost in marginal costing is the nature of cost, which gives an idea of the cost behavior, that has a great impact on the profitability of the firm.
- **Special technique**: It is not a unique method of costing, like contract costing, process costing, batch costing. But, marginal costing is a different type of technique, used by the managers for the purpose of decision making. It provides a basis for understanding cost data so as to gauge the profitability of various products, processes and cost centers.
- **Decision Making**: It has a great role to play, in the field of decision making, as the changes in the level of activity pose a serious problem to the management of the undertaking.

Marginal Costing assists the managers in taking end number of business decisions, such as replacement of machines, discontinuing a product or service, etc. It also helps the management in ascertaining the appropriate level of activity, through break even analysis, that reflect the impact of increasing or decreasing production level, on the company's overall profit.

Margin of Safety

Definition: Margin of Safety (MOS) is defined as **the excess of actual or projected sales over break-even sales**, that can be expressed in monetary terms or units, or as a percentage of total sales.

The margin of Safety implies the sales point over and above the break-even point, that results in profit. Break-even point (BEP), is the point wherein total cost and total revenue are at equilibrium and profit is zero. It can be calculated as:

$$\text{Margin of Safety} = \text{Total Sales} - \text{Break even sales}$$

Another way to calculate the margin of safety if to find out the difference between budgeted and break-even sales (in units) and then multiply the result by the contribution per unit. This is because, at BEP, fixed overheads are absorbed and any further contribution, will amount to profit. It can be computed as:

$$\text{Margin of Safety} = \frac{\text{Profit}}{\text{P/V Ratio}}$$

The Margin of Safety is vital to the company, as a reduced activity level, will lead to losses. The size of the margin of safety is an indicator of company's financial health, i.e. **low margin of safety represent high fixed overheads**, and profits are not earned, until and unless the activity level so high that it covers fixed costs.

On the other hand, **high margin of safety represents that the break-even point is highly less than the actual sales**. Therefore, even if there is a decrease in sales, the business will be able to earn profits. So, the higher the margin, the greater are the chances to make profits or responsive to any sudden decline in company's revenue, thus reducing the risk of losses in business.

Average Cost

Definition: The **Average Cost** is the per unit cost of production obtained by dividing the total cost (TC) by the total output (Q). By per unit cost of production, we mean that all the fixed and variable cost is taken into the consideration for calculating the average cost. Thus, it is also called as **Per Unit Total Cost**.

Symbolically, the average cost is expressed as:

AC = TC/Q

Also,

AC = Average Variable cost (AVC) + Average Fixed cost (AFC)

Where,

Average variable cost = Total Variable Cost (TVC) / Total output (Q)
Average fixed cost = Total Fixed Cost (TFC) / Total output (Q)

The average cost is greatly influenced by the time period of production, such as increasing or expanding the production in the short run might be quite expensive or impossible. Thus, the economists study both the **short-run average costs** and **long-run average costs** to decide the production for a given period.

The short-run average cost is the cost that varies with the production of goods, provided the fixed costs are zero, and the variable costs are constant. While the long-run average cost includes all the cost involved in the variation of the quantities of all the inputs used for the production. The long-run is the time period wherein the quantities of all the inputs to be used can vary, even capital. Thus, the average cost is an important factor in determining the supply and demand within the market.

- **Marginal costing** is a method where the variable costs are considered as the product cost and the fixed costs are considered as the costs of the period.
- **Absorption costing**, on the other hand, is a method that considers both fixed costs and variable costs as product costs. This costing method is important particularly for reporting purposes. Reporting purpose includes both financial reporting and tax

Marginal Costing vs Absorption Costing Infographics

As these two costing methods are completely different from each other, obviously, there would be multiple differences between marginal costing vs absorption costing.

Let's look at the most significant differences between these two .

As you can see marginal costing vs absorption costing are completely different from each other, here are the key differences between them –

- Marginal costing doesn't take fixed costs into account under product costing or inventory valuation. Absorption costing, on the other hand, takes both fixed costs and variable costs into account.

- Marginal costing can be classified as fixed costs and variable costs. Absorption costing can be classified as production, distribution, and selling & administration.
- The purpose of marginal costing is to show forth the contribution of the product cost. The purpose of absorption costing is to provide a fair and an accurate picture of the profits.
- Marginal costing can be expressed as contribution per unit. Absorption costing can be expressed as net profit per unit.
- Marginal costing is a method of costing and it isn't a conventional way of looking at costing method. Absorption costing, on the other hand, is used for financial and tax reporting and it is the most conventional method of costing.

Basis Comparison for marginal costing and Absorption Costing

S.No.	Basis for Comparison – marginal costing vs absorption costing	Marginal Costing	Absorption Costing
1	**Meaning**	Marginal costing is a technique that assumes only variable costs as product costs.	Absorption costing is a technique that assumes both fixed costs and variables costs as product costs.
2	**What it's all about**	Variable cost is considered as product cost and fixed cost is assumed as cost for the period.	Both fixed cost and variable cost are considered in product cost.
3	**Nature of overheads**	Fixed costs and variable costs.	Overheads in the case of absorption costing are quite different – production, distribution, and selling & administration.
4	**How profit is calculated?**	By using profit volume ratio (P/V ratio)	Fixed costs are considered in product costs; that's why profit gets reduced.
5	**Determines**	The cost of the next unit.	The cost of each unit.
6	**Opening & Closing stocks**	Since the emphasis is on the next unit, change in opening/closing stocks	Since the emphasis is on each unit, change in opening/closing stocks

		doesn't affect the cost per unit.	affects the cost per unit.
7	**Most important aspect**	Contribution per unit.	Net profit per unit.
8	**Purpose**	To show forth the emphasis of contribution in product cost.	To show forth the accuracy and fair treatment of product cost.
9	**How it is presented?**	It is presented by outlining the total contribution.	It is presented in the most conventional way for the purpose of financial and tax reporting.

Definition of 'Pricing Strategies'

Definition

Price is the value that is put to a product or service and is the result of a complex set of calculations, research and understanding and risk taking ability. A pricing strategy takes into account segments, ability to pay, market conditions, competitor actions, trade margins and input costs, amongst others. It is targeted at the defined customers and against competitors.

Premium pricing

High price is used as a defining criterion. Such pricing strategies work in segments and industries where a strong competitive advantage exists for the company. Example: Porche in cars and Gillette in blades.

Penetration pricing

Price is set artificially low to gain market share quickly. This is done when a new product is being launched. It is understood that prices will be raised once the promotion period is over and market share objectives are achieved. Example: Mobile phone rates in India; housing loans etc.

Economy pricing

No-frills price. Margins are wafer thin; overheads like marketing and advertising costs are very low. Targets the mass market and high market share. Example: Friendly wash detergents;

Nirma; local tea producers.

Skimming strategy: high price is charged for a product till such time as competitors allow after which prices can be dropped. The idea is to recover maximum money before the product or segment attracts more competitors who will lower profits for all concerned. Example: the earliest prices for mobile phones, VCRs and other electronic items where a few players ruled attracted lower cost Asian players.

How to choose a pricing strategy for your small business

It's no secret that small businesses play a vital role in the US economy. However, revenue for small businesses can be scarce. For instance, small businesses that do not have any employees average just $44,000 a year in annual revenue with two-thirds of these companies earning less than $25,000 per year. While various factors can affect a business's revenue potential, one of the most important factors is the pricing strategy that its owners and team members utilize.

If you're not familiar with what a pricing strategy is or how to choose between different prices for your goods or services, now is the time to learn. Once you have a firm understanding of what a pricing strategy is, you can start reviewing the various approaches and choose the best one for your product.

What is a pricing strategy and why is it important?

In short, a pricing strategy refers to all of the various methods that small businesses use to price their goods or services. It's an all-encompassing term that can account for things like:

- Market conditions
- Actions that competitors take
- Account segments
- Trade margins
- Input costs
- Consumers' ability to pay
- Production and distribution costs
- Variable costs

Pricing strategies are useful for numerous reasons, though those reasons can vary from company to company. Choosing the right price for a product will allow you to maximize profit margins if that's what you want to do. Contrary to popular belief, pricing strategies aren't always about profit margins. For instance, you may opt to set the cost of a good or service at a low price to maintain your hold on market share and prevent competitors from encroaching on your territory.

In these cases, you may be willing to sacrifice profit margins in order to focus on competitive pricing. But you must be careful when engaging in an action like this. Although it could be useful for your business, it also could end up crippling your company. A good rule of thumb to remember when pricing products is that your customers won't purchase your product if you price it too high, but your business won't be able to cover expenses if you price it too low.

10 different pricing strategies for your small business to consider

As we've just identified, project management and strategic, actionable decisions go into setting the price of a product. Here are ten different pricing strategies that you should consider as a small business owner.

1. Pricing for market penetration

As a small business owner, you're likely looking for ways to enter the market so that your product becomes more well-known. Penetration strategies aim to attract buyers by offering lower prices on goods and services than competitors.

For instance, imagine a competitor sells a product for $100. You decide to sell the product for $97, even if it means you're going to take a loss on the sale. Penetration pricing strategies draw attention away from other businesses and can help increase brand awareness and loyalty, which can then lead to long-term contracts.

Penetration pricing can also be risky because it can result in an initial loss of income for the business. Over time, however, the increase in awareness can drive profits and help small businesses stand out from the crowd. In the long run, after penetrating a market, business owners can increase prices to better reflect the state of the product's position within the market.

