IT Project Management

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Subject Matter Expert

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Module - I: Introduction to Project Management

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Learning Objectives:

At the end of this module, you will be able to understand:

- Basic Concepts and Importance of Project Management
- Characteristics of Projects
- Software Development Product Life Cycle Processes and Activities
- Concept related to SDLC Selection Criteria
- Stages of Project Management
- Developing Project Management Plan Components
- Tools and Techniques for Plan Scope Management
- Dependency Considerations during Project Management
- Key Concepts of Project Resource Management
- Trends and Emerging Practices in Project Resource Management
- Concept of Developing and Managing the Team
- Introductory Concept of Communication Planning
- Need of Communication Requirement Analysis
- Different Communication Models, Information Distribution
- Method of Performance Reporting
- Factors for Success and Failures of Project

Introduction

Based on the nature of their business, organisations create and execute initiatives that can be classed as internally or externally funded. Efficiency in project management is the means by which the amount of real profit is increased in organisations that perform externally funded projects for a fee (of sorts) on behalf of external clients. If the organization's principal line of business is service, manufacturing, or research, the projects are most likely internally funded, and project teams' tasks are to improve operational efficiency, develop new goods, or expand into new markets.

Internally sponsored projects, however indirectly, play a significant effect in the profit margin. In the case of a non-profit organisation, projects are carried out either internally or externally and are designed to further the organization's core goal, which is to promote a social cause rather than make a profit. However, the basic project management principles of effective and efficient resource use remain true and crucial as they seek to grow their services for social causes without increasing their resources.

The manner of coordination, communication, and management used by a team throughout the life cycle of a project is referred to as project organisation. Each team member is encouraged to participate in the project, and varied abilities and skills are valued.

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The team's involvement is depicted graphically in an organisational structure chart that displays where each person fits into the project framework. Project organisational charts are helpful for determining who does what, gaining buy-in, and setting group expectations.

A sequence of processes called project planning determines how to attain a certain community or corporate goal, or a collection of related goals. This objective might be found in a community or strategic plan. Community goals or action strategies generated through community meetings and gatherings, tribal council or board meetings, or other planning processes can also be used to inform project plans.

The project planning phase's goals are to:

- Establish business requirements.
- Establish cost, schedule, list of deliverables, and delivery dates.
- Establish resources plans.

Obtain management approval and proceed to the next phase.

1.1 Introduction to Project Management

Every organisation is likely to face a circumstance that necessitates a change. Starting a new office, launching a new product or service, upgrading an existing work process, installing a new computer system, combining with another firm, moving to a new site, entering a new market, meeting a social need, and so on are some examples of these changes. These adjustments are required to achieve an organization's operational or strategic objectives. And projects are used to achieve these objectives. Furthermore, an organization's principal goal is to produce value for its investors, which is accomplished when the business generates a healthy profit through achieving its strategic objectives. And projects are the vehicles via which a company achieves its strategic goals.

1.1.1 Basic Concepts of Project Management

Project and Project Management

To talk about project management, you must first grasp what a project is. A project is defined as "a short-term undertaking intended to produce a one-of-a-kind product, service, or result." 9 Operations, on the other hand, is the work done in businesses to keep them running. It focuses on ongoing goods and service production. Projects differ from operations in that they finish when the project's objectives are met or the project is completed. It's crucial to remember that those responsible for operations and projects must collaborate to ensure a smooth transition. DevOps for example, is a relatively new word in software development that describes a culture of collaboration between software development and operations teams in order to produce, test, and deliver dependable software more quickly.

Before getting into project management, it's necessary to understand the difference between project management and organisational procedures. A process is described as the continuous and day-to-day actions that companies participate in to generate goods and services. A process is a method of integrating efforts in a repeatable manner

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using current systems. It is also a part of the line organisation, which has a number of goals. A project, on the other hand, is carried out in a distinct manner from routine and process-driven labour. A project, unlike a process, is a non-repetitive activity with a distinct beginning and end to the sequence of tasks. Cost, scheduling, and performance constraints are typically established. Projects necessitate the use of skills and talents from many organisational functions.

A project is defined as a 'temporary activity undertaken to generate a unique product or service,' according to the PMBOK [2008] Guide, which is regarded a standard definition.

A project is defined as the accomplishment of a certain goal, whereas project management is the process of planning, scheduling, and controlling a project in order to fulfil the goals. This does not cover the important human relations and project evaluation tasks that must be completed once the project is completed. Project management is the process of effectively managing change that is brought about by a project.

Project management is defined as "the application of knowledge, skills, tools, and procedures to project activities in order to meet or exceed stakeholder demands and expectations from a project" by PMI.

Program management and Portfolio management

A programme is a collection of interconnected projects that are mutually dependent. Projects are part of a programme that is coordinated and managed as a whole to get benefits and control that are not possible with individual management. It has a same aim, and the end result or service can be a product or a service. The focus of programme management is primarily on project interdependencies, which provides for an optimal approach to project management. Resolving resource restrictions, aligning strategy directions, and resolving change management challenges are all critical actions of interdependencies.

Program management is described as the 'centralised coordinated management of a programme to achieve the program's strategic objectives and benefits,' according to the PMBOK 2008 reference.

A portfolio is a collection of projects and/or programmes that are grouped together to allow effective management in order to achieve a strategic business goal. Portfolio management is essential because it allows initiatives to share a shared strategic aim and resources. Portfolio management also maintains a healthy balance between long-term strategic goals and immediate requirements and limits. Portfolio management is defined by the PMBOK as "the centralised management of one or more portfolios, which includes identifying, prioritising, authorising, managing, and controlling projects, programmes, and other related work to achieve specific strategic business objectives," according to the PMBOK, 2008.

Many project managers also support an emerging business strategy known as project portfolio management (or portfolio management, as it is referred to in this text), in which organisations group and manage projects and programmes as a portfolio of investments that contribute to the overall success of the company. Portfolio managers assist their companies in making sound investment decisions by assisting in the

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selection and analysis of projects from a strategic standpoint. Portfolio managers may or may not have prior project or programme management experience. It is critical that they have excellent financial and analytical skills, as well as an understanding of how projects and programmes can help achieve strategic objectives.

Project Management Body of Knowledge

The PM body of knowledge is the industry standard for project management. It's a broad term that refers to a person's comprehensive knowledge of the project management field. It contains tried-and-true tools and techniques for managing project management processes in order to achieve a successful project outcome. The PMI's PMBOK handbook, which identifies and recognises excellent practices, is growing into the Body of Knowledge. The body of knowledge defines key project management skills and activities that all practitioners must understand and master in order to be fully trained in their field. This section of the knowledge base covers a wide overview of project management processes. According to the PMBOK handbook, there are nine knowledge areas.

"The application of knowledge, skills, tools, and procedures to project activities in order to achieve project requirements," according to project management. Project managers must not only aim to accomplish particular project scope, schedule, cost, and quality targets, but also to facilitate the entire process in order to meet the requirements and expectations of everyone involved in or affected by project operations.

Project Scope Management

Scope definition, Work break-down structure (WBS), project delivery plan, and scope change control are all important aspects of project scope management. Scope project management is applied in a standardised manner to all completed projects. Scope management ensures that the scope is effectively defined and communicated to all stakeholders in a clear and concise manner.

Project Time Management

Estimating the duration of project work packages, estimating resource requirements, project scheduling (including sequencing and prioritisation), and time change control are the four important activities in time management, as they are in scope change management.

Project Cost Management

The key actions conducted in project cost management include methods for cost estimation of work packages, project cost plan, and cost change control.

Project Quality Management

In the context of a project, quality management refers to the actions through which the executing organisation creates and implements quality policies, objectives, standards, and responsibilities in order to meet the needs for which it was created. The major procedures in project quality management are quality planning, quality assurance, and quality control. Because the outputs of various project management procedures are measured against specified standards, this knowledge area is critical.

Project Human Resource Management

Human resource management is a fundamental component of project success and a key component of the project management knowledge areas. It is the procedure for making the most effective use of a project's human resources. Customers, sponsors, project stakeholders, project team members, individual contributors, and others are all included in project HRM. HRM comprises three key procedures, according to PMBOOK 2008.

- Organisational planning: Identifying, documenting, and assigning project roles, responsibilities, and reporting linkages are all part of organisational planning (individuals and groups).
- Staffing: involved with obtaining the necessary human resources and assigning them to the project.
- Team development: is concerned with improving the managerial and technical abilities of stakeholders and teams.

Project Risk Management

The process of recognising and responding to project risk is known as project risk management. Risk management maintains a balance of focus on threats and opportunities, and the chance of detected risks can be decreased or avoided with correct management activities. Risk identification, risk analysis, risk response and contingency plans, and risk ownership are all part of project risk management.

Project Communication Management

Project Communication Management establishes vital connections between people, ideas, and information that are required for project success. It entails determining who requires what information, at what level of detail, in what medium, and within what time range. It is the most crucial component of the project management knowledge areas, ensuring that project information is generated, gathered, stored, transmitted, and disseminated on time and in accordance with the formal communication plan.

Project Procurement Management

Contract management is another term for project procurement management. It entails the procedures for obtaining goods and services from suppliers. It also handles procurement strategy, product and service bid solicitation, vendor selection, contract administration, and contract close-out.

Project Integration Management

This knowledge area is used to integrate the outputs of other project management bodies of knowledge for the project planning process, as well as the creation of consistent, comprehensive, and well-designed project processes and activities, as well as the coordination of the various project planning, execution, and control activities.

Project charter, PM strategy, Scope statement (project deliverables and objectives), WBS, Cost estimates, Scheduled start/finish dates, Responsibility assignments, Performance measurement, Milestones schedules, Key staff required, Key risks,

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Constraints, Assumptions, Subsidiary management plans, and other supporting details are included in the integrated project plan (outputs from other planning process not included in the project plan, documentation of technical details and relevant standards).

Project Life Cycle (PLC)

As a process of working to attain a certain goal, a project goes through multiple distinct periods or stages, which are referred to as the project life cycle. It's also known as project development stages. PLC illustrates the logical structure for project management. It serves as a guide for developing our strategies, determining when to commit resources, and assessing the project's success [Pinto, 2010, p.32]. Because a project's exact deliverables and activities can change over time, it's critical to chart the project's life cycle and cost over time. Several project managers divided PLC into stages based on the size and complexity of the project. The project lifecycle is divided into four stages, according to PMBOK [2008].

- Starting the project
- Organizing and preparing
- Carrying out the project
- Closing the project

Each project phase is viewed as a distinct division for managing deliverables and allowing the project manager to divide the task into more manageable chunks. The boundaries may or may not be integrated, and the total project stages demand distinct skills, control, and monitoring systems [PMBOK2008, p.15]. During the planning phase, fewer people (key stakeholders) are involved, and the cost is lower, however during the execution phase, where the actual project tasks are carried out, the level of staff participation and cost is higher, as illustrated in the diagram below.

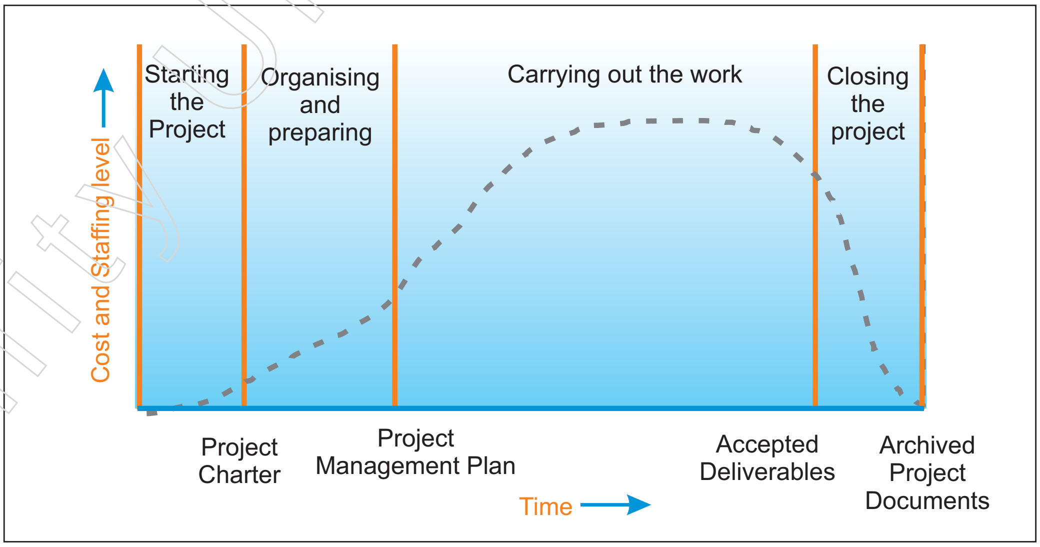

Figure: Typical cost and staffing levels across the Project Life Cycle

1.1.2 Importance of Project Management

The application of information, skills, tools, and procedures to project activities in order to achieve project requirements is referred to as project management. The appropriate use and integration of the project management processes established for the project is how project management is performed. Organizations can use project management to carry out projects more successfully and efficiently.

Individuals, groups, and public and commercial organisations benefit from effective project management because it enables them to:

- Meet business objectives;
- Satisfy stakeholder expectations;
- Be more predictable;
- Increase chances of success;
- Deliver the right products at the right time;
- Resolve problems and issues;
- Respond to risks in a timely manner;
- Optimize the use of organizational resources;
- Identify, recover, or terminate failing projects;
- Manage constraints (e.g., scope, quality, schedule, costs, resources);
- Balance the influence of constraints on the project (e.g., increased scope may increase cost or schedule); and
- Manage change in a better manner.

Poorly managed projects, or the lack of project management, can lead to the following outcomes:

- Missed deadlines,
- Cost overruns,
- Poor quality,
- Rework,
- Uncontrolled project expansion,
- Organizational reputation loss,
- Dissatisfied stakeholders, and
- Failure to meet project objectives

Project management is no longer a niche discipline. It's quickly becoming the norm in the business world. Project Management in Action: 2009 is a snapshot from practice. Projects are taking up an increasing percentage of a typical firm's time and effort. The importance and role of projects in contributing to an organization's strategic direction is expected to grow in the future. A number of causes for this are briefly mentioned below.