2. Economy pricing

This pricing strategy is a "no-frills" approach that involves minimizing marketing and production expenses as much as possible. Used by a wide range of businesses, including generic food suppliers and discount retailers, economy pricing aims to attract the most price-conscious consumers. Because of the lower cost of expenses, companies can set a lower sales price and still turn a slight profit.

While economy pricing is incredibly useful for large companies like Walmart and Target, the technique can be dangerous for small businesses. Because small businesses lack the sales volume of larger companies, they may find it challenging to cut production costs. Additionally, as a young company, they may not have enough brand awareness to forgo custom branding.

3. Pricing at a premium

With premium pricing, businesses set costs higher because they have a unique product or brand that no one can compete with. You should consider using this strategy if you have a considerable competitive advantage and know that you can charge a higher price without being undercut by a product of similar quality.

Because customers need to perceive products as being worth the higher price tag, a business has to work hard to create a perception of value. Along with creating a high-quality product, owners should ensure that the product's packaging, the store's decor, and the marketing strategy associated with the product all combine to support the premium price.

An example of premium pricing is seen in the luxury car industry. Companies like Tesla can get away with higher prices because they're offering products, like autonomous cars, that are more unique than anything else on the market.

4. Price skimming

Designed to help businesses maximize sales on new products and services, price skimming involves setting rates high during the initial phase of a product. The company then lowers prices gradually as competitor goods appear on the market. An example of this is seen with the introduction of new technology, like an 8K TV, when currently only 4K TVs and HDTVs exist on the market.

One of the benefits of price skimming is that it allows businesses to maximize profits on early adopters before dropping prices to attract more price-sensitive consumers. Not only does price skimming help a small business recoup its development costs, it also creates an illusion of quality and exclusivity when you first introduce your product to the marketplace.

5. Psychological pricing

Psychological pricing refers to techniques that marketers use to encourage customers to respond based on emotional impulses, rather than logical ones.

For example, setting the price of a watch at $199 is proven to attract more consumers than setting it at $200, even though the actual difference here is quite small. One explanation for this trend is that consumers tend to put more attention on the first number on a price tag than the last. The goal of psychology pricing is to increase demand by creating an illusion of enhanced value for the consumer.

6. Bundle pricing

With bundle pricing, small businesses sell multiple products for a lower rate than consumers would face if they purchased each item individually. A useful example of this occurs at your local fast food restaurant where it's cheaper to buy a meal than it is to buy each item individually.

Not only is bundling goods an effective way to reduce inventory, it can also increase the value perception in the eyes of your customers. Customers feel as though they're receiving more bang for their buck. Many small businesses choose to implement this strategy at the end of a product's life cycle, especially if the product is slow selling.

Small business owners should keep in mind that the profits they earn on the higher-value items must make up for the losses they take on the lower-value product. They should also consider how much they'll save in overhead and storage space by pushing out older products.

7. Geographical pricing

If you expand your business across state or international lines, you'll need to consider geographical pricing. Geographical pricing involves setting a price point based on the location where it's sold. Factors for the changes in prices include things like taxes, tariffs, shipping costs, and location-specific rent.

Another factor in geographical pricing could be basic supply and demand. For instance, imagine you sell sports performance clothing. You may choose to set a higher price point for winter clothes in your cold-climate retail stores than you do in your warm-climate stores. You know

people are more likely to buy the clothes in the winter environments, so you set a higher price to take advantage of demand.

8. Promotional pricing

Promotional pricing involves offering discounts on a particular product. For instance, you can provide your customers with vouchers or coupons that entitle them to a certain percentage off the good or service. You could also entertain a "Buy One Get One" campaign, tacking on an additional product as an add-on.

Promotional pricing campaigns can be short-term efforts. For instance, you may run a promotional pricing strategy over an extended holiday, like Memorial Day Weekend. By offering these deals as short-term offers, business owners can generate buzz and excitement about a product. Promotional pricing also incentivizes customers to act now before it's too late. This pricing strategy plays to a consumer's fear of missing out.

9. Value pricing

If you notice that sales are declining because of external factors, you may want to consider a value pricing strategy. Value pricing occurs when external factors, like a sharp increase in competition or a recession, force the small business to provide value to its customers to maintain sales.

This pricing strategy works because customers feel as though they are receiving an excellent "value" for the good or service. The approach recognizes that customers don't care how much a product costs a company to make, so long as the consumer feels they're getting an excellent value by purchasing it.

This pricing strategy could cut into the bottom line, but businesses may find it beneficial to receive "some" profit rather than no profit. An example of value pricing is seen in the fashion industry. A company may produce a product line of high-end dresses that they sell for $1,000. They then make umbrellas that they sell for $100.

The umbrellas may cost more than the dresses to make. However, the dresses are set at a higher price point because customers feel as though they are receiving much better value for the product. Would you pay $1,000 for an umbrella? Probably not. Thus, external factors like customer perceptions force the value pricing strategy.

10. Captive pricing

If you have a product that customers will continually renew or update, you'll want to consider a captive pricing strategy. A perfect example of a captive pricing strategy is seen with a company like Dollar Shave Club. With Dollar Shave Club, customers make a one-time purchase for a razor. Then, every month, they purchase new razor blades to replace the existing one on the head of the razor.Because the customer purchased a DSC razor handle, he or she has no choice but to buy blades from the company as well. Thus, the company holds customers "captive" until they decide to break away and buy a razor handle from another company. Businesses can increase prices so long as the cost of the secondary product does not exceed the cost that customers would pay to leave for a competitor.

UNIT-V

QUANTITATIVE TECHNIQUES

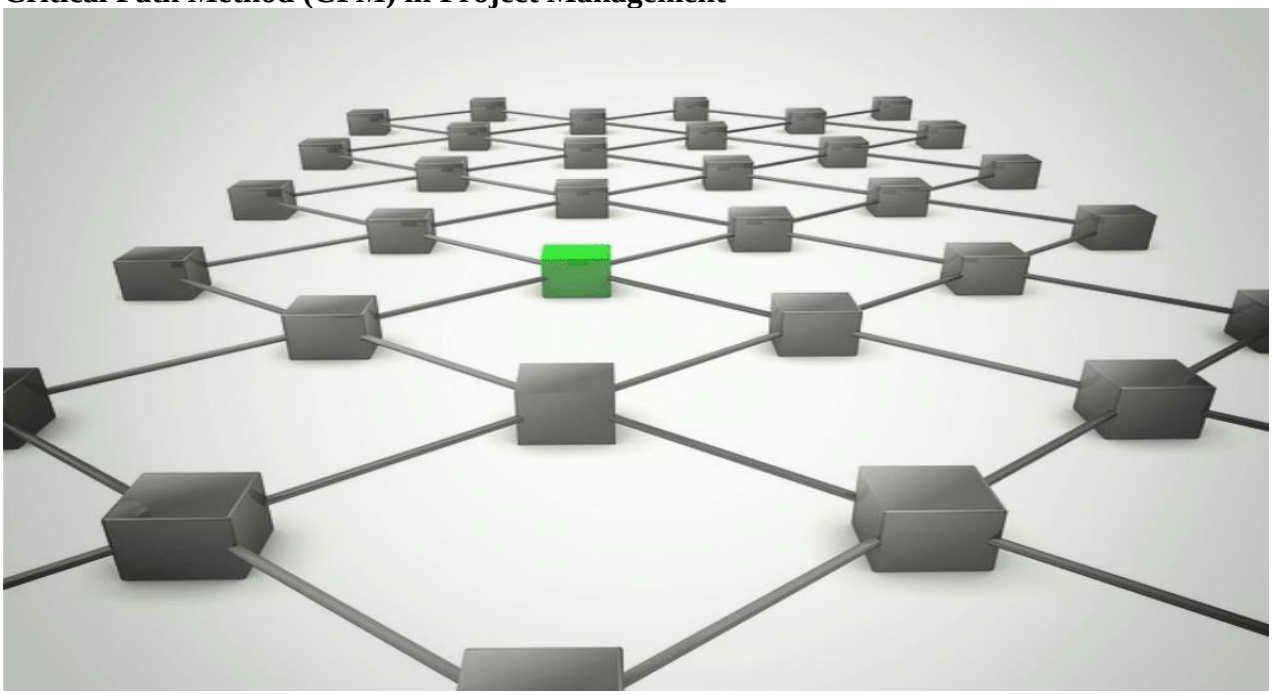
What is Quantitative Analysis?

Quantitative analysis is the process of collecting and evaluating measurable and verifiable data such as revenues, market share, and wages in order to understand the behavior and performance of a business. In the past, business owners and company directors relied heavily on their experience and instinct when making decisions. However, with the era of data technology, quantitative analysis is now considered a better approach to making informed decisions.

critical path

The critical path for any network is the longest path through the entire network. Since all activities must be completed to complete the entire project, the length of the critical path is also the shortest time allowable for completion of the project. Thus if the project is to be completed in that shortest time, all activities on the critical path must be started as soon as possible. A quantitative analyst's main task is to present a given hypothetical situation in terms of numerical values. Quantitative analysis helps in evaluating performance, assessing financial instruments, and making predictions. It encompasses four main techniques of measuring data: regression analysis, linear programming, factor analysis, and data mining.

Critical Path Method (CPM) in Project Management



You might have heard about the critical path method (CPM); a project modeling technique developed by Morgan R. Walker and James E. Kelly in late 1950s (Wikipedia) if you have experience in project management.

The critical path method (CPM) is used extensively by project planners worldwide for developing the project schedule in all types of projects including IT, research, and construction.

This method is the basis of the project schedule and is discussed very extensively in the PMBOK Guide. You can expect to see two to three questions or more in your PMP exam on this topic.

In this blog post, I will discuss the critical path using a real-world example, identify the critical path in a network diagram, and calculate the float for each path. I will then list some of the benefits and limitations of the critical path method.
Once you become familiar with it, I will walk you through every step required for calculating Early – Start, Early – Finish with a forward pass, and then calculate Late – Start, Late – Finish with a backward pass.

Make sure you understand each step described, otherwise you might face some difficulties when working with these calculations. Feel free to reach out to me at any time if you think you need any clarification.

Quantitative Analysis Techniques

1. Regression Analysis

Regression analysis is a common technique that is not only employed by business owners but also by statisticians and economists. It involves using statistical equations to predict or estimate the impact of one variable on another. For instance, regression analysis can be used to determine how interest rates affect consumers' behavior regarding asset investment. One other core application of regression analysis is establishing the effect of education and work experience on employees' annual earnings.

In the business sector, owners can use regression analysis to determine the impact of advertising expenses on business profits. By using this approach, a business owner can establish whether there's a positive or negative correlation between two variables.

2. Linear Programming

Most companies occasionally encounter a shortage of resources such as facility space, production machinery, and labor. In such situations, company managers must find ways to allocate resources effectively. Linear programming is a quantitative method that determines

how to achieve such an optimal solution. It is also used to determine how a company can make optimal profits and reduce its operating costs, subject to a given set of constraints, such as labor.

3. Data Mining

Data mining is a combination of computer programming skills and statistical methods. The popularity of data mining continues to grow in parallel to the increase in the quantity and size of available data sets. Data mining techniques are used in evaluating very large sets of data, with the aim of finding patterns or correlations concealed within them.

Applications of Quantitative Analysis in the Business Sector

Business owners are often forced to make decisions under conditions of uncertainty. Luckily, quantitative techniques enable them to make the best estimates and thus minimize the risks associated with a particular decision. Ideally, quantitative models provide company owners with a better understanding of information, to enable them to make the best possible decisions.

Project Management

One area where quantitative analysis is considered an indispensable tool is in project management. As mentioned earlier, quantitative methods are used to find the best ways of allocating resources, especially if these resources are scarce. Projects are then scheduled based on the availability of certain resources.

Production Planning

Quantitative analysis also helps individuals to make informed product-planning decisions. Let's say a company is finding it challenging to estimate the size and location of a new production facility. Quantitative analysis can be employed to assess different proposals for costs, timing, and location. With effective product planning and scheduling, companies will be more able to meet their customers' needs while also maximizing their profits.

Marketing

Every business needs a proper marketing strategy. However, setting a budget for the marketing department can be tricky, especially if its objectives are not set. With the right quantitative method, marketers can find an easy way of setting the required budget and allocating media

purchases. The decisions can be based on data obtained from marketing campaigns.

Finance

The accounting department of a business also relies heavily on quantitative analysis. Accounting personnel use different quantitative data and methods such as the discounted cash flow model to estimate the value of an investment. Products can also be evaluated, based on the costs of producing them and the profits they generate.

Purchase and Inventory

One of the greatest challenges that businesses face is being able to predict the demand for a product or service. However, with quantitative techniques, companies can be guided on just how many materials they need to purchase, the level of inventory to maintain, and the costs they're likely to incur when shipping and storing finished goods.

The Bottom Line

Quantitative analysis is the use of mathematical and statistical techniques to assess the performance of a business. Before the advent of quantitative analysis, many company directors based their decisions on experience and gut. Business owners can now use quantitative methods to predict trends, determine the allocation of resources, and manage projects.

Quantitative techniques are also used to evaluate investments. In such a way, organizations can determine the best assets to invest in and the best time to do so. Some of the quantitative analysis methods include regression analysis, linear programming, and data mining.

Network models have three main advantages over linear programming:

1. They can be solved very quickly. Problems whose linear program would have 1000 rows and 30,000 columns can be solved in a matter of seconds. This allows network models to be used in many applications (such as real-time decision making) for which linear programming would be inappropriate.
2. They have naturally integer solutions. By recognizing that a problem can be formulated as a network program, it is possible to solve special types of integer programs without resorting to the ineffective and time consuming integer programming algorithms.
3. They are intuitive. Network models provide a language for talking about problems that is much more intuitive than the \variables, objective, and constraints" language of linear and integer programming.

These activities are called **critical activities**. If the project has to be completed ahead of the schedule, then the time required for at least one of the critical activity must be reduced. Further, any delay in completing the critical activities will increase the project duration.

The activity, which does not lie on the critical path, is called **non-critical activity.** These non-critical activities may have some slack time. The slack is the amount of time by which the start of an activity may be delayed without affecting the overall completion time of the project. But a critical activity has no slack. To reduce the overall project time, it would require more resources (at extra cost) to reduce the time taken by the critical activities to complete.

Scheduling of Activities: Earliest Time and Latest Time

Before the critical path in a network is determined, it is necessary to find the earliest and latest time of each event to know the earliest expected time (TE) at which the activities originating from the event can be started and to know the latest allowable time (TL) at which activities terminating at the event can be completed.

Forward Pass Computations (to calculate Earliest, Time TE)

Procedure

Step 1: Begin from the start event and move towards the end event.

Step 2: Put TE = 0 for the start event.

Step 3: Go to the next event (i.e node 2) if there is an incoming activity for event 2, add calculate TE of previous event (i.e event 1) and activity time.

Note: If there are more than one incoming activities, calculate TE for all incoming activities and take the maximum value. This value is the TE for event 2.

Step 4: Repeat the same procedure from step 3 till the end event.

Backward Pass Computations (to calculate Latest Time T Network Model **L)**

Procedure

Step 1: Begin from end event and move towards the start event. Assume that the direction of arrows is reversed.

Step 2: Latest Time TL for the last event is the earliest time. TE of the last event.

Step 3: Go to the next event, if there is an incoming activity, subtract the value of TL of previous event from the activity duration time. The arrived value is TL for that event. If there are more than one incoming activities, take the minimum TE value.

Step 4: Repeat the same procedure from step 2 till the start event.

The two important components of any activity are the cost and time. Cost is directly proportional to time and vice versa. For example, in constructing a shopping complex, the expected time of completion can be calculated using be time estimates of various activities. But if the construction has to the finished earlier, it requires additional cost to complete the project. We need to arrive at a time / cost trade-off between total cost of project and total time required to complete it.

Normal time: Normal time is the time required to complete the activity at normal conditions and cost.

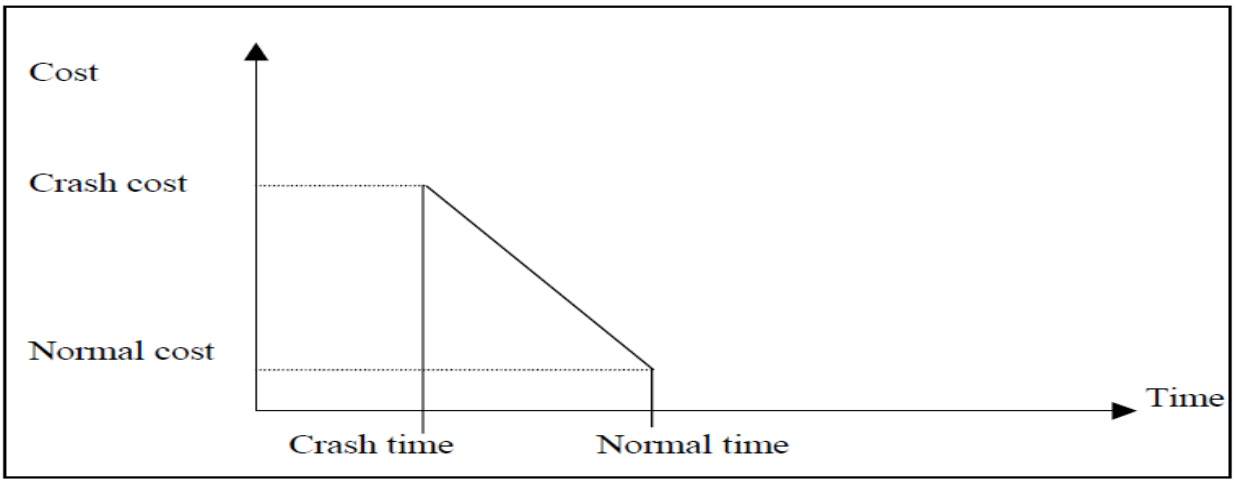
Crash time: Crash time is the shortest possible activity time; crashing more than the normal time will increase the direct cost.

Cost Slope in network analysis

Cost Slope

Cost slope is the increase in cost per unit of time saved by crashing. A linear cost curve is shown in Figure.

Linear Cost Curve



Cost slope=Crash cost C_c– Normal cost N_c/Normal time Ntt

Example : An activity takes 4 days to complete at a normal cost of Rs. 500.00. If it is possible to complete the activity in 2 days with an additional cost of Rs. 700.00, what is the incremental cost of the activity?