Compression of the Product Life Cycle

The shortening of the product life cycle is one of the most major driving forces behind the demand for project management. In today's high-tech industry for example, the average product life cycle is 1 to 3 years. Life cycles of 10 to 15 years were normal until 30 years ago. For new products with limited life cycles, time to market has become increasingly critical. A six-month project delay can result in a 33 percent loss in product revenue share, according to a typical rule of thumb in the area of high-tech

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product development. As a result, speed has become a competitive advantage, with an increasing number of companies relying on cross-functional project teams to bring new products and services to market as rapidly as feasible.

Knowledge Explosion

Because projects incorporate the most recent breakthroughs, the complexity of projects has evolved as new information has grown. Building a road for example, was a very simple operation 30 years ago. Materials, standards, codes, aesthetics, equipment, and required specialists have all become more sophisticated in recent years. In today's digital, electronic world, it's getting increasingly difficult to discover a new device that doesn't include at least one microchip. The requirement to connect disparate technologies has grown as a result of product complexity. Project management has emerged as a critical skill for accomplishing this goal.

Triple Bottom Line (planet, people, profit)

Because of the threat of global warming, sustainable business practices have risen to the fore. Businesses can no longer focus solely on increasing profits at the expense of the environment and society. Effective project management is key to reducing carbon emissions and maximising the use of renewable resources. Changes in the objectives and strategies utilised to execute projects reflect the impact of this shift toward sustainability. See Dell's Children Becomes World's First "Green" Hospital in a Snapshot from Practice.

Corporate Downsizing

Organizational life has been dramatically restructured over the last decade. Many businesses have found that downsizing (or rightsizing, if you're still employed) and sticking to core capabilities are now crucial for survival. Middle management is a relic of a bygone era. Project management is replacing middle management as a means of ensuring that things get done in today's flatter and leaner businesses, where change is continuous. Corporate downsizing has also resulted in a shift in how businesses approach projects. Significant portions of project work are outsourced, and project managers are responsible for not only their own employees but also their colleagues in other firms.

Increased Customer

Focus Customer satisfaction has become more important as a result of increased competition. Customers are no longer content with generic goods and services. They want products and services that are tailored to their individual requirements. This regulation necessitates a much closer collaboration between the provider and the recipient. As they engage with their organisation to meet the particular needs and desires of clients, account executives and sales reps are increasingly taking on the position of project manager.

Customized products and services have also been developed as a result of increased client attention. Buying a set of golf clubs for example, was a very simple procedure 10 years ago: you choose a set based on pricing and feel. There are golf clubs for tall and short players for players who slice the ball and for players who hook

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the ball for high-tech clubs with the newest metallurgical discoveries guaranteed to add distance, and so on. Project management is essential for developing personalised products and services as well as maintaining profitable customer relationships.

1.1.3 Characteristics of Projects

A project is a collection of interconnected actions designed to accomplish a certain goal while adhering to a set of deadlines, budgets, and quality standards. It entails group activity coordination, in which the management plans, organises, staffs, directs, and controls to attain a goal while keeping time, cost, and end product performance restrictions in mind. The term “project management” refers to a combination of the terms “project” and “management.”

Planning is one of the most important aspects of making a project more successful and efficient in terms of resource usage in order to meet the project’s objectives. We will focus on project characteristics such as how objectives are important for achieving the goal, the total time duration of the project, calculated risk and uncertainty of the project, the total estimated cost of the project, and so on. We will also discuss some other project characteristics such as team spirit, required funds, directions, uniqueness, flexibility, and sub-contracting, among others. Let’s take a look at each one separately.

Projects are not all alike. Each project is unique in its own way. The following are the distinguishing qualities of a project:

Objectives

Every project starts with a goal or aim, such as time, budget, quality, or number, and when those goals are met, the project continues to exist. You can begin by defining the project’s objectives, or what it needs to accomplish. The project’s objectives are the essential qualities that will show you how far you’ve progressed, and a time-to-time analysis will show you how much you’ve accomplished.

Single Entity

A project is a whole package. This means that, despite the fact that different people contribute to a project, it is still acknowledged as a single entity. Often, the teams are put together particularly for a single project.

Life Span

There is no such thing as an endless or indefinite enterprise. It must have one, and it must not go beyond it. Every endeavour is inextricably linked to a deadline. You will see the project’s time phase during planning, where the team can work independently on project modules. Consider the following project, which is divided into three modules: A, B, and C. If a project’s overall duration is 5 months, you can determine the duration of each module independently, such as A can be completed in 2 months, B in 2 months, and C in 1 month, depending on the requirements.

Require Funds

To attain its goal, every endeavour needs funding. No project can be implemented properly without sufficient money. One of the most important aspects of every business

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is cost estimation. As a result, calculating the project's required funds ahead of time will be quite beneficial.

Life Cycle

Every project has a life cycle that includes stages such as inception, growth, maturity, and decay. A project must go through several stages in order to be completed. If the project is related to software development, the SDLC (Software Development Lifecycle) will be the project's life cycle, which will include numerous stages such as planning, defining, designing, building, testing, and deployment, among others.

Team Spirit

Because the project consists of numerous personnel with various qualities and from various fields, team spirit is necessary to finish the project. However, missionary passion and team spirit are required to accomplish common goal harmony.

Risk and Uncertainty

In general, the project is built on forecasts. As a result, projects are always connected with risk and uncertainty. Those projects that are not properly defined will have a significant level of risk. Only the degree of risk and uncertainty control vary depending on the project being developed based on the information provided.

Because a project differs from previous work, it entails a degree of unfamiliarity. A project may also include new technology, which introduces major elements of uncertainty and risk for the organization/firm executing the project.

Directions

The project is always completed according to the customer's instructions in terms of time, quality, and quantity, among other things. The supply side of economics' conveniences, such as labour availability, ore resources, and management expertise, are all secondary issues, with the fundamental concern being the customer's necessity.

Projects go through multiple unique phases during the process, which are referred to as the project life cycle. As the project progresses from one phase to the next, the tasks, people, organisations, and other resources will change. With each successive phase, the organisational structure and resource expenditures grow, peak, and then fall as the project nears completion.

Uniqueness

Each project is distinct in its own right, with its own set of characteristics. Even if the sort of organisation is the same, no two projects are alike. The originality of a project may be measured by taking into account a variety of aspects such as the project's aims, characteristics, and applicability, among others.

It necessitates doing something new, something that has never been done before. Even with seemingly "regular" undertakings like home construction, factors like geography, access, zoning rules, labour market, public services, and local utilities make each project unique. A project is a one-time, one-of-a-kind action that will never be done again exactly the same manner.

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Flexibility

The terms “change” and “project” are interchangeable. Throughout the course of a project’s existence, it undergoes numerous adjustments. Projects might become more dynamic and flexible as a result of these adjustments.

Sub-Contracting

Subcontracting is a component of all projects, and without it, no project can be finished unless it is a small or private corporation. The more the project’s complexity, the greater the scope of contracting. Every project necessitates the assistance of an outside consultant, engineer, or subject matter expert.

Cost

If the project’s quality has to be improved, this may have an impact on the project’s cost. If additional resources are needed to accomplish the project faster, the cost may rise.

Projects are Temporary Activities

A project is an impromptu grouping of people, materials, equipment, and facilities put together to achieve a certain aim. This objective must be accomplished within a certain amount of time. When a goal is achieved, the organisation that was formed to achieve it is disbanded or reconstructed to work on a new objective (project).

Projects Cut Across Organizational Lines

Projects always cut over a company’s normal organisational divisions and frameworks. They do this because the project necessitates the participation of many professions and departments within the firm, as well as outside organisations. Advanced technology’s complexity frequently leads to additional project challenges, as it creates task interdependencies that can generate new and unique problems.

1.1.4 Software Development Product Life Cycle Processes and Activities

Within a software organisation, the SDLC is a process that is followed for a software project. It is a detailed strategy that explains how to build, maintain, replace, and change or improve certain software. The life cycle is a mechanism for enhancing software quality and the development process as a whole.

The many steps of a typical SDLC are depicted graphically in the diagram below.

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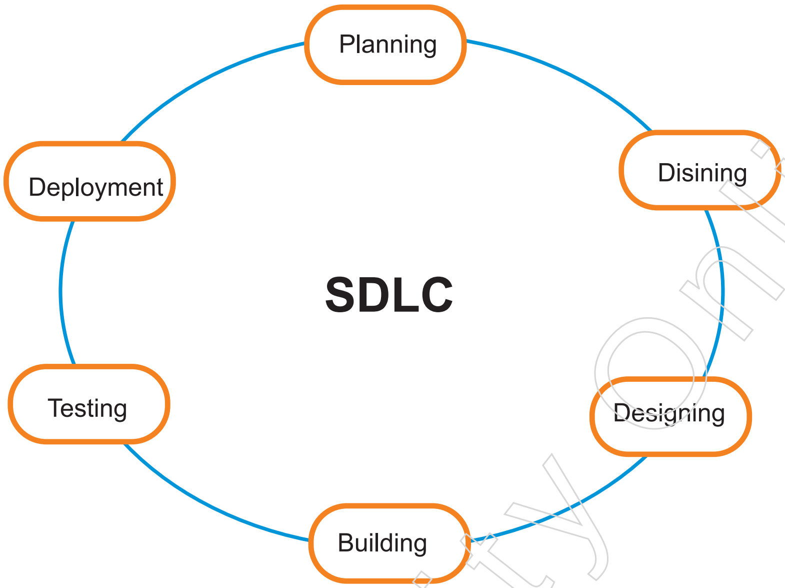

Figure: Software Development Cycle

Stage 1: Planning and Requirement Analysis

The most critical and fundamental level of the SDLC is requirement analysis. It is carried out by the team's top members, with input from the customer, the sales department, market surveys, and industry domain specialists. This data is then utilised to establish the main project approach and conduct product feasibility studies in the areas of economics, operations, and technology.

The planning step also includes determining the project's quality assurance requirements and identifying the project's risks. The technical feasibility study's goal is to identify the many technical techniques that can be used to successfully implement the project with the least amount of risk.

Stage 2: Defining the Requirements

Following the requirement analysis, the product needs must be properly defined and documented, and they must be approved by the client or market analysts. This is accomplished through the use of an SRS (Software Requirement Specification) document, which contains all of the product requirements that must be defined and developed throughout the project life cycle.

Stage 3: Designing the Product

Architecture SRS is the go-to resource for product architects looking to create the greatest architecture for a new product. Typically, many design approaches for the product architecture are presented and documented in a DDS - Design Document Specification based on the criteria given in the SRS.

This DDS is reviewed by all essential stakeholders, and the optimal design strategy for the product is chosen based on many parameters such as risk assessment, product robustness, design modularity, budget, and time restrictions.

A design approach identifies all of the product's architectural modules, as well as the product's communication and data flow representation with external and third-party modules (if any). All of the modules of the proposed architecture's internal design should be thoroughly documented in DDS, down to the tiniest of details.

Stage 4: Building or Developing the Product

The actual development of the product begins at this stage of the SDLC. During this stage, the programming code is generated according to DDS. Code generation can be done quickly and easily if the design is done in a precise and organised manner.

Developers must adhere to their organization's coding rules, and programming tools such as compilers, interpreters, and debuggers are used to develop code. Code is written in a variety of high-level programming languages, including C, C++, Pascal, Java, and PHP. The programming language is chosen based on the type of software that is being created.

Stage 5: Testing the Product

As testing operations are mainly included in all phases of SDLC in modern SDLC models, this stage is usually a subset of all stages. However, this stage only refers to the product's testing step, during which flaws are reported, monitored, repaired, and retested until the product meets the SRS's quality criteria.

Stage 6: Deployment in the Market and Maintenance

The product is formally released in the appropriate market once it has been thoroughly tested and is ready for deployment. Product rollout is sometimes done in stages, depending on the company's business strategy. The product could be introduced in a limited market and tested in a real-world setting first (UAT- User acceptance testing).

The product may then be released as is or with proposed enhancements in the intended market segment based on the feedback. Following the product's release to the market, it is maintained for the current client base.

SDLC Models

During the software development process, numerous software development life cycle models have been established and designed. Software Development Process Models" is another name for these models. To assure success in the software development process, each process model follows a set of stages specific to its type.

The most essential and widely used SDLC models in the industry are as follows:

Waterfall Model

Benington initially reported the waterfall model, sometimes known as the cascade model, in 1956, and Winston Royce improved it in 1970. It has served as the cornerstone for all previous models since it established a robust framework for defining and analysing needs prior to any design or development.

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- A Sequential model is an example of a waterfall model. The software development activity is organised into distinct phases in this paradigm, with each phase consisting of a sequence of activities and achieving different goals.
- It is divided into phases, with one phase's output becoming the input for the next. Before moving on to the next phase, each phase must be completed. In a nutshell, the Waterfall model has no overlap.
- The development of one phase begins only after the completion of the previous phase in a waterfall design. As a result of this, each phase of the waterfall model is extremely exact and well defined. It's called a waterfall model because the phases descend from a higher level to a lower one, similar to a waterfall.

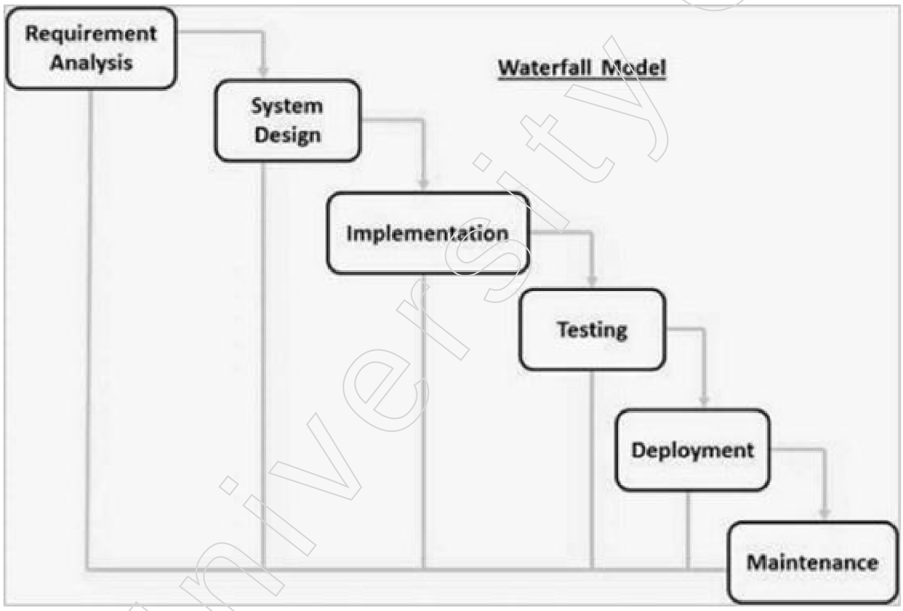

Figure: Waterfall Model

Advantages of using Waterfall model

- Simple and straightforward to comprehend and apply.
- The waterfall methodology works effectively for smaller projects and produces adequate outcomes.
- It is simple to maintain since the phases are strict and accurate, and each phase is completed one at a time.
- The entry and exit criteria are well specified, making quality assurance simple and systematic.

The final results have been meticulously recorded.

Disadvantages of using Waterfall model

- Changes in requirements are impossible to implement.
- Returning to the phase becomes extremely tough. For example, if the application has progressed to the testing stage and a requirement change, it is tough to go back and make changes.

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- The final product is being delivered late since there is no prototype that can be presented in the meantime.
- This strategy is not suitable for larger and more complex projects since the risk factor is higher.
- Not suitable for projects with continuously changing requirements.
- This method is ineffective for long-term projects.
- Because testing is done at a later time, it is difficult to detect the obstacles and hazards in the early stages, making risk mitigation strategy preparation harder.

The waterfall paradigm emphasises the need of signing off on each phase's deliverables. Although most projects now use Agile and Prototype approaches, the Waterfall technique is still useful for smaller projects. The Waterfall model will produce the greatest outcomes if the requirements are simple and testable.

Prototyping

The main idea behind the Prototype model is that instead of freezing requirements before moving forward with design or coding, a throwaway prototype is created to gain a better understanding of the needs.

This prototype is based on the needs that are currently known. A prototype model is a method for developing software. The client can gain a "real feel" for the system by interacting with the prototype, since interactions with the prototype can help the customer better comprehend the requirements of the intended system. Prototyping is a compelling concept for complex and massive systems for which there is no manual procedure or existing system to assist in defining needs.

The prototype is typically not a complete system, and many of the intricacies are not included. The goal is to create a system that is functional in general.

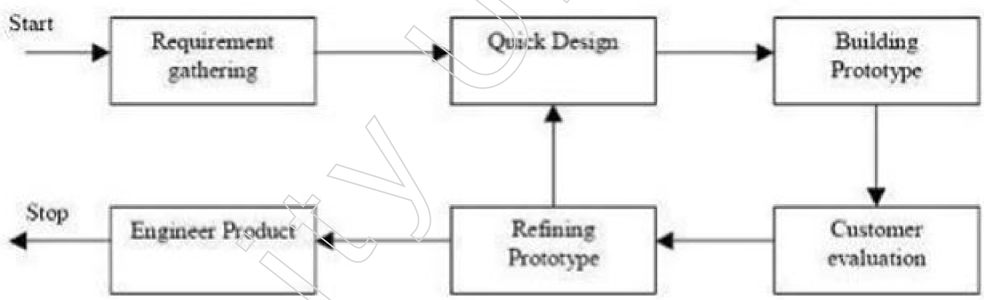

Figure: Prototype model

Advantages of Prototype model

- Users are involved in the development process.
- Because a functioning model of the system is provided as part of this process, users gain a better knowledge of the system being developed.
- Errors can be identified considerably earlier in the process.
- User feedback is provided more quickly, resulting in better solutions.
- It's simple to spot missing functionality.

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Disadvantages of Prototype model:

- This leads to the implementation of and then the repair of building systems.
- In practice, because the scope of the system may go beyond the original plans, this process may enhance the system's complexity.

When the proposed system requires a lot of interaction with the end users, a prototype model should be employed. Prototype models are ideally suited for online systems and web interfaces that have a lot of interaction with end users. It may take some time to develop a system that is simple to use and requires little training for the end user. Prototyping guarantees that end users interact with the system on a regular basis and provide input that is incorporated into the prototype to create a usable system. They're fantastic at creating user-friendly computer interfaces.

Incremental Model

The iterative waterfall model, also known as the incremental waterfall model, is a three-dimensional depiction of the waterfall model. The waterfall models on the z-axis reflect the number of iterations that would be made to incrementally increase the functionality of the eventual product. In this respect, the incremental model is a variation of the waterfall that approaches the spiral model.

The following are the model's primary advantages:

- Feedback from previous iterations can be integrated into this one.
- Stakeholders can be involved throughout the iterations, which aids in the early detection of architectural concerns.
- Early, incremental releases that evolve to a complete feature set with each iteration make it easier to provide the product.
- To limit risks, incremental implementation allows changes to be monitored and issues to be isolated and handled.

V-Model

NASA developed the v-model, sometimes known as the vee model, which was originally presented at the 1991 NCOSE summit in Chattanooga, Tennessee. The model is a V-shaped waterfall model folded in half at the lowest level of decomposition, as seen in the diagram below.

The left leg of the V shape reflects the breakdown and definition of user requirements into smaller and smaller components; the right leg represents the integration and verification of system components into successive levels of implementation and assembly. The vertical axis indicates the level of decomposition, from system level at the top to component level at the bottom. As a result, the more complicated a system is, the deeper the V shape and the greater the number of steps. Because the V-model is three-dimensional, it also features a z-axis that runs parallel to the plane. This is a list of components that are linked to numerous deliveries. Time is thus represented by two axes, one running from left to right and the other running into the plane.

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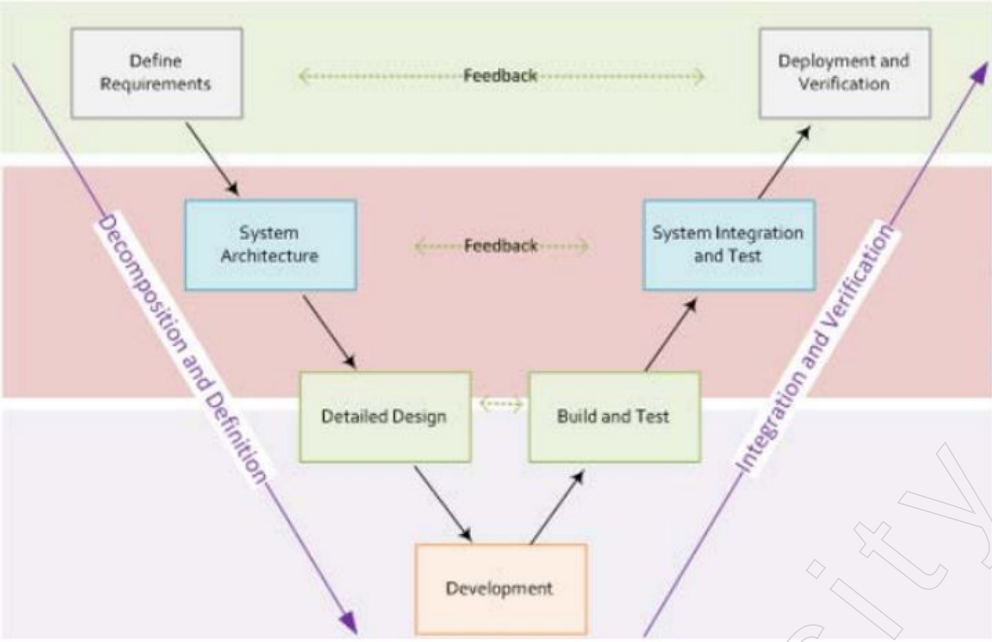

Figure: V-model's built-in quality assurance

Because the v-model is symmetrical across both legs, the verification and quality assurance methods for the right leg are defined during the same stage as the left leg. This guarantees that the requirements and design are SMART (Specific, Measurable, Achievable, Realistic, and Timebound) to prevent words like "user friendly," which is an acceptable but unverifiable need.

The vee+ model is a modification of the v-model. The z-axis of the v-model now includes user interaction, dangers, and opportunities. As a result, consumers stay involved until the decompositions no longer fascinate them. Any anomalies discovered during the integration and assembly stages are fed to the user for acceptance or, if rejected, resolution at the appropriate levels of decomposition; the abnormalities could then be resolved as mistakes or accepted as design features. Alternatively, the vee+ model is a modification of the v-model. The z-axis of the v-model now includes user interaction, dangers, and opportunities.

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The spiral model, on the other hand, incorporates user participation during risk reduction operations, whereas the v and waterfall models do so during the initial requirements definition phase. Furthermore, because of the vee+'s risks and opportunities feature, certain stages of the v at lower decomposition levels may be reduced in order to integrate COTS (commercial, off-the-shelf software) packages. This means that varied levels of products at different stages of disintegration can be seamlessly integrated into the life cycle.

The v-model, like the waterfall, is better suited to category 1 systems; the developers changed the model to the vee+ for categories 1 and 3, and then to the

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vee++ for all categories. However, a fundamental characteristic of the v-model is that it can be utilised in very big projects including a variety of contractors, subcontractors, and teams; the v-model allows for decomposition, integration, and verification at each level with all stakeholders involved before moving on to the next. The time parameter, which is represented by the model's y and z axes, recognises this factor. Using a requirements-driven approach, a huge number of parties and stakeholders in a large project become intrinsically interconnected.

Spiral Model

In 1986, Boehm updated the waterfall model by adding multiple iterations that spiral out from small beginnings. Start small, think large is a popular idiom that describes the spiral method's concept.

The spiral model seeks to address the waterfall model's two fundamental flaws:

1. In some cases, the two design stages are optional; nevertheless,
2. the top-down approach must be tempered with a lookahead step to allow for software reusability or the early detection of risks and concerns.

The spiral model offers a paradigm change from the specification-driven approach of the water fall to a risk-driven approach. Each cycle travels through four quadrants, as shown in the diagram below. These are the following:

- Determine objectives.
- Evaluate alternatives and identify and resolve risks.
- Develop and test.
- Plan the next iteration.

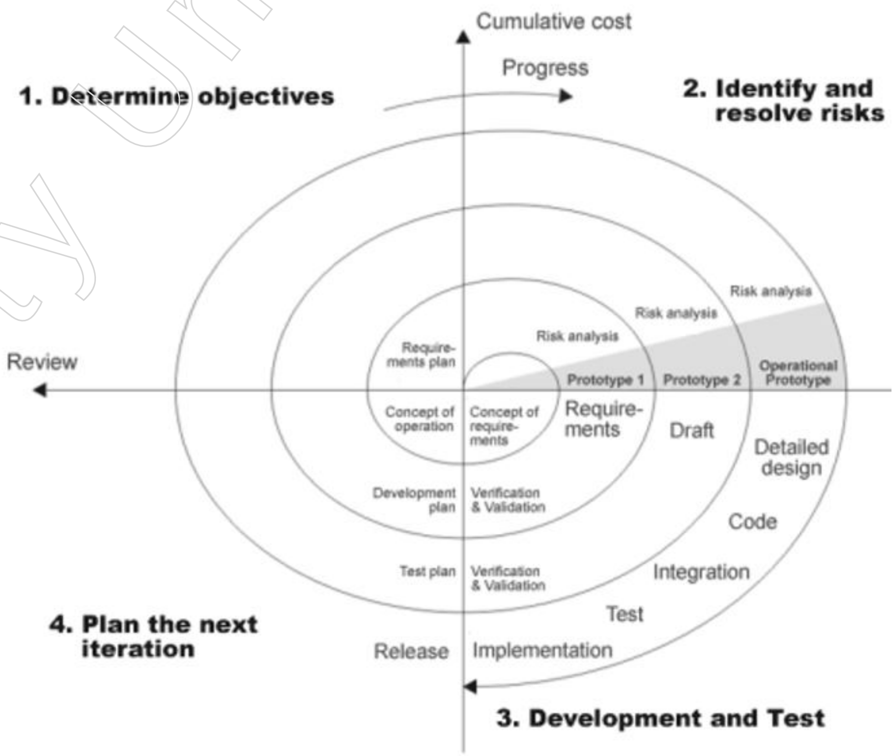

Figure: Boehm's spiral lifecycle

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Agile Process Model

Incremental development is also a sort of Agile development paradigm. Software is created in rapid, incremental cycles. As a result, modest incremental releases are made, with each one building on the previous one's features. To ensure that software quality is maintained, each release is rigorously tested. It's employed in time-sensitive applications. One of the most well-known agile development life cycle models is Extreme Programming (XP).

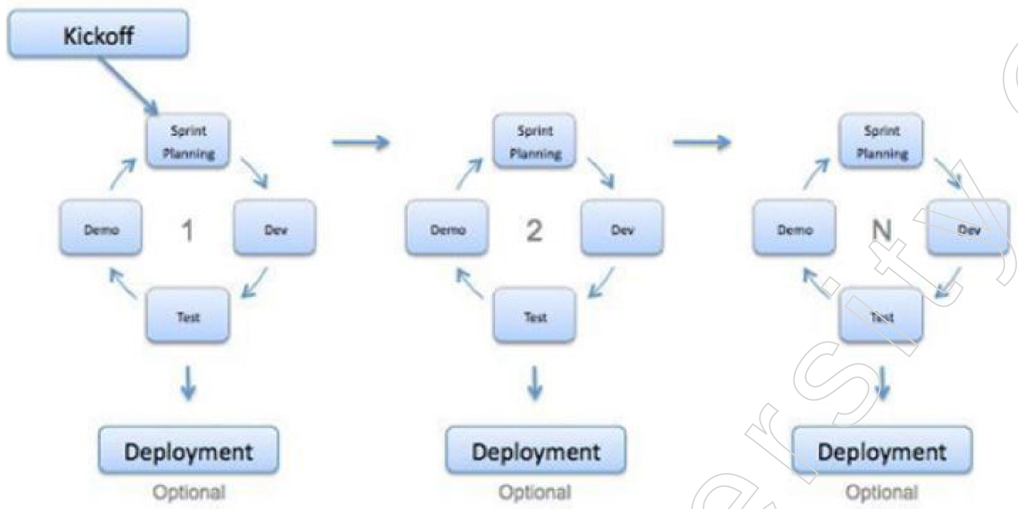

Figure: Agile model

Advantages of Agile Model:

- Customer satisfaction is achieved by the distribution of useful software in a timely and consistent manner.
- Process and tools are less important than people and relationships. Customers, developers, and testers are continuously in contact.
- Working software is routinely given (weeks rather than months).
- The best kind of communication is face-to-face communication.
- Businesspeople and developers work together on a daily basis.
- Consistent focus on technical quality and aesthetics.
- Adapting to new circumstances on a regular basis.
- Even last-minute demand adjustments are welcomed.