Solution:

Incremental Cost or Cost Slope = $C_c – N_c$ / Ntt

= 700-500/4-2 = Rs. 100.00

It means if one day is reduced we have to spend Rs. 100/- extra per day.

Project Crashing

Procedure for crashing

***Step1*:** Draw the network diagram and mark the Normal time and Crash time.

Step2: Calculate TE and TL for all the activities.

***Step3*:** Find the critical path and other paths.

Step 4: Find the slope for all activities and rank them in ascending order.

Step 5: Establish a tabular column with required field.

Step 6: Select the lowest ranked activity; check whether it is a critical activity. If so, crash the activity, else go to the next highest ranked activity.

Note: The critical path must remain critical while crashing.

Step 7: Calculate the total cost of project for each crashing.

Step 8: Repeat Step 6 until all the activities in the critical path are fully crashed.

Example: The following Table 8.13 gives the activities of a construction project and other data.

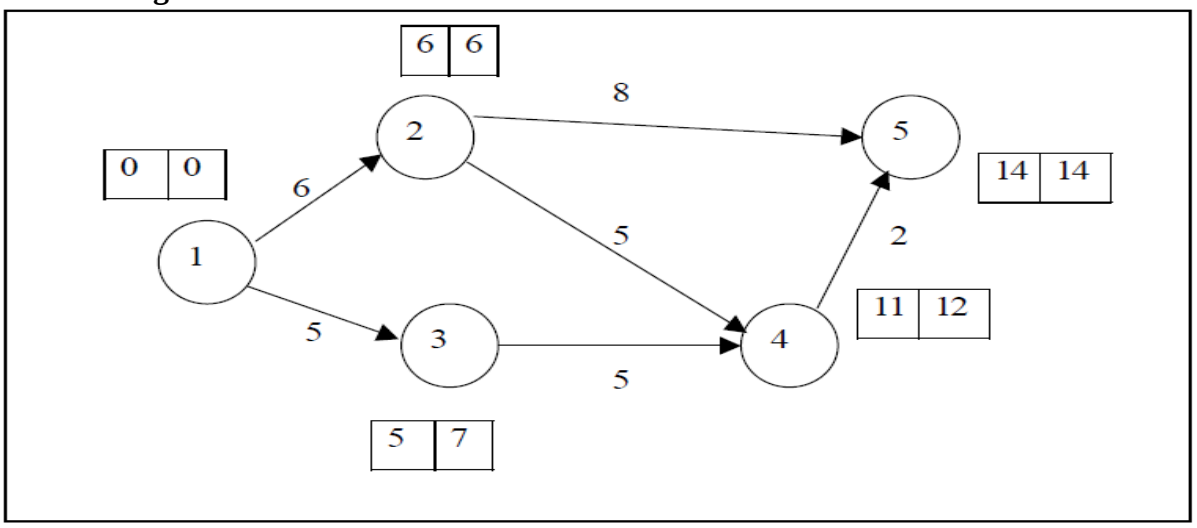
Construction Project Data

Activity	Normal		Crash	
	Time (days)	Cost (Rs)	Time (days)	Cost (Rs)
1-2	6	50	4	80
1-3	5	80	3	150
2-4	5	60	2	90
2-5	8	100	6	300
3-4	5	140	2	200
4-5	2	60	1	80

If the indirect cost is Rs. 20 per day, crash the activities to find the minimum duration of the project and the project cost associated.

Solution: From the data provided in the table, draw the network diagram and find the critical path.

Network Diagram



From the diagram, we observe that the critical path is 1-2-5 with project duration of 14 days The cost slope for all activities and their rank is calculated as shown in table below

Cost slope=Crash cost C_c– Normal cost N_c/Normal time Ntt

Cost Slope for activity 1– 2 = 80 – 50/6 – 4 = 30/2 = 15.

Cost Slope and Rank Calculated

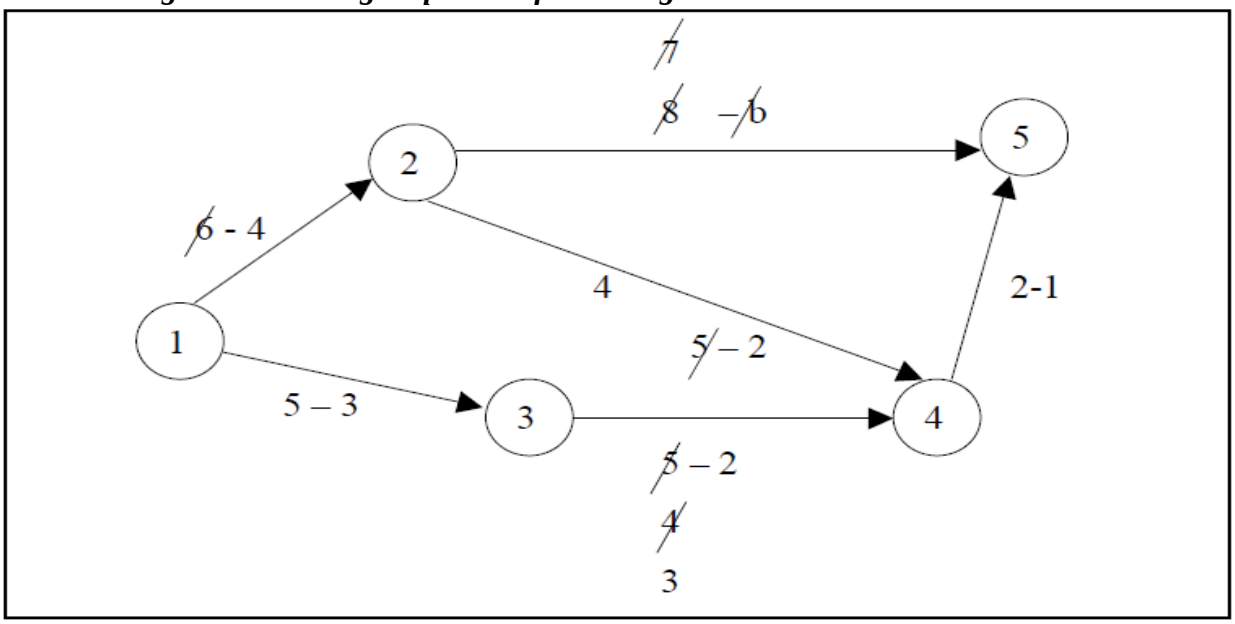
Activity	Cost Slope	Rank
1-2	15	2
1-3	35	4
2-4	10	1
2-5	100	5
3-4	20	3
4-5	20	3

The available paths of the network are listed down in Table indicating the sequence of crashing.

Sequence of Crashing

Path	Number of days crashed
1-2-5	~~14~~ ~~12~~ ~~11~~ 10
1-2-4-5	~~13~~ ~~11~~ ~~11~~ 10
1-3-4-5	~~12~~ ~~12~~ ~~11~~ 10

Network Diagram Indicating Sequence of Crashing



The sequence of crashing and the total cost involved is given in the following table

Initial direct cost = sum of all normal costs given = Rs. 490.00

Sequence of Crashing & Total Cost

Activity Crashed	Project Duration	Critical Path	Direct Cost in (Rs.)	Indirect Cost (in Rs.)	Total Cost (in Rs)
–	14	1 – 2 – 5	490	14 × 20 = 280	770
1 – 2(2)	12	1 – 2 – 5	490 + (2 × 15) = 520	12 × 20 = 240	760
2 – 5 (1) 3 – 4 (1)	11	1 – 2 – 5 1 – 3 – 4 – 5 1 – 2 – 4 – 5	520 + (1 × 100) + (1 × 20) = 640	11 × 20 = 220	860
2 – 5 (1) 2 – 4 (1) 3 – 4 (1)	10	1 – 2 – 5 1 – 3 – 4 – 5 1 – 2 – 4 – 5	640 + (1 × 100) + (1 × 10) + (1 × 20) = 770	10 × 20 = 200	970

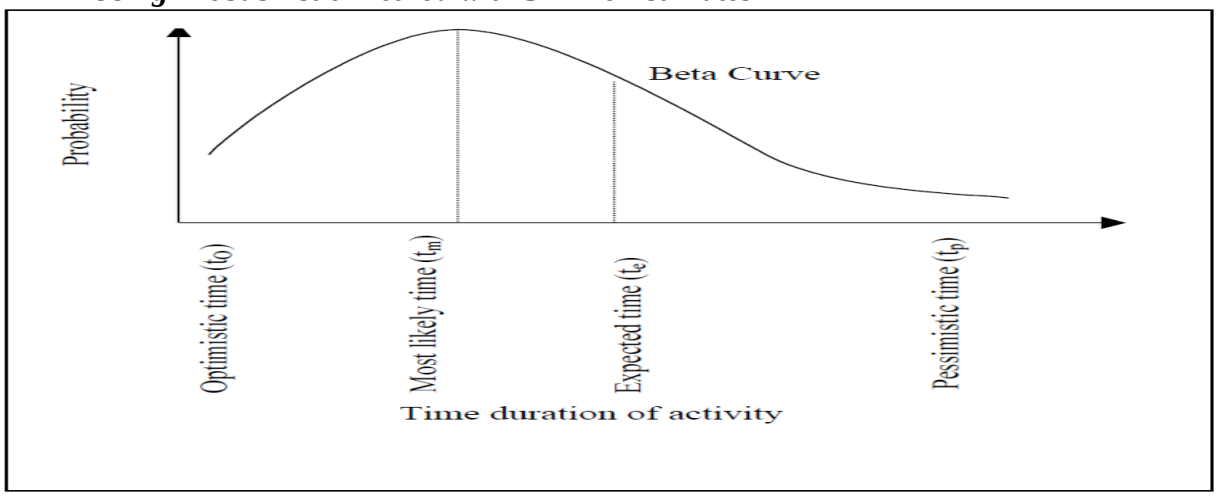
It is not possible to crash more than 10 days, as all the activities in the critical path are fully crashed. Hence the Project Review Techniques

The project review techniques are

In the critical path method, the time estimates are assumed to be known with certainty. In certain projects like research and development, new product introductions, it is difficult to estimate the time of various activities. Hence PERT is used in such projects with a probabilistic method using three time estimates for an activity, rather than a single estimate, as shown in Figure.

minimum project duration is 10 days with the total cost of Rs. 970.00.