Disadvantages of Agile Model

- It might be difficult to estimate the effort necessary at the start of the software development life cycle for some software deliverables, particularly large ones.
- The importance of appropriate design and documentation is undervalued.
- If the client representative is unclear about the desired end result, the project can easily become derailed.

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- Only senior programmers are capable of making the kinds of decisions needed during development. As a result, rookie programmers have no place in it unless they are paired with experienced resources.

When it is necessary to make new adjustments. Agile gives you a lot of flexibility when it comes to change. Because of the frequency with which new increments are produced, new alterations can be applied at a low cost. To roll back and install a new feature, developers only need to lose a few days' worth of work, if not just hours.

Unlike the waterfall paradigm, the agile methodology requires very little planning to get started on a project. Agile argues that in a fast-paced business and IT environment, end users' needs are constantly changing. Changes can be debated, and features can be added or withdrawn in response to user feedback. This effectively provides the customer with the completed system they desire or require.

Both system developers and stakeholders discover that they have more time and options than they would if the software was produced in a more rigid sequential manner. Having options allows them to defer crucial decisions until additional or better data, or even complete hosting programmes, become available, allowing the project to proceed without risk of coming to a halt.

1.1.5 Concept related to SDLC Selection Criteria

It's critical to choose the right SDLC(s) for software development based on the project requirements. If we choose the wrong SDLC(s) and discover that we made a mistake, we must change to one that is more appropriate for our project.

Choosing the wrong SDLC might lead to disaster:

- Increased costs and a longer development time.
- Tasks that aren't completed or are ordered incorrectly, jeopardising project planning and efficiency.
- Stakeholder dissatisfaction with the project (i.e., customers, upper managers, and project members).
- Exposure to danger.

SDLc Selection Methods

For SDLC selection, the following methods/techniques are used:

- Using expert systems and other ruled-based approaches.
- Dillman proposes a decision cube with three criteria (Dynamic or Static Functionality), Budget (low or high), and Time Horizon (short or long), each with two conditions, and the resultant quadrant is the proposed SDLC.
- Using SDLC comparison tables.
- Using one or more heuristic ranking algorithms (The output may be a list of models together with the ascribed score).
- Expert guidance is used in the selection process; experts from outside the project/company decide on the suitable SDLC. Experts usually make decisions based on previous successes and failures.

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- The procedures established by the firm or foundation compel you to choose SDLC in accordance with the methods. Some companies/foundations for example, characterise the development process as a series of steps in a single cycle, such as requirement specification, design, coding, integration, and testing, with each phase generating a set of documents. You may feel compelled to employ waterfall or waterfall-style SDLCs in this situation.
- All projects must follow the company's decision to employ a (or more) well-known SDLC.
- Examine the literature and the internet to choose one or more SDLCs (s).
- Ad hoc selection: There is no standard/formal SDLC selection solution/technique. Project managers make a heuristic decision on which SDLC to use. Every time, project/company management follows the same SDLC.
- Using Fuzzy Logic, which was created specifically for this investigation.

SDLC Selection Criteria

When choosing an SDLC for a project, the following criteria should be taken into account:

- Budget, time span, and functionality (project functional requirements will be dynamic (changing) or static (nonchanging) throughout the life cycle) (short term versus long term).
- Requirements clarity.
- Size of the product and the staff (number of developers).
- Software or system complexity.
- Developers' and users' experience (including application domain experience), users' ability to explain needs, developers' application domain experience, and developers' software engineering experience are all factors to consider.
- The project team's knowledge and skill sets, the IT and organisational infrastructure required to support the development effort and the application, and the project's size, degree of structure, development time, and position within the company.
- There are a lot of (serious) hazards.
- Estimation of costs and early functional requirements
- The extent to which the client is involved in the project.
- Organizational features, degree of expertise with the technology to be utilised, and competitive needs for launching the project are all factors to consider in the project (development) environment.
- The type of information system, the size and complexity of the software, system architecture, modularity and level of module integrity, and the diversity and clarity of user needs are all product-related criteria.
- Basic project dimensions such as the projected timeline and cumulative costs of the project, resource characteristics, project risks, and types of users based on

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computer abilities and fluency with computer systems are among the project-related criteria.

1.1.6 Stages of Project Management

One of the most important aspects of every project is project management. This is because project management is the glue that holds all of the other project activities and processes together.

There are numerous project management activities to choose from. These numerous project management operations, however, can be divided into five primary processes.

Project Initiation

The beginning of any project is called project initiation. All efforts linked to winning a project take place throughout this procedure. Pre-sale is usually the main activity of this era.

During the pre-sale stage, the service provider demonstrates to the client his or her eligibility and capacity to complete the project, and ultimately wins the contract. Following that is the gathering of precise needs.

All customer needs are gathered and analysed for implementation during the requirements gathering activity. Negotiations may take undertaken during this activity in order to amend or eliminate specific requirements.

Typically, the project initiation process concludes with the approval of requirements.

Project Planning

One of the most important project management activities is project planning. If the project management team gets this step wrong, it could have serious ramifications in the project's later stages.

As a result, the project management team will need to pay close attention to this project's procedure.

The project plan is created throughout this process in order to address project needs such as scope, budget, and schedules. Following the creation of the project plan, the project schedule is created.

The resources are subsequently distributed to the project based on the budget and timetable. When it comes to project cost and effort, this is the most critical phase.

Project Execution

After all of the documentation is completed, the project management team conducts the project in order to meet the project's goals.

When it comes to execution, each team member completes their individual tasks within the timeframe allotted for each activity. The project's progress will be tracked using the detailed project schedule.

Many reporting actions must be completed during the project's execution. The company's senior management will expect daily or weekly status updates on the project's development.

In addition, the client may want to keep tabs on the project's progress. Keeping track of the project's effort and expense during execution is essential for determining whether the project is heading in the right direction.

During the project's execution, there are various deliverables to be made in addition to reporting. Project deliveries are typically not one-time deliveries done at the conclusion of the project. Instead, the deliveries are spaced out over the course of the project's execution and are made according to agreed-upon schedules.

Control and Validation

The project activities should be thoroughly regulated and validated throughout the project life cycle. Controlling can be done mostly by following the project's basic protocols, such as the project plan, quality assurance test plan, and communication plan.

There are several situations that are not addressed by such protocols. In such scenarios, the project manager should employ appropriate and necessary measurements to keep such situations under control.

Validation is a supporting activity that takes place from the beginning to the end of a project. Each activity and delivery should have its own validation criteria to ensure that the desired outcome or completion is achieved.

A separate team called the 'quality assurance team' will aid the project team with validation and verification functions when it comes to project deliveries and requirements.

Closeout and Evaluation

It's time to hand over the implemented system and close out the project once all of the project requirements have been met. The project will be accepted and paid by the customer if the project deliveries meet the acceptance criteria set by the client.

After the project is closed out, it's time to assess the entire project. During this evaluation, the project team's errors will be highlighted, and required steps will be taken to avoid them in future projects.

During the project evaluation phase, the service provider may discover that they have not achieved the desired project margins and have exceeded the timescales set forth at the outset.

In such circumstances, the service provider's endeavour is not a complete success. As a result, such incidents should be thoroughly investigated, and required steps taken to prevent them in the future.

Project management is a procedure that requires responsibility. The project management process brings all of the other project tasks together and ensures that the project runs smoothly. As a result, the project management team should have a thorough awareness of all project management procedures as well as the tools that can be used for each one.

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1.2 Project Planning Process

The heart of the project life cycle is project planning, which tells everyone involved where you're going and how you're going to get there. The project plans are documented, the project deliverables and requirements are specified, and the project timeline is created during the planning phase. It entails developing a set of strategies to steer your team through the project's implementation and closure phases. This phase's plans will aid you in managing time, cost, quality, modifications, risk, and other associated issues. They will also assist you in maintaining control over your employees and external vendors to guarantee that the project is completed on time, on budget, and on schedule.

1.2.1 Developing Project Management Plan Components

A good project management strategy is required to organise and integrate information across project management knowledge domains and across the company. A project management plan is a document that helps guide the execution and control of a project by coordinating various project planning papers. The plans generated in the other knowledge domains are treated as ancillary to the overall project management strategy.

Project management plans also serve as a baseline for progress measurement and project control by documenting project planning assumptions and decisions, facilitating communication among stakeholders, defining the content, scope, and timing of key management reviews, and defining the content, scope, and timing of key management reviews. When the environment or the project evolves, project management plans should be dynamic, flexible, and subject to modification. These plans should make it much easier for the project manager to guide the team and analyse the project's progress.

Because information from all of the project management knowledge domains is required to construct and assemble a strong project management plan, the project manager must practice the art of project integration management. Working on a project management plan with the project team and other stakeholders will aid the project manager in guiding the project's execution and understanding the entire project.

The project charter, outputs from other processes, enterprise environment considerations, and organisational process assets are the major inputs for designing a project management plan. Expert judgments, data collection, interpersonal and team skills, and meetings are the major tools and techniques, and the product is a project management plan.

Project Management Plan Contents

The project management plan summarises the project's overall scope, timeline, and cost baselines. More thorough baseline information is provided by specific plans in each of those knowledge categories. The project management plan for example, may give a high-level budget baseline for the entire project, whereas the cost baseline developed as part of the project cost management knowledge area may provide precise cost forecasts by WBS by month.

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A project life cycle description and development approach can also be included in the project management plan.

When the environment or the project evolves, project management strategies should be dynamic, flexible, and adaptable. These plans should make it much easier for the project manager to guide the team and analyse the project's progress. Project plans, like projects, are one-of-a-kind. A project charter, scope statement, and Gantt chart may be the only formal project planning documents required for a short project involving a few people over a few months; a separate project management plan is not required. A detailed project management strategy and distinct plans for each knowledge area would be beneficial for a huge project involving 100 workers over three years. Because every project plans should aid in the completion of the specific project, they should be customised for each one.

Most project management plans, however, have the following aspects in common:

- Introduction/overview of the project.
- Project organization.
- Management and technical processes (including project lifecycle description and development approach, as applicable).
- Work to be performed (scope).
- Schedule and budget information.
- References to other project planning documents.

Guidelines to Create Project Management Plans

To build project management strategies, many firms employ guidelines. Microsoft Project 2016 and other project management software packages include a number of template files that can be used as a guide. A project management plan is not to be confused with a Gantt chart. As previously stated, the project management plan is much more than a Gantt chart.

Many government entities also offer advice on how to create project management plans. The US Department of Defense (DOD) Standard 2167, Software Development Plan for example, specifies the format to be used by contractors when establishing a software development plan for DOD projects. The contents of its Software Project Management Plan are described in IEEE Standard 1058–1998 by the Institute of Electrical and Electronics Engineers (IEEE) (SPMP).

This or a comparable standard must be followed by companies working on software development projects for the Department of Defense.

Specific documentation standards are not as strict in many private firms; nonetheless, there are usually rules for drafting project management plans. To make project management plans easier to execute, it's a good idea to follow the organization's standards or criteria when creating them.

Table: IEEE software project management plan (SPMP)

Notes

Major Section Headings	Section Topics
Overview	Purpose, scope, and objectives; assumptions and constraints; project deliverables; schedule and budget summary; evolution of the plan
Project Organization	External interfaces; internal structure; roles and responsibilities
Managerial Process Plan	Start-up plans (estimation, staffing, resource acquisition, and project staff training plans); work plan (work activities, schedule, resource, and budget allocation); control plan; risk management plan; closeout plan
Technical Process Plans	Process model; methods, tools, and techniques; infrastructure plan; product acceptance plan
Supporting Process Plans	Configuration management plan; verification and validation plan; documentation plan; quality assurance plan; reviews and audits; problem resolution plan; subcontractor management plan; process improvement plan

Directing and Managing Project Work

Directing and managing project work entails overseeing and carrying out the tasks outlined in the project management plan, which is one of the most important inputs to the process. Approved change requests, enterprise environmental factors, and organisational process assets are among the other inputs. The majority of a project's time, as well as the majority of its budget, is usually spent on execution.

Because products are generated during the execution phase, the project's application area has a direct impact on project execution. During project execution for example, the next-generation DNA-sequencing instrument from the opening case, as well as the accompanying software and documentation, would be created. To construct a successful product, the project team would need to draw on its experience in biology, hardware and software development, and testing.

To successfully execute the project management plan, the project manager must focus on leading the project team and managing stakeholder relationships. Stakeholder management, project resource management, and communications management are all critical to a project's success.

Coordinating Planning and Execution

Project planning and execution are linked and indivisible activities in project integration management. The primary goal of developing a project management plan is to provide direction for project execution. A good plan should aid in the production of good products or work outcomes, as well as document what defines good work outcomes. Plans should be updated to reflect knowledge learned from earlier stages of the project. Anyone who has attempted to develop a computer programme from incomplete requirements understands the value of a well-thought-out strategy. Anyone who has had to document a badly coded system understands the value of proper execution.

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Following this simple concept, those who will do the work should plan the job, is a common-sense approach to improve project plan formulation and execution coordination. All project personnel must learn to plan and execute projects, and they must have prior expertise in these areas. Programmers who have to develop thorough specifications and then create code from them improve their writing skills in IT projects. Similarly, most systems analysts start out as programmers, so they know what kind of analysis and documentation they'll need to develop good code. Although project managers are in charge of creating the overall project management plan, they must also seek advice from project team members who are working on plans in each knowledge area.

Providing Strong Leadership and a Supportive Culture

During project execution, strong leadership and a supportive company culture are essential. Project managers must set an example by generating strong project plans and then following through with them during project execution. Project managers frequently make plans for tasks that they must complete themselves. Project managers who stick to their own plans are more likely to have their team members do the same.

A supportive organisational culture is also required for successful project execution. Organizational procedures for example, might aid or delay project implementation. It will be easier for project managers and their teams to plan and execute their work if a company has appropriate project management standards and templates that everyone in the organisation follows. The culture will foster the relationship between effective planning and execution if the organisation uses project plans as the basis for conducting work and monitoring progress during execution. Project managers and their teams will be disappointed if organisations have complex or bureaucratic project management requirements that prevent them from getting work done or monitoring progress against plans.

Even in the presence of a supportive company culture, project managers may find it essential to breach the rules in order to deliver project deliverables on time. Politics will play a part in the outcomes when project managers disobey the rules. If a project necessitates the use of nonstandard software for example, the project manager must utilise political skills to persuade relevant stakeholders that standard software would be insufficient. Breaking organisational rules — and getting away with it — necessitates strong leadership, communication, and political abilities.

Capitalising on Product, Business, and Application Area Knowledge

To complete projects successfully, project managers must have product, business, and application area knowledge in addition to excellent leadership, communication, and political abilities. Prior technical experience or at least a working knowledge of IT products is generally beneficial for IT project managers. For example, understanding the language of the business and technical specialists on the team would be beneficial if the project manager was heading a team to help create user requirements.

Due to the modest size of many IT projects, project managers may be necessary to do some technical work or mentor team members in order to complete the project. A project manager who can accomplish some of the technical work would be most beneficial to a three-month project to develop a Web-based application with only three

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team members. The project manager's major role on larger projects, however, is to lead the team and communicate with key project stakeholders. The project manager is unable to complete the technical job due to a lack of time. In this instance, it is normally preferable for the project manager to be more familiar with the project's business and application area than with the technology involved.

On very big projects, the project manager must be familiar with the project's business and application areas. Northwest Airlines for example, has recently completed a series of projects to build and upgrade its reservation systems. During peak periods, the company spent millions of dollars and had more than 70 full-time employees working on the projects. PeeterKivestu, the project manager, had never worked in an IT department before, but he was well-versed in the airline sector and the reservations procedure. He chose his team leaders with care, ensuring that they had the necessary technical and product understanding. ResNet was Northwest Airlines' first significant IT project overseen by a business manager rather than a technical specialist, and it was a huge success. Many firms have discovered that major IT initiatives necessitate skilled general managers who are familiar with the technology's business and application areas, rather than the technology itself.

1.2.2 Tools and Techniques for Plan Scope Management

Project management necessitates the use of specialised tools and procedures, some of which are unique to the field. Project managers can undertake actions that are part of the execution process with the use of certain tools and methodologies. The following are some of them:

Expert judgment: Anyone who has worked on a large, complex project understands how critical expert judgement is in making sound judgments. Project managers should not be afraid to seek advice from specialists on a variety of areas, such as which methodology to use, which programming language to use, and which training method to employ.

Meetings: During the course of a project's execution, meetings are essential. Meetings with individuals or groups of people, as well as phone and virtual meetings, are essential. Meetings allow people to build relationships, pick up on important body language or tone of voice, and conduct a conversation to help solve problems. Establishing set meeting times for multiple parties is frequently beneficial. Nick for example, may have organised a short meeting with senior management once a week. He may have additionally planned 10-minute stand-up sessions for the project team every morning.

Project management information systems: Today, there are hundreds of project management software programmes on the market. Many large companies utilise sophisticated enterprise project management systems that are available over the Internet and integrate with other systems, such as financial systems. Project managers or other team members can construct Gantt charts that include linkages to other planning documents on an internal network, even in smaller firms. Nick or his helper for example, could have used Project 2016 to generate a detailed Gantt chart for their project, as well as linkages to other important planning documents created in Word, Excel, or PowerPoint.

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Project Scope Management refers to the procedures that must be followed to guarantee that the project includes all of the work that is required, and only the work that is required, in order to be completed effectively. Its main purpose is to define and manage what is and is not included in the project.

a rundown of the most important project scope management processes:

- Initiation—committing the organization to begin the next phase of the project.
- Scope Planning—developing a written scope statement as the basis for future project decisions.
- Scope Definition—subdividing the major project deliverables into smaller, more manageable components.
- Scope Verification—formalizing acceptance of the project scope.
- Scope Change Control—controlling changes to project scope.

Initiation

The process of formally recognising the existence of a new project or the continuation of an existing project into its next phase is known as initiation. This formal start connects the initiative to the performing organization's current activities. In some organisations, a project isn't officially started until a feasibility study, a preliminary plan, or another equivalent kind of analysis has been completed. Some types of projects, particularly internal service projects and new product development projects, are started informally and only a small amount of work is done to get the necessary clearances. Typically, projects are approved as a result of one or more of the following:

- A market requirement (e.g., an oil company authorises a project to build a new refinery in response to chronic gasoline shortages).
- A business requirement (e.g., a training company authorises a project to create a new course in order to increase its revenues).
- A request from a customer (e.g., an electric utility authorises a project to build a new substation to serve a new industrial park).
- A technological breakthrough (e.g., an electronics firm authorises a new project to develop a video game player after the introduction of the video cassette recorder).
- A legal obligation (e.g., a paint manufacturer authorises a project to establish guidelines for the handling of toxic materials).

Tools and Techniques for Initiation

Project selection methods. Methods of project selection often fall into one of two categories:

- Benefit measurement methods—comparative approach es, scoring models, benefit contribution, or economic models.
- Constrained optimization methods—mathematical models using linear, nonlinear, dynamic, integer, and multi-objective programming algorithms.

Decision models are a term used to describe these procedures. Generalized techniques (decision trees forced choice, and others) as well as specialised techniques

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(decision trees forced choice, and others) are used in decision models (Analytic Hierarchy Process, Logical Framework Analysis, and others). In a sophisticated model, applying complex project selection criteria is frequently addressed as a separate project phase.

Expert judgment. The inputs to this procedure will frequently necessitate expert judgement. Any group or individual with specific knowledge or training can supply such expertise, which can be obtained from a variety of sources, including:

- Other units within the performing organization.
- Consultants.
- Professional and technical associations.
- Industry groups.

Scope Planning

Scope planning is the process of creating a written scope statement that will serve as the foundation for future project choices, including the criteria for determining whether a project or phase has been effectively completed. Both projects and subprojects require a written scope statement. A scope statement describing the boundaries of an engineering firm's work on a design subproject for example, is required for an engineering firm hired to design a petroleum processing plant. By specifying both the project objectives and the primary project deliverables, the scope statement serves as the foundation for an agreement between the project team and the project customer.

Tools and Techniques for Scope Planning

- Product analysis. The goal of product analysis is to have a deeper understanding of the project's product. Systems engineering, value engineering, value analysis, function analysis, and quality function deployment are some of the methodologies used.
- Benefit/cost analysis. Benefit/cost analysis entails assessing the tangible and intangible costs (outlays) and benefits (returns) of numerous project options, and then evaluating the relative desirability of the found alternatives using financial indicators such as return on investment or payback period.
- Alternatives identification. This is a blanket term for any technique used to produce various project approaches. The most popular general management approaches utilised here are brainstorming and lateral thinking.

Scope Definition

Scope definition entails breaking down the project's key deliverables (as defined in the scope statement) into smaller, more manageable parts in order to:

- Cost, time, and resource predictions will be more accurate.
- Establish a benchmark for measuring and controlling performance.
- Make it easier to give explicit responsibilities.

The definition of scope is crucial to the project's success. "When scope definition is weak, final project costs are likely to be greater due to the unavoidable modifications that break project rhythm, generate rework, extend project time, and impair labour productivity and morale."

Tools and Techniques for Scope Definition

- Templates for work breakdown structures. A previous project's work breakdown structure can often be utilised as a template for a new project. Although each project is unique, WBSs are frequently "reused" because most projects are similar to one another in some way. Most projects inside a given organisation for example, will follow the same or similar project life cycles, with the same or comparable deliverables expected at each step. WBSs that are standard or semi-standard in several application areas can be utilised as templates. The US Department of Defence for example, has established standard WBSs for Defence Materiel Items.
- Decomposition. Decomposition entails breaking down large project deliverables into smaller, more manageable components until the outputs are detailed enough to enable subsequent project activities (planning, executing, controlling, and closing). The following are the major steps in decomposition:
  1. Determine the project's primary components. The project deliverables and project management will be the most important aspects in general. The primary elements, on the other hand, should always be stated in terms of how the project will be managed.
  2. Determine whether adequate cost and duration estimates for each piece can be created at this level of detail.
  3. Identify the deliverable's constituent pieces. To make performance measurement easier, constituent pieces should be stated in terms of actual, verifiable outcomes.
  4. Verify if the decomposition is correct.

Scope Verification

The process of formalising stakeholder acceptance of the project scope is known as scope verification (sponsor, client, customer, etc.). It necessitates going over work items and results to confirm that everything was done correctly and satisfactorily. The scope verification procedure should identify and document the level and amount of completion if the project is terminated early. Scope verification varies from quality control in that it focuses on the acceptance of the work results, whereas quality control focuses on the accuracy of the work results.

Tools and Techniques for Scope Verification

Inspection. Inspection entails tasks such as measuring, examining, and testing to see if the results meet the specifications. Inspections are referred to as reviews, product reviews, audits, and walk-throughs, among other titles. These phrases have narrow and particular connotations in several application areas.

Scope Change Control

Scope change control entails (a) controlling the circumstances that cause scope

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changes to ensure that they are beneficial, (b) detecting when a scope change has occurred, and (c) managing the actual changes when and if they occur. Scope change control must be fully integrated with all other control procedures (such as time, cost, and quality control).

Tools and Techniques for Scope Change Control

- Control mechanism for scope changes. The methods for changing the project scope are defined by a scope change control system. It includes all of the necessary paperwork, tracking systems, and approval levels for making changes. When a project is completed under contract, the scope change control system must adhere to all contractual requirements.
- Measuring performance. Techniques for assessing performance. Determine what is causing the variation and whether it requires corrective action is a key aspect of scope change control.
- Additional planning is required. Only a few projects go according to plan. Changes in scope may necessitate changes to the WBS or a review of alternative methodologies.

1.2.3 Dependency Considerations during Project Management

Any tasks, events, or conditions that are either dependent on the completion of a prior task or on which a task is dependent are referred to as project dependencies. It's the connection between two distinct activities that are part of a broader endeavour.

It can range from something as easy as waiting for a response from another team member to something more involved like data centre migrations with third-party providers.

They exist in every industry, technical and non-technical, and if they aren't managed properly, they can lead to an overburdened backlog, wasteful work, overall project risk, destabilised velocity, and delayed value.

Blockers, Bottlenecks and Constraints

When it comes to project management, there are a few more terminology that are frequently connected with dependencies.

Blockers are internal or external impediments that hinder jobs from moving through the workflow.

Bottlenecks are systemic limitations that stifle the flow of work.

When it comes to project management, constraints and dependencies are inextricably linked. Within the framework of the current task, a project constraint is a restriction, limitation, or setback.

They can be internal, such as a scarcity of labour, funds, or expertise.

Let's imagine you need to prune ten trees but only have one gardener who is qualified and prepared to do so. As a result, tree trimming is automatically dependent on the completion of the trimming at a given time.

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They might be internal or exterior. If you're building a house for example, you'll need to obtain the proper permits and building plans approved before you start laying the foundation and constructing the structure.

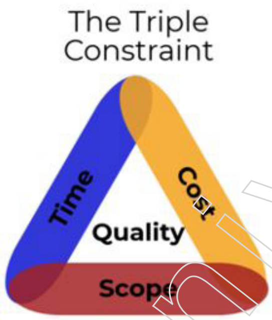
Constraints have caused project dependencies in the cases above, but dependencies can also be the cause of a constraint.

If you're an event planner for example, you won't be able to start setting up the venue until the supplies and decorations arrive. If there is a delay in the movement of these materials, everything else will be delayed as well.

The longer it takes you to come, the less time you have to prepare for the event before it begins.

Constraints are unavoidable, and every project manager has to deal with them (or the "Iron Triangle" for some).

- Cost: the financial constraints or budget of a project.
- Scope: all the tasks required to complete the project in full.
- Time: the proposed timeline or schedule for the project to be completed.



A project manager must keep track of all limitations and dependencies and reallocate resources as needed to ensure the project's success.

Projects should always be run with the goal of delivering useful and high-quality results. Progress is stymied by roadblocks, bottlenecks, limitations, and dependence.

However, when properly handled, they don't have to be a source of stress for the project manager, team, or company.

The critical path, which refers to the longest unbroken sequence of consecutive actions, is also crucial. It has the potential to change the time it takes for activities to be completed, producing delays in the initial project schedule.

Types of Dependencies in Project Management

Project or task dependencies can be classified in a variety of ways (for example, hard logic vs. discretionary) based on circumstances, relationships, and other considerations.

Causal Dependencies - These are dependencies that arise naturally in the course of a project's tasks. To bake a cake for example, you must first purchase the ingredients, then combine them, place them in the oven, and wait for them to bake.

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Each activity is dependent on the completion of the one before it, and skipping one step or task in the process will result in a project failure.

Resourced Based Dependencies- they are determined by restrictions and are not causally related. All tasks and project management activities can be accomplished simultaneously if all resources are available. Internal restrictions for example, could exist inside technical user stories due to a lack of expertise or a lack of awareness of technical concepts or processes.