PERT Using Probabilistic Method with 3 Time Estimates



Optimistic time tO:

It is the shortest time taken to complete the activity. It means that if everything goes well then there is more chance of completing the activity within this time.

Most likely time t_m:

It is the normal time taken to complete an activity, if the activity were frequently repeated under the same conditions.

Pessimistic time t_p:

It is the longest time that an activity would take to complete. It is the worst time estimate that an activity would take if unexpected problems are faced.

Taking all these time estimates into consideration, the expected time of an activity is arrived at.

The average or mean (t_a) value of the activity duration is given by,

$T_a = t_0 + 4t_m + t_p/6$ .....(5)

The variance of the activity time is calculated using the formula,

$T_a = t_0 + 4t_m + t_p/6$ .....(6)

Probability for Project Duration

The probability of completing the project within the scheduled time (Ts) or contracted time may be obtained by using the standard normal deviate where Te is the expected time of project completion.

$$Z_0 = \frac{T_s - T_e}{\sqrt{\Sigma\sigma^2 \text{ in critical path}}} \quad \text{.....(7)}$$

Probability of completing the project within the scheduled time is,

P (T≤ Ts) = P (Z≤ Z0) (from normal tables) .....(8)

Example :

An R & D project has a list of tasks to be performed whose time estimates are given in the table, as follows.

Time expected for each activity is calculated using the formula (5):

$T_a = t_0 + 4t_m + t_p/6$

= 4+4(6)+8/6 = 36/6 = 6 days for activity A

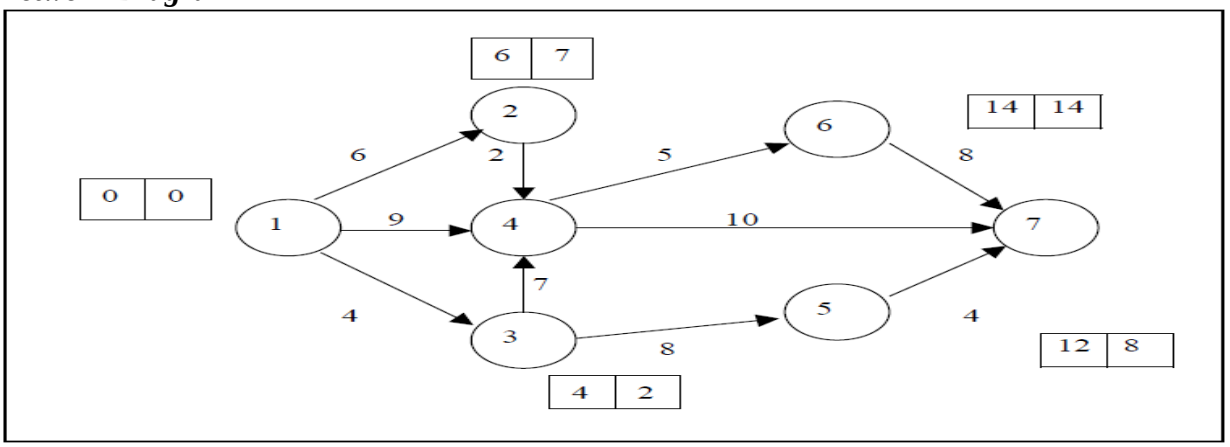
Similarly, the expected time is calculated for all the activities. The variance of activity time is calculated using the formula (6).

$$\sigma_i^2 = \left(\frac{t_p - t_0}{6}\right)^2$$

$$= \left(\frac{8-4}{6}\right)^2 = 0.444$$

Similarly, variances of all the activities are calculated. Construct a network diagram and calculate the time earliest, TE and time Latest TL for all the activities.

Network Diagram



Time Estimates for R & D Project

Activity i j	Activity Name	T_0	t_m (in days)	t_p
1-2	A	4	6	8
1-3	B	2	3	10
1-4	C	6	8	16
2-4	D	1	2	3
3-4	E	6	7	8
3-5	F	6	7	14
4-6	G	3	5	7
4-7	H	4	11	12
5-7	I	2	4	6
6-7	J	2	9	10

a. Draw the project network.
b. Find the critical path.
c. Find the probability that the project is completed in 19 days. If the probability is less that 20%, find the probability of completing it in 24 days.

Solution:

Calculate the time average t_a and variances of each activity as shown in the following $t_a$ble.

Te & s2 Calculated

Activity	T_o	T_m	T_p	T_a	σ^2
1-2	4	6	8	6	0.444
1-3	2	3	10	4	1.777
1-4	6	8	16	9	2.777
2-4	1	2	3	2	0.111
3-4	6	7	8	7	0.111
3-5	6	7	14	8	1.777
4-6	3	5	7	5	0.444
4-7	4	11	12	10	1.777
5-7	2	4	6	4	0.444
6-7	2	9	10	8	1.777

From the network diagram Figure, the critical path is identified as 1-4, 4-6, 6-7, with project duration of 22 days. The probability of completing the project within 19 days is given by,

$$Z_0 = \left(\frac{T_s - T_e}{\sqrt{\Sigma\sigma \text{ in critical path}}} \right)$$

$$= \left(\frac{19 - 22}{\sqrt{2.777 + 0.444 + 1.777}} \right)$$

$$= \left(\frac{-3}{\sqrt{5}} \right) = -1.3416 \text{ days}$$

we know, $P(Z < Z_0) = 0.5 - Y\ (1.3416)$ (from normal tables, $Y\ (1.3416) = 0.4099$)

$$= 0.5 - 0.4099$$

$$= 0.0901$$

$$= 9.01\%$$

Thus, the probability of completing the R & D project in 19 days is 9.01%. Since the probability of completing the project in 19 days is less than 20%, we find the probability of completing it in 24 days.

$$Z_0 = \frac{T_s - T_e}{\sqrt{\Sigma\sigma \text{ in critical path}}}$$

$$= \left(\frac{24-22}{\sqrt{5}}\right) = \left(\frac{2}{\sqrt{5}}\right) = 0.8944 \text{ days}$$

$$P(Z \le Z_0) = 0.5 - Y(0.8944) \quad \text{(from normal tables, } Y(0.8944) = 0.3133)$$

$$= 0.5 + 0.3133$$

$$= 0.8133$$

$$= 81.33\%$$

Head event slack and Tail event slack

The head event slack of an activity in a network is the slack at the head.The tail event slack of an activity in a network is the slack at the tail.

As discussed earlier, the non – critical activities have some slack or float. The ***float*** of an activity is the amount of time available by which it is possible to delay its completion time without extending the overall project completion time.

For an activity i = j, let

t_{ij} = duration of activity

TE = earliest expected time

T_L = latest allowable time

ES_{ij} = earliest start time of the activity

EF_{ij} = earliest finish time of the activity

LS_{ij} = latest start time of the activity

LF_{ij} = latest finish time of the activity

Total Float TF_{ij}: The total float of an activity is the difference between the latest start time and the earliest start time of that activity.

$TF_{ij} = LS_{ij} - ES_{ij}$ .....(1)

or

$TF_{ij} = (T_L - TE) - t_{ij}$ .....(2)

Free Float FF_{ij}: The time by which the completion of an activity can be delayed from its earliest finish time without affecting the earliest start time of the succeeding activity is called free float.

$FF_{ij} = (E_j - E_i) - t_{ij}$ .....(3)

FF_{ij} = Total float – Head event slack

Independent Float IF_{ij}: The amount of time by which the start of an activity can be delayed without affecting the earliest start time of any immediately following activities, assuming that the preceding activity has finished at its latest finish time.

$IF_{ij} = (E_j - L_i) - t_{ij}$ .....(4)

IF_{ij} = Free float – Tail event slack

Where tail event slack = $L_i - E_i$

The negative value of independent float is considered to be zero.

Critical Path: After determining the earliest and the latest scheduled times for various activities, the minimum time required to complete the project is calculated. In a network, among various paths, the longest path which determines the total time duration of the project is called the ***critical path*.** The following conditions must be satisfied in locating the critical path of a network.

An activity is said to be critical only if both the conditions are satisfied.

1. $T_L - T_E = 0$ 2. $T_{Lj} - t_{ij} - T_{Ei} = 0$

Example : A project schedule has the following characteristics as shown in the table

Project Schedule

Activity	Name	Time	Activity	Name	Time (days)
1-2	A	4	5-6	G	4
1-3	B	1	5-7	H	8
2-4	C	1	6-8	I	1
3-4	D	1	7-8	J	2
3-5	E	6	8-10	K	5
4-9	F	5	9-10	L	7

i. Construct PERT network.