Preferential Dependencies - Best practices, protocols, and recommended methods are used to determine project dependencies. They are frequently institutionalised in order to concentrate on the quality of the deliverables. When painting the interior of a home for example, the sequence in which the rooms and then the walls are painted can be determined by a range of factors such as the amount of furniture that needs to be removed, the most often used room, or other preferences.

Cross-Team Dependencies - Cross-team dependencies are a significant concern for larger firms. When two or more teams are required to complete an end-to-end project, these are common.

External Dependencies - These are dependencies that are outside the control of project managers or teams and rely on the completion of 3rd parties or outside vendors.

FS (Finish-To-Start) Dependencies - In project management, this is the most prevalent and logical dependency type (and the real world for that matter). It follows the natural flow of tasks from one to the next. Task A must be completed before Task B may begin.

SF (Start-To-Finish) Dependencies - This signifies that the successor task (Job B) will not be completed until the predecessor project activity or task is started (Task A). Let's imagine you already have a website up and operating, but you want to replace it with a new one. You wouldn't deactivate the old website (Task A) until the new one was planned and developed (Task or Activity B).

SS (Start-To-Start) Dependencies - This signifies that the successor task (task B) will not be able to begin until the prior project work is completed. To put it another way, both jobs start at the same moment and can execute concurrently. For example, if you're planning a three-part meal, you can start making the salad while the main course is baking.

FF (Finish-To-Finish) Dependencies - This signifies that the successor task cannot be completed until the predecessor task is completed.

Outside-Inside Dependencies - It's not unusual for activities to have both internal and external dependencies.

Company In – Project In Dependencies

These are used in a project's sequential tasks. Booking the event location for example, is required to hold an event.

Company In – Project Out Dependencies

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When there are dependencies between two different projects, these are used. Before Project #2 can begin, the first step in Project #1 must be performed.

Company Out – Project In Dependencies

These are responsibilities that have been delegated to a third party. Although the project's outcome has an impact on your business, you have no control over the operations.

Company Out – Project Out Dependencies

These are aspects that are not part of the project yet have an impact on the project's outcome. For example, labour unions, government institutions, and so on.

1.3 Establishing Project Organisation

The structure of the project is the project organisation. It's done in pieces, with specialists and employees from various departments contributing. These individuals report to the project manager. Project management is a procedure. It sets up the framework for making decisions on how to carry out a project. It determines how the project will be carried out, including expenses, timeframes, staff, and tools. After that, the project's structure is presented to the project's stakeholders.

1.3.1 Key Concepts of Project Resource Management

The most efficient technique of planning, organising, scheduling, and managing a project's resources — people, tools, equipment, technology, and facilities. Maximizing and guaranteeing that the project's elements are used to their full potential.

A resource is defined as everything or anybody who can be scheduled or booked to fulfil a task or project. Resources differ depending on the industry.

The majority of reusable resources are used in resource planning and scheduling. Human resources, such as your workforce and their specialised abilities, are an example. Non-human resources, such as computers, equipment, rooms, vehicles, and so on, can also be used.

The techniques required to make the most effective use of the people and physical resources (facilities, equipment, materials, supplies, and so on) involved with a project are referred to as project resource management. All project stakeholders are included in human resource management: sponsors, customers, project team members, support employees, project suppliers, and so on. Facilities, equipment, materials, and supplies are examples of physical resources. The four procedures that make up project resource management are as follows:

1. Planning resource management determines how to estimate, acquire, manage, and employ project resources. A resource management plan, a team charter, and project document updates are the major outputs.
2. Estimating activity resources estimating the human and physical resources required to perform project work is part of this process. Resource requirements, basis of

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estimates, a resource breakdown structure, and project document revisions are among the outputs.

3. Acquiring resources obtaining team members, facilities, equipment, materials, supplies, and other resources as needed is part of this process. Physical and project team assignments, resource calendars, modification requests, and updates to many documents are all examples of outputs.
4. Developing the project team involves enhancing project performance by developing individual and group capabilities. Many project managers struggle with team-building abilities. Team performance assessments, change requests, and updates to many documents are the key outcomes of this procedure.
5. Managing the project team tracking team member performance, motivating team members, offering timely feedback, resolving difficulties and conflicts, and organising adjustments to improve project success are all part of the job. Change requests, project management plan updates, project document updates, and organisational process assets changes are all examples of outputs from this procedure.
6. Controlling resources ensures that a project's physical resources are available as planned, keeping track of planned versus actual resource consumption, and taking remedial action as appropriate. Work performance data, modification requests, and updates to the project management plan and project papers are all examples of outputs.

Project Resource Management Techniques

Resource allocation – assists you in determining the types and quantities of resources required to complete your projects. Specific resources are assigned to specific project tasks throughout the allocation phase.

Resource aggregation – depicts the quantity of resources consumed on a daily, weekly, or monthly basis. It's simply the total amount of resources needed for a single work or project over a set period of time.

Resource scheduling – It is considerably easier to schedule resources to actual resource and project plans if you know their allocation and have a good understanding of their consumption. Resource plans show when a resource is required. Resource planning ensures that:

- the effective and efficient use of resources;
- a realistic timetable with task start and finish dates;
- see if there are any potential issues or conflicts as a result of a shortage of project resources;
- Better planning for the future.

Resource Capacity in Project Management

Once you have a number of projects in your portfolio, you must make certain that all of them are completed. It is at this point that resource capacity planning comes into play. Here are a few strategies for ensuring that there are enough hands to handle the workload.

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Resource levelling – is a solution to the problem of requiring a single resource to perform multiple activities at the same time. Or when a project assignment requires more resources than are now available. You can balance the workload of different resources across one or more projects by using resource levelling. Using resource management software that provides a visual picture is your best choice for precise levelling. A resource-based Gantt chart for example. This can tell you when a project will be completed and which resources will be used. Along the road, you'll be able to assist in the resolution of problems.

For example:

if Eric the Engineer is assigned two duties at the same time, resource levelling is required because he may only work 8 hours each day. So, Eric can finish his task, you'll need to change the plan and timeline. Alternatively, you may need to reallocate your resources so that Eric can finish on time. It's crucial to keep in mind how your project's timeline may shift during the resource levelling process.

Resource smoothing – When working with an inflexible schedule, this is the best method to maximise your resources. This may imply that you are restricted to a set time range or that you are unable to adjust your schedule. In this instance, you must make the best use of your resources within the time constraints you have.

Consider the following scenario:

Eric, the Engineer, is eager to fulfil both of his tasks. This, however, will result in resource levelling and a two-day delay in the project. To overcome this problem with resource smoothing, you'll need to make better use of your other resources to compensate for the extra two days. When there is an uneven distribution of work, resource smoothing can help.

Resource overallocation – If a resource has too much work to handle, it is over-allocated. To remedy this, you'll need to balance the team's workloads. Alternatively, you can look for alternative options. It's possible that you'll need to reassign someone from another team or employ someone entirely new. Failure to do so could lead to overtime or project delays. Both are expensive for your project, team, and budget.

Consider the following scenario:

Eric the Engineer is part of a project team that includes two other employees and a bulldozer. The work is expected to be completed by the end of the week, allowing the next phase to begin. The project will run behind time unless another bulldozer is assigned to the team, which could lead to employee and team burnout.

1.3.2 Trends and Emerging Practices in Project Resource Management

The Resource Management Plan: Best Practices

A good resource management plan isn't always straightforward to put in place, but it can make the project management process go more smoothly. We may offer some of the tips and methods we've acquired based on our expertise and user feedback. These will assist you in becoming a resource master.

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"Patience you must have my young Padawan"

Yoda's insightful words come to mind. Take some time to learn about resource management if it's new to you. On a daily basis, changes, adaptations, and reallocations can occur. It's not a one-time event; it's a continuous process. Taking the effort to learn about it, on the other hand, can avoid your project from falling into the "dark side."

Know the team's skills

You'll need to plan the required talents and resources before allocating resources. The easier your task will be if you know your team and what skills they have. That way, you can be certain that you're allocating the appropriate resources to each activity.

Never plan 100% of utilisation

Despite the fact that every organisation needs to maximise resource utilisation, planning resources for 90-95 percent utilisation helps in the event of unanticipated situations. It's impossible to plan for everything. You can, however, anticipate them!

Be flexible

There are always going to be changes. You'll be able to observe which jobs are taking longer or moving faster than intended, as well as which tasks are lagging behind, as the project progresses. Tracking and making adjustments is unavoidable and required for you as the project manager. You'll be able to get the best utilisation and efficiency this way.

Teamwork makes the team work

One of the most common reasons for a project's failure is a lack of communication. Make sure your team is always up to date on any changes. Whether you have a small team sharing a single office or an internationally distributed company, this is critical. Also, remember to congratulate yourself on your accomplishments and milestones. The most successful and engaging approach to manage your team is through good team communication.

Focus on your critical and valuable resources

Some resources are more important than others. Different resources can have a greater impact on the outcome than others. Keep an eye on the most important assets. Also, make certain that their chores are completed first.

Time

Your most important asset. And it's one you shouldn't overlook. In order to make a realistic strategy, you must consider all possible uses of time. Even administrative time, such as responding emails, is valuable. As a result, there will be less time lost overall.

"People are our most precious asset," is a cliché that no senior management team member would dispute. However, for many organisations, the fact is that their personnel remain.

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- under valued
- under trained
- under utilized
- poorly motivated, and consequently
- perform well below their true capability

Organizations must absorb and manage change at a much faster rate than in the past because the rate of change has never been greater. Organizations, large and small, must ensure that they have the right personnel capable of delivering the strategy in order to create a successful business strategy to meet this issue.

Human resource management contributions differ according to the size, goals, functions, complexity, construction, physical character of the product, and employer appeal of organisations. However, in most cases, the function's ultimate goal is to "ensure that the business is correctly staffed at all times by the right number of individuals with the abilities relevant to the business needs," i.e., neither overstaffed nor understaffed overall or in respect of any one discipline or work grade.

Human resource outsourcing

Human Resource Outsourcing is a business practice in which a corporation hires a third party to handle its HR activities. A corporation may outsource some or all of its HR-related activities to a single or a group of service providers in countries such as India, China, and the Philippines.

Organizations are spending more time focusing on their core business due to rapidly changing market dynamics and worldwide competitive pressures. Organizations are quickly recognising that they can't be everything to everyone. So, whether it's a software firm, a service provider, or a manufacturing firm, organisations today determine what they're strong at and outsource the rest, i.e., focus on their core competency and let someone else handle the rest more efficiently and cost-effectively.

As a result, outsourcing human resources is becoming more common. The number of organisations outsourcing HR functions continues to grow, as does the extent of outsourced HR functions. Payroll administration (printing checks, handling taxes, dealing with sick time and vacations), employee benefits (health, medical, life insurance, cafeteria, etc.), human resource management (hiring and firing, background interviews, exit interviews, and wage reviews), risk management, and other HR functions may be outsourced. Outsourcing has been a frequent approach to better manage people and technological resources, improve services, and reduce costs.

Services offered by HR Outsourcing

- Maintenance of personnel records
  - Annual review and revision of employee handbook.
  - Audit of HR strategies, policies and procedures.
  - Implementation of employment/termination procedures.
  - Job description process.

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- o Exit interviews.
- o Employee development program.
- o Performance management process.
- o On-site support.
- o Employee retention programs.
- o Long term incentive/equity stock option programs.
- o Employee Morale Building.
- o Compensation plan review.

- Recruiting services
  - o Retained Search
  - o Job Description Development Strategy
  - o Ad Placement
  - o Applicant Screening
  - o Reference and Background Check
  - o Candidate Interviews and Recommendations
  - o Development and Coordination of Offer
  - o Integration of New Hire
- HR management services
  - o Compensation plan review and analysis
  - o Culture development
  - o Due diligence/Acquisition planning
  - o Incentive and retention programs
  - o Executive Coaching
  - o Succession Planning
- Benefits administration
  - o Brokerage Services
  - o Custom Benefit Plan Strategies and Design
  - o Benefit analysis, cost control and reduction recommendations
  - o Development of Employee Communications
  - o Eligibility and Enrolment Services
  - o Employee claims resolution
  - o Monthly invoice audit and reconciliation
  - o On-line employee access to benefits information
- Payroll services
  - o Employee self-service features

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- o Payroll processing and reporting
- o Payroll tax reporting
- o Time off tracking
- o Online benefits enrolment

Greater Reliance on Digital and Remote Teams

Project management, like other professions, is no longer confined to the four walls of a traditional office. Digital and remote teams are more common than ever before, thanks to a variety of causes such as increased connection, shifting corporate ideals, and the rise of the gig economy.

The start of the Coronavirus (COVID-19) pandemic triggered an unusual shift in the predominance of remote work, which was already on the rise. Organizations all around the world have implemented new work-from-home policies that prioritise digital communication over face-to-face connection in an effort to protect workers and restrict the spread of the virus. Up to half of American workers are now telecommuting, and this trend is expected to continue even after the pandemic has passed, posing significant issues for project managers.

Some business functions for example, are easier to carry out when all members of a project team are in the same location. When all members of the team are in close proximity to one another, spontaneous cooperation, team building, project alignment, and other project management responsibilities are simply easier to manage.

This difficulty does not, however, imply that digital or remote teams are inevitably ineffective. Remote work has a number of advantages, including improved flexibility, which can help a company attract and retain top people from around the world.

Project managers must develop strategies to eliminate friction and inefficiencies that may arise as a result of the boom in remote labour, which is expected to remain even after the global health crisis fades. Clear and open communication has always been a vital approach for efficient project management, but as this trend continues to expand, it will become even more important.

A Closer Connection between Projects and Strategy

Project management is traditionally an organisational technique for working toward and achieving defined goals, such as the introduction of a single product or service or the pursuit of a specific outcome. In this view, a project is a temporary undertaking with a defined beginning and finish, and the project manager's job is to see it through to completion.

However, in recent years, project management has begun to play a larger role in many firms. The paradigm is increasingly being extended to broader strategy and objectives, making project management more than just a tool for achieving specific goals.

"As associate teaching professor in Northeastern's Master of Science in Project Management programme, we understand the importance of strategy and vision inside the firm," says Joseph Griffin, a certified PMP. "However, the question that emerges

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again and time again is: How do we execute?" "How can we put that strategy into action?"