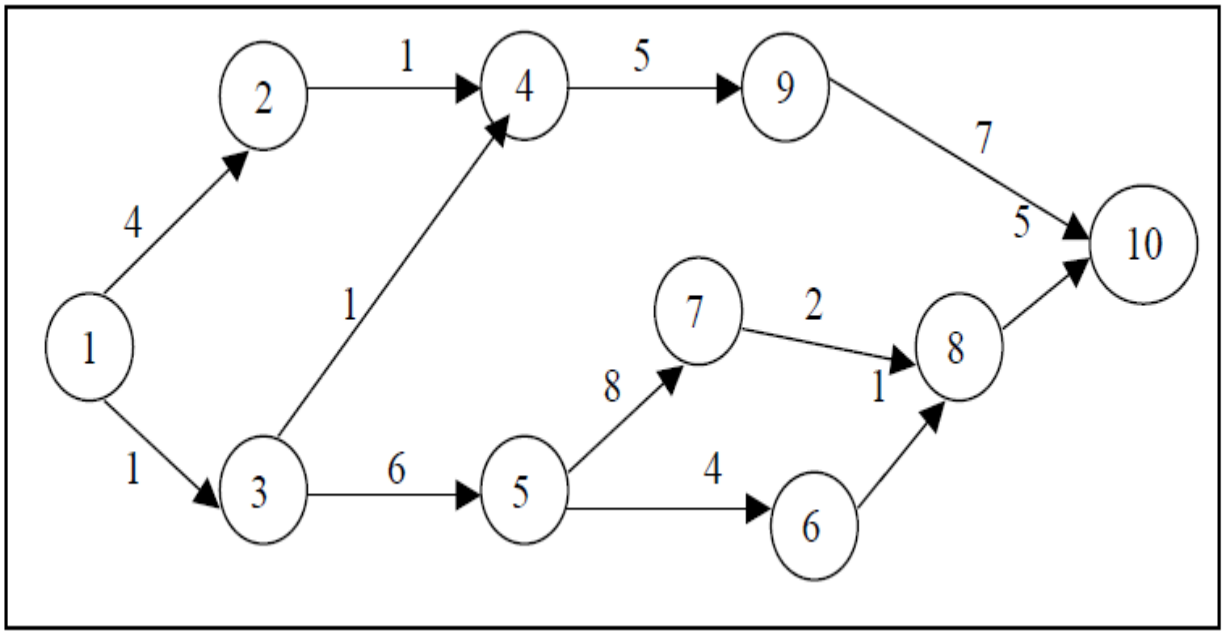
ii. Compute T_E and T_L for each activity.

iii. Find the critical path.

Solution:

(i) From the data given in the problem, the activity network is constructed as shown in the following figure.

Activity Network Diagram



(ii) To determine the critical path, compute the earliest, time T Network Model E and latest time T_L for each of the activity of the project. The calculations of TE and T_L are as follows:

To calculate $T_E$for all activities,

$T_{E1} = 0$

$T_{E2} = T_{E1} + t_1, 2 = 0 + 4 = 4$

$T_{E3} = T_{E1} + t_1, 3 = 0 + 1 = 1$

$T_{E4} = \max (T_{E2} + t_2, 4 \text{ and } T_{E3} + t_3, 4)$

$= \max (4 + 1 \text{ and } 1 + 1) = \max (5, 2)$

= 5 days

$T_{E5} = T_{E3} + t\ 3, 6 = 1 + 6 = 7$

$T_{E6} = T_{E5} + t\ 5, 6 = 7 + 4 = 11$

$T_{E7} = T_{E5} + t_5, 7 = 7 + 8 = 15$

T_{E8} = max (T_{E6} + t 6, 8 and T_{E7} + t_7, 8)

= max (11 + 1 and 15 + 2) = max (12, 17)

= 17 days

T_{E9} = T_{E4} + t_4, 9 = 5 + 5 = 10

T_{E10} = max (T_{E9} + t_9, 10 and T_{E8} + t_8, 10)

= max (10 + 7 and 17 + 5) = max (17, 22)

= 22 days

To calculate T_L for all activities

T_{L10} = T_{E10} = 22

T_{L9} = T_{E10}– $t_{9,10}$ = 22 – 7 = 15

T_{L8} = T_{E10}– $t_{8, 10}$ = 22 – 5 = 17

T_{L7} = T_{E8}– $t_{7, 8}$ = 17 – 2 = 15

T_{L6} = T_{E8}– $t_{6, 8}$ = 17 – 1 = 16

T_{L5} = min (T_{E6}– $t_{5, 6}$ and T_{E7}– $t_{5, 7}$)

= min (16 – 4 and 15 –8) = min (12, 7)

= 7 days

T_{L4} = T_{L9} – $t_{4, 9}$ = 15 – 5 =10

T_{L3} = min (T_{L4} – $t_{3, 4}$ and T_{L55}– $t_{3, 5}$)

= min (10 – 1 and 7 – 6) = min (9, 1)

= 1 day

T_{L2} = T_{L4}– t_2, 4 = 10 – 1 = 9

T_{L1} = Min (T_{L2}– $t_{1, 2}$ and T_{L3}– $t_{1, 3}$)

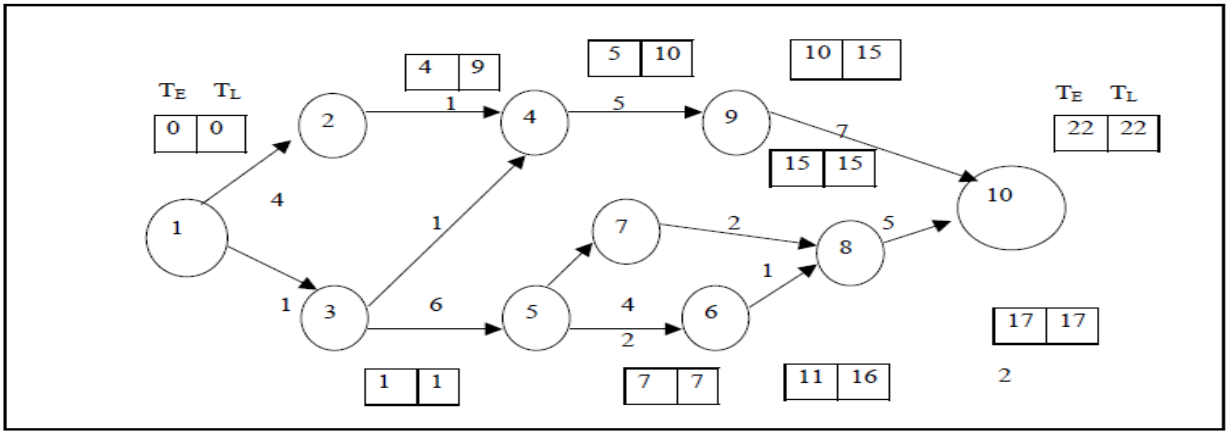
= Min (9 – 4 and 1 – 1) = 0

Various Activities and their Floats

Activity	Activity Name	Normal Time	Earliest Time		Latest Time		Total Float
			Start	Finish	Start	Finish	
1-2	A	4	0	4	5	9	5
1-3	B	1	0	1	0	1	0
2-4	C	1	4	5	9	10	5
3-4	D	1	1	2	9	10	8
3-5	E	6	1	7	1	7	0
4-9	F	5	5	10	10	15	5
5-6	G	4	7	11	12	16	5
5-7	H	8	7	15	7	15	0
6-8	I	1	11	12	16	17	5
7-8	J	2	15	17	15	17	0
8-10	K	5	17	22	19	22	0
9-10	L	7	10	17	15	22	5

(iii) From the table, we observe that the activities 1 – 3, 3 – 5, 5 – 7,7 – 8 and 8 – 10 are critical activities as their floats are zero

.Critical Path of the Project



The critical path is 1-3-5-7-8-10 (shown in double line in the above figure) with the project duration of 22 days.

DETERMINATION OF FLOAT AND SLACK TIMES - QUANTITATIVE TECHNIQUES FOR MANAGEMENT

Head event slack and Tail event slack

The head event slack of an activity in a network is the slack at the head.The tail event slack of an activity in a network is the slack at the tail.

As discussed earlier, the non – critical activities have some slack or float. The ***float*** of an activity is the amount of time available by which it is possible to delay its completion time without extending the overall project completion time.

For an activity i = j, let

t_{ij} = duration of activity

TE = earliest expected time

T_L = latest allowable time

ES_{ij} = earliest start time of the activity

EF_{ij} = earliest finish time of the activity

LS_{ij} = latest start time of the activity

LF_{ij} = latest finish time of the activity

Total Float TF_{ij}: The total float of an activity is the difference between the latest start time and the earliest start time of that activity.

$TF_{ij} = LS_{ij} – ES_{ij}$ .....(1)

or

$TF_{ij} = (T_L – TE) – t_{ij}$ .....(2)

Free Float FF_{ij}: The time by which the completion of an activity can be delayed from its earliest finish time without affecting the earliest start time of the succeeding activity is called free float.

$FF_{ij} = (E_j – E_i) – t_{ij}$ .....(3)

FF_{ij} = Total float – Head event slack

Independent Float IF_{ij}: The amount of time by which the start of an activity can be delayed without affecting the earliest start time of any immediately following activities, assuming that the preceding activity has finished at its latest finish time.

$IF_{ij} = (E_j – L_i) – t_{ij}$ .....(4)

IF_{ij} = Free float – Tail event slack

Where tail event slack = $L_i - E_i$

The negative value of independent float is considered to be zero.

Critical Path: After determining the earliest and the latest scheduled times for various activities, the minimum time required to complete the project is calculated. In a network, among various paths, the longest path which determines the total time duration of the project is called the ***critical path*****.** The following conditions must be satisfied in locating the critical path of a network.

An activity is said to be critical only if both the conditions are satisfied.

1. $T_L - T_E = 0$

2. $T_{Lj} - t_{ij} - T_{Ej} = 0$

Example :

A project schedule has the following characteristics as shown in the table

Project Schedule

Activity	Name	Time	Activity	Name	Time (days)
1-2	A	4	5-6	G	4
1-3	B	1	5-7	H	8
2-4	C	1	6-8	I	1
3-4	D	1	7-8	J	2
3-5	E	6	8-10	K	5
4-9	F	5	9-10	L	7

i. Construct PERT network.

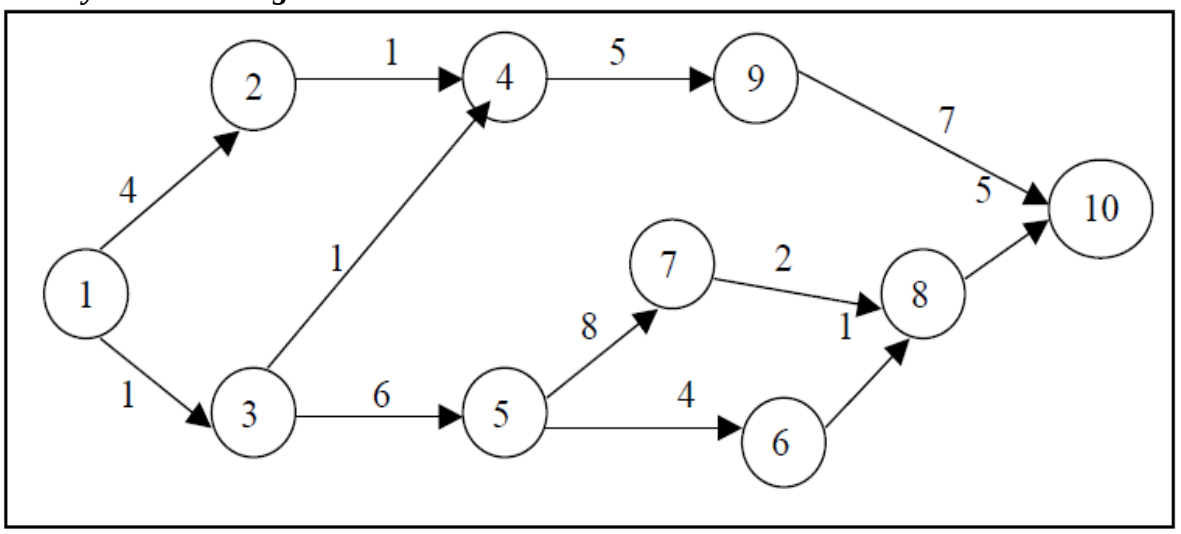
ii. Compute T_E and T_L for each activity.

iii. Find the critical path.

Solution:

(i) From the data given in the problem, the activity network is constructed as shown in the following figure.

Activity Network Diagram



(ii) To determine the critical path, compute the earliest, time T Network Model E and latest time T_L for each of the activity of the project. The calculations of TE and T_L are as follows:

To calculate $T_E$for all activities,

$T_{E1} = 0$

$T_{E2} = T_{E1} + t_1, 2 = 0 + 4 = 4$

$T_{E3} = T_{E1} + t_1, 3 = 0 + 1 = 1$

$T_{E4} = \max (T_{E2} + t_2, 4 \text{ and } T_{E3} + t_3, 4)$

$= \max (4 + 1 \text{ and } 1 + 1) = \max (5, 2)$

$= 5$ days

$T_{E5} = T_{E3} + t\ 3, 6 = 1 + 6 = 7$

$T_{E6} = T_{E5} + t\ 5, 6 = 7 + 4 = 11$

$T_{E7} = T_{E5} + t_5, 7 = 7 + 8 = 15$

$T_{E8} = \max (T_{E6} + t\ 6, 8 \text{ and } T_{E7} + t_7, 8)$

$= \max (11 + 1 \text{ and } 15 + 2) = \max (12, 17)$

$= 17$ days

$T_{E9} = T_{E4} + t_4, 9 = 5 + 5 = 10$

$T_{E10} = \max (T_{E9} + t_9, 10 \text{ and } T_{E8} + t_8, 10)$

$= \max (10 + 7 \text{ and } 17 + 5) = \max (17, 22)$

$= 22$ days

To calculate T_L for all activities

$T_{L10} = T_{E10} = 22$

$T_{L9} = T_{E10} - t_{9,10} = 22 - 7 = 15$

$T_{L8} = T_{E10} - t_{8,10} = 22 - 5 = 17$

$T_{L7} = T_{E8} - t_{7,8} = 17 - 2 = 15$

$T_{L6} = T_{E8} - t_{6,8} = 17 - 1 = 16$

$T_{L5} = \min (T_{E6} - t_{5,6}$ and $T_{E7} - t_{5,7})$

= min (16 – 4 and 15 –8) = min (12, 7)

= 7 days

$T_{L4} = T_{L9} - t_{4,9} = 15 - 5 = 10$

$T_{L3} = \min (T_{L4} - t_{3,4}$ and $T_{L55} - t_{3,5})$

= min (10 – 1 and 7 – 6) = min (9, 1)

= 1 day

$T_{L2} = T_{L4} - t_{2}, 4 = 10 - 1 = 9$

$T_{L1} = \text{Min} (T_{L2} - t_{1,2}$ and $T_{L3} - t_{1,3})$

= Min (9 – 4 and 1 – 1) = 0

Various Activities and their Floats

Activity	Activity Name	Normal Time	Earliest Time		Latest Time		Total Float
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5-7	H	8	7	15	7	15	0
6-8	I	1	11	12	16	17	5
7-8	J	2	15	17	15	17	0
8-10	K	5	17	22	19	22	0
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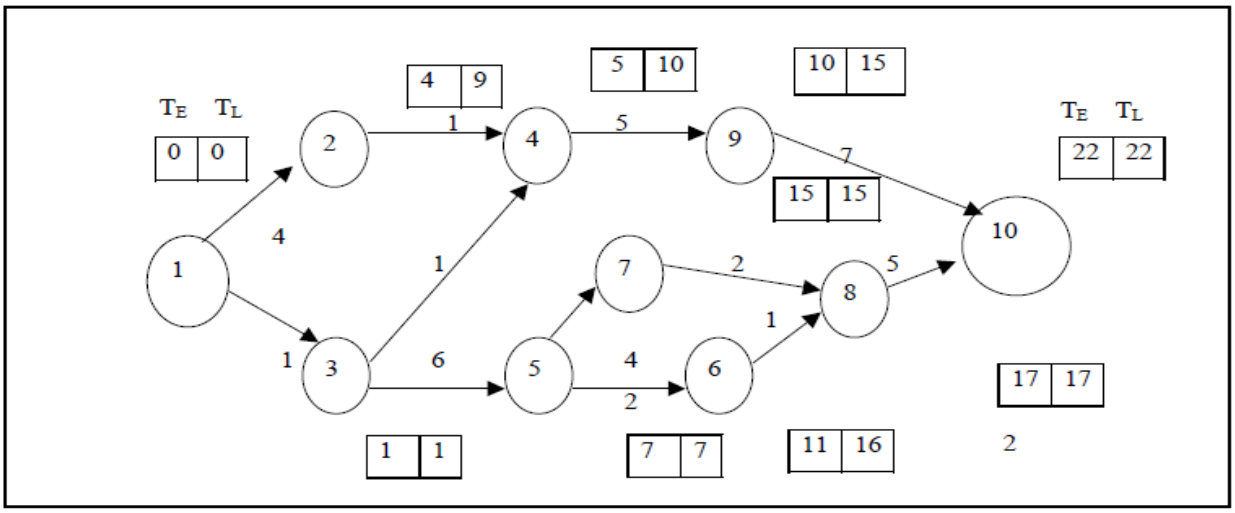
(iii) From the table, we observe that the activities 1 – 3, 3 – 5, 5 – 7,7 – 8 and 8 – 10 are critical activities as their floats are zero.

Critical Path of the Project



The critical path is 1-3-5-7-8-10 (shown in double line in the above figure) with the project duration of 22 days.

Transportation Problems, Assignment problems, Simulation, Learning Curve Theory.

Linear programming is a mathematical method that is used to determine the best possible outcome or solution from a given set of parameters or list of requirements, which are represented in the form of linear relationships. It is most often used in computer modeling or simulation in order to find the best solution in allocating finite resources such as money, energy, manpower, machine resources, time, space and many other variables. In most cases, the "best outcome" needed from linear programming is maximum profit or lowest cost.