"We're able to execute and make that plan actionable through the vehicles of projects and programmes," he continues. "One of the key trends we're seeing right now is a focus on programme and portfolio management, and how it may help us execute and manage strategy in an organisation."

Understanding the link between project, programme, and portfolio management is critical for project managers who want to put their abilities to greater strategic use within their organisation. This will enable you to identify how specific initiatives link to one another and to larger strategic goals, allowing you to make more informed decisions for your company in the future.

Project Management and Change Management

An organisation can go through dozens, if not hundreds, of organisational changes per year. Small changes to internal procedures to complete overhauls of a company's products, services, supply chain, strategy, or structure are all possible. While this has always been the case, the discovery of the new coronavirus has compelled many businesses to accept significant reform initiatives while still finishing old projects.

Project managers are increasingly being tasked with overseeing not only their own projects but also the organization's change initiatives.

According to the International Project Management Association's (IPMA) most recent Project Management Survey, 63 percent of firms perform projects that include at least some type of change management. Only 30% of these firms believe their change management capabilities are "very" or "very" effective, according to the same research.

You might be thinking, "What exactly does a project manager do?" Fortunately, even during times of significant organisational change, there are steps you can do to better manage your projects. For example, as part of your overarching project plan, you can create a change management strategy that describes the actions and regulations that your team will follow.

The Emergence of Hybrid Project Management Approaches

In the not-too-distant past, project managers—and even entire organisations—tended to follow a single project management technique for all projects. While project managers and organisations may have used different methodologies, a dependence on a single framework was often the rule.

However, in recent years, project managers and the businesses for which they work have become more adaptive in their approaches. Some have even combined several methodologies to create hybrid ways that are unique to their project or industry's demands. This trend has been aided by the rising acceptance of alternative project management approaches such as Kanban, Agile, and Scrum, as well as shifting corporate principles that allow for greater flexibility.

Hybrid approaches are being adopted by an increasing number of businesses. According to a recent survey, more than half of the manufacturers questioned utilise a combination of methods. According to the same survey, individuals who employ a combination are the most satisfied with their project management techniques.

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While there are advantages to concentrating in a single framework, people who want to keep up with the project management business should endeavour to become familiar with all of the major techniques.

An Emphasis on Soft Skills

To be effective in their responsibilities, project managers must have a particular level of analytical and organisational skills. However, a project manager's job does not finish with the completion of project scope and budget documents. Understanding people and how to manage them in a way that produces the best results is at the heart of their business. As a result, having a strong set of "soft skills" might be just as crucial as having the hard talents that are commonly associated with the subject.

Effective project managers must be able to anticipate their team's needs, comprehend their hopes and motives, and detect and eliminate impediments before they impede project development.

According to the Project Management Institute's (PMI) "Pulse of the Profession" study, most firms are increasingly emphasising leadership capabilities nearly as much as technical skills. The necessity for these qualities is supported by data from the World Economic Forum's "Future of Jobs" study, which shows that social skills are one of the top skillset businesses look for in new recruits, and that this trend is likely to continue.

The Impact of Artificial Intelligence and Data Analytics

The advent of artificial intelligence (AI), machine learning, and the explosion of data collecting and analysis that has characterised much of the twenty-first century will have an impact on project management, as it has on virtually every other business.

It's difficult to say with certainty what this influence will look like. Most experts, however, agree that some disruption is unavoidable, as the Association for Project Management points out in its "Projecting the Future" report.

Many administration-focused duties that currently fall to project managers, such as resource allocation, project balance, and schedule and budget updates, will likely be automated as a result of artificial intelligence. Another example would be resource allocation automation, which has traditionally featured variable degrees of automation.

While some may be concerned about the effects of automation on the profession, these changes also carry a lot of promise. By automating low-value-add processes, project managers may focus their resources and energy on tasks that will have the most impact on their organisation, allowing them to make more change and increase the likelihood of meeting the project's strategic goals.

To prepare for these changes, project management professionals do not need to become specialists in AI or data analytics, but they should seek to understand their organization's AI plans in order to anticipate changes in their responsibilities and everyday work.

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1.3.3 Concept of Developing and Managing the Team

The difference in productivity between an average team and a high-performing, turned-on team is not 10%, 20%, or 30%, but 100%, 200 percent, or even 500 percent!

The term "synergy," which comes from the Greek word sunergos, which means "working together," captures the wonder and power of teamwork. Synergy can be both beneficial and bad. The expression "the total is greater than the sum of the parts" captures the core of positive synergy. Negative synergy, on the other hand, happens when the total is less than the sum of its parts.

Synergy is best seen on a basketball court, soccer field, or football field, as teammates work together to defeat a superior opponent (see Snapshot from Practice: The 2008 Olympic Redeem Team). Positive and negative synergy can be noticed and felt in the daily operations of project teams, albeit it is less evident than in team sports. Here's a description from one of the team members we spoke with:

"We fractionalized into a succession of subgroups instead of operating as a single large team." The marketing team, as well as the systems team, stayed together. A significant amount of time was spent talking and grumbling about one another. When the project began to fall behind schedule, everyone began to conceal their tracks and attempt to shift blame to others. After a while, we stopped having face-to-face conversations and instead used e-mail. Management finally pulled the plug on the project and brought in a new team to save it. It was one of the most dreadful project management situations I've ever had."

The following are some of the characteristics that are frequently connected with high-performing teams that have positive synergy:

- The team has a sense of common purpose, and each member is eager to contribute to the project's success.
- Individual abilities and experience are identified and utilised by the team, based on the project's demands at any given time. The team voluntarily accepts the influence and leadership of the individuals whose abilities are pertinent to the immediate work at hand at these times.
- To enhance work completion as well as sentiments of group cohesion and morale, roles are balanced and shared.
- Rather of being depleted by interpersonal concerns or competitive struggles, the team devotes its energy to problem solution.
- Different points of view are welcomed and freely expressed.
- Mistakes are considered as learning opportunities rather than punishments to encourage risk-taking and inventiveness.
- Members establish high personal performance goals for themselves and encourage one another to achieve the project's goals.
- Members identify with the group and see it as a valuable source of professional and personal development.

High-performing teams become champions, creating game-changing products, exceeding customer expectations, and completing projects on time and on budget.

Mutual interdependence and a common aim or vision bind them together. They have a high level of trust and teamwork between them.

The Five-Stage Team Development Model

- Forming: During this stage, the members become familiar with one another and gain a better understanding of the project's scope. They start by determining what behaviours are appropriate in terms of both the project (what function they will play, what performance goals are in place) and interpersonal relationships (who is truly in charge). When members begin to see themselves as part of a group, this stage is complete.
- Storming: This stage is characterised by a high level of internal conflict, as the name implies. Members acknowledge that they are part of a project group, but they object to the project's and group's restrictions on their uniqueness. There is a disagreement about who will be in charge of the group and how decisions will be made. The project manager's leadership becomes accepted when these disagreements are overcome, and the group progresses to the next stage.
- Norming: The third stage involves the development of close ties and the demonstration of group cohesion. Camaraderie and shared responsibility for the project are at an all-time high. When the group structure is solidified and the group adopts a common set of expectations for how members should collaborate, the norming phase is accomplished.
- Performing: At this stage, the team's functioning structure is completely functional and acceptable. The focus of the group's energy has shifted from getting to know one another and figuring out how to work together to achieving the project's objectives.
- Adjourning: Performing is the final stage of growth for traditional labour groups. There is, however, a finishing phase for project teams. The team is preparing for its own disbandment at this point. High performance isn't as important as it once was. Instead, the focus is on completing the project. Members' reactions differ at this level. Some members are optimistic, praising the project team's achievements. Others may feel depressed as a result of the loss of camaraderie and friendships formed throughout the project's execution.

This paradigm has various consequences for project team members. The first is that the model provides a framework within which the group can comprehend its own growth. Project managers have found that sharing the model with their teams has been beneficial. It assists members in accepting the tensions of the storming phase and refocusing their attention on the more productive stages.

Another result is that it emphasises the importance of the norming phase, which has a substantial impact on the degree of productivity in the performance phase. As we will see, project managers must play an active part in developing group norms that will contribute to the project's eventual success. See the Punctuated Equilibrium Research Highlight for an alternative model of group growth.

Notes

Situational Factors Affecting Team Development

High-performance project teams are significantly more likely to develop under the following conditions, according to experience and research:

- There are 10 or fewer members per team.
- Members volunteer to serve on the project team.
- Members serve on the project from beginning to end.
- Members are assigned to the project full time.
- Members are part of an organization culture that fosters cooperation and trust.
- Members report solely to the project manager.
- All relevant functional areas are represented on the team.
- The project involves a compelling objective.
- Members are located within conversational distance of each other.

In practice, a project manager is unlikely to be allocated a project that fits all of these criteria. Many projects for example, necessitate the active participation of more than ten people and may involve a complicated network of interlocking teams totalling more than 100 people. In many organisations, project members are assigned by functional managers or central manpower departments with little participation from the project manager.

Team members' involvement may be part-time or participants may shift in and out of the project team on an as-needed basis to maximise resource usage. In the case of ad hoc task forces, no one on the team is dedicated to the project full-time. In many companies, there is an NIH (not invented here) culture that discourages cross-functional collaboration.

Team members are frequently assigned to multiple managers, and in some situations, the project manager has no direct influence over team member performance evaluations or development chances. It is possible that key functional areas will not be represented throughout the project, but will only be involved in a sequential fashion. Not every initiative has a compelling goal. It can be difficult to elicit enthusiasm for ordinary projects such as a simple product extension or a standard housing complex. Finally, team members are frequently dispersed throughout multiple corporate locations and buildings, or across the globe in the case of a virtual project.

It's critical for project managers and team members to understand the limits they're working with and do their best to work within them. It would be naïve to suppose that every project team has the same ability to develop into a high-performing unit. It may be difficult just to meet project goals in less-than-ideal circumstances. To maximise the effectiveness of a project team, ingenuity, discipline, and attention to team dynamics are required.

Building High-Performance Project Teams

Project managers are crucial in the development of high-performing project teams. They recruit members, hold meetings, construct a team identity, create a shared vision or a common sense of purpose, manage a reward system that encourages teamwork, coordinate decision-making, handle internal issues, and renew the team when energy wanes. Project managers take use of situational aspects that naturally aid team development while improvising around those that hinder it. They demonstrate a very engaged management style that exemplifies teamwork by doing so.

Reward and Recognition Systems

The implementation of team-based reward and recognition systems is another significant technique for encouraging team development. Management will encourage or reinforce the concept that people perform more efficiently in groups if they reward teamwork. Employees that accomplish or exceed corporate or project goals may be rewarded with bonuses, trips, or other incentives. People who willingly labour overtime to accomplish an aggressive schedule objective or go out of their way to help a teammate can be recognised and rewarded in a project context. People who work overtime for the sake of greater income or because of their own bad work or planning should not be rewarded by project managers.

Project managers must evaluate their team's performance on a regular basis. It's their job to figure out the best approach to grow their people and increase performance when they uncover areas where individuals or the entire team may improve.

The project manager must not only establish the project team, but also lead them through numerous project activities. (Note that PMI prefers the term "managing the project team" over "leading the project team," thus that terminology is used here as well.) After evaluating team performance and related data, the project manager must determine whether changes to the project should be sought, or whether improvements to enterprise environmental factors, organisational process assets, or the project management plan are required. Project managers must employ soft skills to determine the most effective methods for motivating and managing each team member.

General Advice on Managing Teams

"Teamwork remains the one lasting competitive advantage that has been completely untapped," says Patrick Lencioni, a well-known author and consultant on teams. "Teamwork is nearly always lacking within firms that fail, and often present within those that win." 36 However, cooperation is difficult to establish, and maintaining teamwork is much more difficult because teams are prone to dysfunction. The following are the five types of team dysfunction:

- Absence of trust
- Fear of conflict
- Lack of commitment
- Avoidance of accountability
- Inattention to results

Each of these dysfunctions is addressed in detail in Lencioni's books. He advises for example, that team members use the Myers-Briggs Type Indicator, which was discussed earlier in this chapter, to help people open up to one another and create trust. He recommends that teams practice having unfiltered, passionate arguments about significant matters to master conflict. He emphasises the need of expressing all conceivable ideas and getting individuals to agree to disagree in order to establish commitment, but then having them commit to decisions.

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Lencioni highlights the significance of defining and focusing on everyone's top priorities in order to embrace accountability. He also claims that peer pressure and the reluctance to disappoint a co-worker are often more effective motivators than authoritative involvement. Finally, employing a scoreboard to focus on team results reduces ambiguity and ensures that everyone understands what it takes to produce positive results.

The following are some additional recommendations for ensuring that teams are productive:

- With your team, be patient and kind. Assume the best in people; don't assume your co-workers are slackers or irresponsible.
- Instead ofblaming people, fix the problem. By concentrating on habits, you can assist people in resolving issues.
- Set up productive meetings on a regular basis. Concentrate on accomplishing project goals and achieving favourable outcomes.
- Allow teams time to complete Tuckman's basic team-building processes of forming, storming, norming, performing, and adjourning. Expect teams to work at their peak performance level over time.
- Workgroups should be limited to three to seven people.
- Plan some social activities to allow members of the project team and other stakeholders get to know one another better. Make the social events enjoyable rather than obligatory.
- Make a big deal of your team's identity. Make traditions that everyone on the team enjoys.
- Team members should be nurtured and encouraged to assist one another. Determine and deliver training to assist individuals and the team as a whole in becoming more effective.
- Recognize individual and group achievements.

Take extra steps to collaborate with virtual team members. When starting a virtual project or introducing a virtual team member, if possible, have a face-to-face or phone meeting. People should be thoroughly screened to ensure that they can function well in a virtual setting. Determine how members of the virtual team will communicate.

Controlling Resources

Controlling resources entails ensuring that the project's physical resources are available when they are needed. It also entails keeping track of planned vs. actual resource usage and taking corrective action as needed. The Manage Team method deals with making optimal utilisation of team members. Data analysis, problem solving, interpersonal and team skills, and project management information systems are examples of tools and techniques. Work performance data, modification requests, project management plan updates, and project document changes are all examples of key outputs.