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For example, suppose there are 1000 boxes of the same size of 1 cubic meter each; 3 trucks that are able to carry 100 boxes, 70 boxes and 40 boxes respectively; several possible routes; and 48 hours to deliver all the boxes. Linear programming provides the mathematical equations to determine the optimal truck loading and route to be taken in order to meet the requirement of getting all boxes from point A to B with the least amount of going back and forth and, of course, the lowest cost at the fastest time possible

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The basic components of linear programming are as follows:

Decision variables - These are the quantities to be determined.
Objective function - This represents how each decision variable would affect the cost, or, simply, the value that needs to be optimized.
Constraints - These represent how each decision variable would use limited amounts of resources.
Data - These quantify the relationships between the objective function and the constraints.

Difference Between PERT and CPM

Project management can be understood as a systematic way of planning, scheduling, executing, monitoring, controlling the different aspects of the project, so as to attain the goal made at the time of project formulation. PERT and CPM are the two network-based project management techniques, which exhibit the flow and sequence of the activities and events. **Program (Project) Management and Review Technique (PERT)** is appropriate for the projects where the time needed to complete different activities are not known.

The two scheduling methods use a common approach for designing the network and for ascertaining its critical path. They are used in the successful completion of a project and hence used in conjunction with each other. Nevertheless, the truth is that CPM is different from PERT in a way that the latter concentrates on time while the former stresses on the time-cost trade-off. In the same manner, there are many differences between PERT and CPM, which we are going to discuss in this article.

Comparison Chart

BASIS COMPARISON	PERT	CPM
Meaning	PERT is a project management technique, used to manage uncertain activities of a project.	CPM is a statistical technique of project management that manages well defined activities of a project.
What is it?	A technique of planning and control of time.	A method to control cost and time.
Orientation	Event-oriented	Activity-oriented
Evolution	Evolved as Research & Development project	Evolved as Construction project
Model	Probabilistic Model	Deterministic Model
Focuses on	Time	Time-cost trade-off
Estimates	Three time estimates	One time estimate
Appropriate for	High precision time estimate	Reasonable time estimate
Management of	Unpredictable Activities	Predictable activities
Nature of jobs	Non-repetitive nature	Repetitive nature
Critical and Non-critical activities	No differentiation	Differentiated
Suitable for	Research and Development Project	Non-research projects like civil construction, ship building etc.

Definition of PERT

PERT is an acronym for Program (Project) Evaluation and Review Technique, in which planning, scheduling, organizing, coordinating and controlling uncertain activities take place. The technique studies and represents the tasks undertaken to complete a project, to identify the least time for completing a task and the minimum time required to complete the whole project. It was developed in the late 1950s. It is aimed to reduce the time and cost of the project.

PERT uses time as a variable which represents the planned resource application along with performance specification. In this technique, first of all, the project is divided into activities and events. After that proper sequence is ascertained, and a network is constructed. After that time needed in each activity is calculated and the critical path (longest path connecting all the events) is determined.

Definition of CPM

Developed in the late 1950s, Critical Path Method or CPM is an algorithm used for planning, scheduling, coordination and control of activities in a project. Here, it is assumed that the activity duration is fixed and certain. CPM is used to compute the earliest and latest possible start time for each activity.

The process differentiates the critical and non-critical activities to reduce the time and avoid the queue generation in the process. The reason for the identification of critical activities is that, if any activity is delayed, it will cause the whole process to suffer. That is why it is named as Critical Path Method.

Key Differences Between PERT and CPM

The most important differences between PERT and CPM are provided below:

1. PERT is a project management technique, whereby planning, scheduling, organising, coordinating and controlling uncertain activities are done. CPM is a statistical technique of project management in which planning, scheduling, organising, coordination and control of well-defined activities take place.

2. PERT is a technique of planning and control of time. Unlike CPM, which is a method to control costs and time.
3. While PERT is evolved as a research and development project, CPM evolved as a construction project.
4. PERT is set according to events while CPM is aligned towards activities.
5. A deterministic model is used in CPM. Conversely, PERT uses a probabilistic model.
6. There are three times estimates in PERT, i.e. optimistic time (to), most likely time ™, pessimistic time (tp). On the other hand, there is only one estimate in CPM.
7. PERT technique is best suited for a high precision time estimate, whereas CPM is appropriate for a reasonable time estimate.
8. PERT deals with unpredictable activities, but CPM deals with predictable activities.
9. PERT is used where the nature of the job is non-repetitive. In contrast to, CPM involves the job of repetitive nature.
10. There is a demarcation between critical and non-critical activities in CPM, which is not in the case of PERT.
11. PERT is best for research and development projects, but CPM is for non-research projects like construction projects.
12. Crashing is a compression technique applied to CPM, to shorten the project duration, along with the least additional cost. The crashing concept is not applicable to PERT.

Simulation, Learn ing Curve Theory

The traditional method of crashing Project Evaluation and Review Technique (PERT) networks ignores the stochastic model to a determinisitic Critical Path Method (CPM) model and simply using activity time means in calculations. The project is then arbitrarily crashed to some desired completion date, without consideration for what the penalty for late completion of the project is. Additionally, the method ignores the fact that reducing some activity times may reduce the mean project completion time more than others, due to such factors as bottlenecks. The authors use a computer simulation model to determine the order in which activities should be crashed as well as the optimal crashing strategy for a PERT network to minimize the expected value of the total (crash + overrun) cost, given a specified penalty function for late completion of the project. Three extreme network types are examined, each with two different penalty functions.

Formal stochastic simulation study has been recognized as a remedy for the shortcomings inherent to classic critical path method (CPM) project evaluation and review technique (PERT) analysis. An accurate and efficient method of identifying critical activities is essential for

conducting PERT simulation. This paper discusses the derivation of a PERT simulation model, which incorporates the discrete event modeling approach and a simplified critical activity identification method. This has been done in an attempt to overcome the limitations and enhance the computing efficiency of classic CPM/PERT analysis. A case study was conducted to validate the developed model and compare it to classic CPM/PERT analysis. The developed model showed marked enhancement in analyzing the risk of project schedule overrun and determination of activity criticality. In addition, the beta distribution and its subjective fitting methods are discussed to complement the PERT simulation model. This new solution to CPM network analysis can provide project management with a convenient tool to assess alternative scenarios based on computer simulation and risk analysis.

Learning Curve Theory

A learning curve is a concept that graphically depicts the relationship between the cost and output over a defined period of time, normally to represent the repetitive task of an employee or worker. The learning curve was first described by psychologist Hermann Ebbinghaus in 1885 and is used as a way to measure production efficiency and to forecast costs.

Understanding Learning Curves

The learning curve also is referred to as the experience curve, the cost curve, the efficiency curve, or the productivity curve. This is because the learning curve provides measurement and insight into all the above aspects of a company. The idea behind this is that any employee, regardless of position, takes time to learn how to carry out a specific task or duty. The amount of time needed to produce the associated output is high. Then, as the task is repeated, the employee learns how to complete it quickly, and that reduces the amount of time needed for a unit of output.

That is why the learning curve is downward sloping in the beginning with a flat slope toward the end, with the cost per unit depicted on the Y-axis and total output on the X-axis. As learning increases, it decreases the cost per unit of output initially before flattening out, as it becomes harder to increase the efficiencies gained through learning.

Benefits of Using the Learning Curve

Companies know how much an employee earns per hour and can derive the cost of producing a single unit of output based on the number of hours needed. A well-placed employee who is set up for success should decrease the company's costs per unit of output over time. Businesses can use the learning curve to conduct production planning, cost forecasting, and logistics schedules. **[Important: The learning curve does a good job of depicting the cost per unit of output over time.]**

The slope of the learning curve represents the rate in which learning translates into cost savings for a company. The steeper the slope, the higher the cost savings per unit of output. This standard learning curve is known as the 80% learning curve. It shows that for every doubling of a company's output, the cost of the new output is 80% of the prior output. As output increases, it becomes harder and harder to double a company's previous output, depicted using the slope of the curve, which means cost savings slow over time.

Key Takeaways

- The learning curve is a concept that describes how new skills or knowledge can be quickly acquired initially, but subsequent learning becomes much slower.
- The slope of the learning curve represents the rate in which learning translates into cost savings for a company.
- The steeper the slope of the learning curve, the higher the cost savings per unit of output.

A **learning curve** is a graphical representation of how an increase in learning (measured on the vertical axis) comes from greater experience (the horizontal axis); or how the more someone (or something) performs a task, the better they get at it.[1]

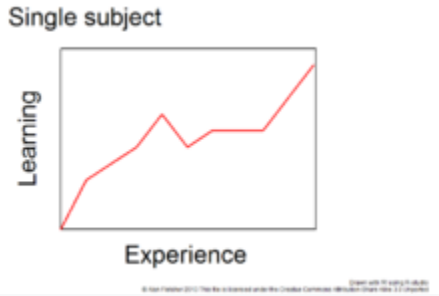

Fig 1: Learning curve for a single subject, showing how learning improves with experience

Fig 2: A learning curve averaged over many trials is smooth, and can be expressed as a mathematical function

The term *learning curve* is used in two main ways: where the same task is repeated in a series of trials, or where a body of knowledge is learned over time. Hermann Ebbinghaus first described the learning curve in 1885 in the field of the psychology of learning, although the name did not come into use until 1903.[2][3] In 1936 Theodore Paul Wright described the effect of learning on production costs in the aircraft industry.[4] This form, in which *unit cost* is plotted against *total production*, is sometimes called[*by whom?*] an experience curve.

The familiar expression "*a steep learning curve*" means that the activity is difficult to learn, although a learning curve with a steep start actually represents rapid progress.