Considerations for Agile/Adaptive Environments

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Team arrangements that optimise concentration and collaboration, such as self-organizing teams with generalising specialists, benefit projects with high variability.

Collaboration is supposed to increase productivity and improve problem-solving creativity. Collaborative teams can help with rapid integration of different job tasks, improved communication, knowledge exchange, and work assignment flexibility, among other things. Because there is less time for centralised tasking and decision making, collaborative teams are typically important to the success of projects with a high degree of variable and rapid changes, despite the benefits of collaboration being applicable to other project environments.

Physical and human resource planning is substantially less predictable in high-variability projects. Agreements for quick supply and lean processes are crucial in these situations for cost reduction and meeting deadlines.

Collaboration, problem solving, and knowledge sharing are all crucial on all types of projects. Team members on agile projects, on the other hand, are usually totally dedicated to a single team. Trust is the foundation of relationships, and collaboration is constantly improved through regular feedback loops. Each sprint's end-of-sprint delivery of usable product for example, decreases uncertainty and increases team confidence. Another distinction is that some agile teams do not employ project managers. They might be self-directing teams, or they could have a Scrum master.

Daily stand-up meetings are intended to improve the frequency of communication among project team members while keeping these brief meetings focused on the topic at hand. Co-location of users and development teams is a significant way to meet social needs. Communication between the development team and the user group is likely to be inadequate, and co-location should be promoted.

Physical resources, in addition to human resources, should be handled in an adaptive manner. Prototypes, simulations, feasibility studies, and other risk-reduction techniques can help you figure out which resources are ideal for the job and how to employ them. This method entails breaking down the task into manageable chunks, each with its own set of resources and costs, and implementing them in a logical order as the deliverables take shape within the larger project.

Much more than using tools to assess and track resource loading and level resources is involved in project resource management. On most projects, people are the most valuable asset, and human resources are distinct from other resources. You can't simply replace people like you can replace a piece of machinery. It is critical to treat individuals with compassion and respect, to comprehend their motivations, and to communicate with them thoughtfully. What makes successful project managers outstanding is their ability to empower project team members to deliver their best work on a project, not their use of tools.

1.3.4 Introductory Concept of Communication Planning

Improper communication planning can result in issues such as message delivery delays, sensitive material being communicated to the wrong audience, or a lack of communication with some of the required stakeholders.

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A communication plan allows the project manager to document the best way to communicate with stakeholders in the most efficient and effective way possible. Information is delivered in the correct format, at the right time, and with the right impact when it is communicated effectively. Only presenting the information that is required is what efficient communication entails. On most projects, communications planning takes place early on, such as with the development of the project management strategy. This enables for the proper allocation of resources, such as time and money, to communication initiatives. To ensure continuous applicability, the outputs of this planning process should be reviewed and amended as needed during the project.

Failure to communicate, according to many experts, is the greatest threat to the success of any project, particularly IT initiatives. Many issues in other areas of knowledge, such as a hazy scope or unreasonable deadlines, suggest communication issues. Project managers and their teams must prioritise good communication, particularly with senior management and other key stakeholders.

The IT field is always changing, and with that shift comes a lot of technical jargon. Technical jargon can often complicate problems and cause confusion when computer specialists engage with those who aren't as adept with or informed about computers—a category that includes many business professionals and senior managers. Despite the fact that the majority of people now use computers, the divide between users and developers is widening as technology progresses. Some of the communication issues between technical personnel and their business colleagues are caused by this knowledge and experience divide. Of course, not every computer expert is a terrible communicator, but communication skills can be improved by almost anyone in any area.

Furthermore, many school institutions favour strong technical skills above excellent communication and social skills for IT graduates. Most IT-related degree programmes include a lot of technical prerequisites, but just a few of them need courses in communication (speaking, writing, listening), psychology, sociology, or the humanities. People frequently believe that mastering these soft skills is simple, yet they are critical skills that must be learned and developed.

Soft skills are needed by IT professionals as much, if not more, than other skills, according to numerous studies. When working on IT projects, you can't completely separate technical and soft abilities. Every project team member requires both types of talents and must continue to develop them through formal education and on-the-job training in order for projects to thrive.

According to studies, there is a great demand for IT workers, and solid communication and business abilities are essential. In an article published in the International Journal of Business and Social Science, it is stated:

- Employers are searching for employees that have the right blend of technical, soft, and business abilities.
- Problem solving, teamwork, listening, ability to adapt to new technologies and languages, time management, ability to transfer knowledge to application, multitasking, verbal communication, ability to visualise and conceptualise, "be the customer" mentality, interpersonal skills, understanding business culture, inter-team communication, and the ability to give and receive constructive criticism are the most important non-technical skills.

- "The need for these non-technical abilities is so high that several IT firms have stated that they will hire someone with only rudimentary technical skills if they can demonstrate strong soft and business skills."

The purpose of project communications management is to guarantee that project information is generated, collected, disseminated, stored, and disposed of in a timely and suitable manner. In project communications management, there are three basic processes:

- Stakeholders' information and communication demands must be determined while planning communications management. What information is required by whom? When are they going to need it? What method will be used to provide the information to them? This procedure produces a communications management plan, project management plan updates, and project document updates, among other things.
- According to the communications management plan, managing communications entails developing, distributing, storing, retrieving, and discarding project communications. Project communications, project management plan updates, project document updates, and organisational process assets changes are the major outputs of this procedure. Formal and informal plans, policies, procedures, guidelines, information systems, financial systems, management systems, lessons learned, and historical information are all examples of organisational process assets. These assets assist people in an organisation in understanding, following, and improving business processes.
- Monitoring communications entails ensuring that the communication demands of stakeholders are satisfied.

1.3.5 Need of Communication Requirement Analysis

Because the organization's structure will have a significant impact on the project's communications requirements, the Plan Communications process is closely tied to enterprise environmental elements.

Following up with an internal communication plan is critical once the project deliverables and work have been clearly specified. Poor communication is frequently cited as a key cause of project failure. A solid communications plan may go a long way toward preventing project issues and ensuring that clients, team members, and other stakeholders get the information they need to do their tasks.

During the early stages of project planning, the project manager and/or the project team normally construct a communication plan.

When it comes to planning and managing project schedules, challenges, and action items, communication is crucial. The plan lays out how information will be distributed to various stakeholders and becomes an important aspect of the overall project plan. A project communication strategy specifies what, who, how, and when information will be communicated to project stakeholders in order to manage schedules, issues, and action items.

The following fundamental questions are addressed in project communication plans:

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- What information should be collected and when should it be collected?
- Who will be the recipients of the information?
- What mechanisms will be employed to collect and store data?
- What, if any, restrictions exist on who has access to certain types of information?
- When will the details be made public?
- What method will be used to communicate it?

The following basic phases are frequently included in developing a communication plan that answers these questions:

- Analysis of the various stakeholders. Determine the target demographics. Customers, sponsors, project teams, project offices, and anybody else that needs project information to make choices and/or contribute to project progress are examples of typical groupings.
- Information is required. What information is important to stakeholders who are involved in the project's development? Top management for example, requires information on how the project is progressing, whether it is experiencing critical issues, and the extent to which project objectives are being met. This data is essential in order for them to make strategic decisions and manage a project portfolio. Schedules, task lists, requirements, and the like are needed by project team members so they know what needs to be done next. Any changes in the timeline and performance requirements of the components they provide must be communicated to external entities. The following are some of the most common information requirements found in communication plans:
    - Reports on the status of projects
    - Issues with deliverables
    - Modifications to the scope
    - Decisions on gating
    - Items to do
    - Meetings to discuss the state of the team
    - Changes to the request were accepted.
    - Reports on significant events
- Information sources. Following the identification of information requirements, the following stage is to identify information sources. To put it another way, where does the data reside? What method will be used to collect it? The minutes and reports of various groups for example, might contain information about the milestone report, team meetings, and project status meetings.
- Modes of dissemination E-mail, teleconferencing, Lotus Notes, SharePoint, and a variety of database sharing technologies are being used to supplement traditional status report meetings in today's world. Many companies, in particular, are using the Internet to construct a "virtual project office" where project information can be stored. Project management software sends data directly to the website, allowing different stakeholders to see essential project information right away. In some

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circumstances, relevant data is immediately transmitted to key stakeholders. Many project updates and action items still require a backup paper hardcopy to specified stakeholders.

- Timing and accountability. Decide who will be in charge of disseminating the information. A frequent practice for example, is for meeting secretaries to forward minutes or specific information to the necessary parties. In some circumstances, the project manager or project office bears accountability. It is necessary to determine the right timing and frequency of delivery for the information.

Establishing a communication plan has the advantage of allowing you to manage the flow of information rather than responding to information requests. This avoids ambiguity and unwanted disruptions, as well as giving project managers more control.

Senior management will feel more comfortable letting the team complete the project without intervention if you report on how things are going and what is happening on a regular basis.

Table: Project Communication Plan

What Information	*Target Audience*	*When?*	*Method of Communication*	*Provider*
Milestone report	Senior management and project manager	Bimonthly	E-mail and hardcopy	Project office
Project status reports & agendas	Staff and customer	Weekly	E-mail and hardcopy	Project manager
Team status reports	Project manager and project office	Weekly	E-mail	Team recorder
Issues report	Staff and customer	Weekly	E-mail	Team recorder
Escalation reports	Staff and customer	When needed	Meeting and hardcopy	Project manager
Outsourcing performance	Staff and customer	Bimonthly	Meeting	Project manager
Accepted change requests	Project office, senior mgmt., customer, staff, and project mgr.	Anytime	E-mail and hardcopy	Design department
Oversight gate decisions	Senior management and project manager	As required	E-mail meeting report	Oversight group or project office

It is impossible to stress the importance of having a plan for delivering critical project information early on. Many of the issues that afflict a project may be traced back to a lack of time spent on a solid internal communication strategy.

The information demands of project stakeholders are determined by analysing the communication requirements. These requirements are created by combining the type and structure of information required with an assessment of its value. Only project resources are used to provide information that is necessary for success or where a lack of communication could lead to failure.

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The number of potential communication channels or paths should also be considered by the project management as an indicator of the project's communication complexity. n(n-1)/2 is the total number of possible communication routes, where n is the number of stakeholders. As a result, a project with ten stakeholders has a total of 10(10-1)/2 = 45 communication channels. As a result, determining and limiting who will contact with whom and who will receive what information is an important part of organising the project's actual communications.

The following information is commonly used to determine project communication requirements:

- Graphs of organisation.
- Relationships between stakeholders and project organisation.
- The project's disciplines, departments, and specialties are all involved.
- The logistics of how many people will be participating in the project and where they will be located.
- Internal data requirements (e.g., communicating across organizations).
- Needs for external data (e.g., communicating with the media, public, or contractors), and
- Information on stakeholders from the stakeholder register and the stakeholder management strategy

1.3.6 Different Communication Models, Information Distribution

A basic communication model, as depicted in the diagram below, depicts how information is delivered and received between two parties, the sender and the receiver. The following are some of the model's most important features:

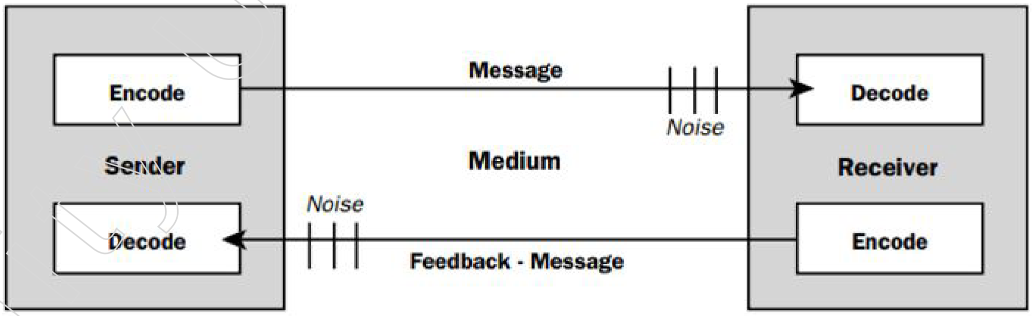

Figure: Basic Communication Model

- Encode. To put one's thoughts or ideas into a language that others can understand.
- Message and feedback-message. The output of encoding.
- Medium. The method used to convey the message.
- noise. Anything that obstructs the message's delivery and comprehension (e.g., distance, unfamiliar technology, lack of background information).
- Decode. Reconcile the message with relevant thoughts or concepts

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A basic communication model is shown in the diagram above. An action to acknowledge a message is built into the model. The receiver acknowledges that he or she has received the message but does not necessarily agree with it. Another activity is a message response, which indicates that the receiver has decoded, comprehended, and is responding to the message.

When considering project communications, the components of the communications model must be considered. The sender is responsible for making the information clear and comprehensive so that the receiver can receive it appropriately, as well as checking that it has been received correctly. The receiver must ensure that the information is received in its completeness, appropriately interpreted, and recognised. A lack of communication might have a detrimental influence on the project.

There are numerous obstacles in properly communicating with project stakeholders utilising these components. Consider a multi-national project team with a high level of technical expertise. Encoding the message in the appropriate language, sending the message using a variety of technologies, and having the receiver decode the message and reply or provide feedback are all examples of how one team member can successfully communicate a technical concept to another team member in another country. Any noise produced along the road detracts from the message's original meaning.

Communication Methods

Information is shared among project stakeholders through a variety of communication strategies. These techniques can be divided into three categories:

Interactive communication. A multidirectional exchange of information between two or more parties. Meetings, phone conferences, video conferencing, and other methods are used to ensure that all participants have a shared knowledge of specific topics.

Push communication. Messages are sent to selected individuals who require the information. This ensures that the information is transmitted, but it does not guarantee that the intended audience received it or comprehended it. Letters, memoranda, reports, emails, faxes, voice mails, and press releases are examples of push communication.

Pull communication. Used when there is a lot of information or a lot of people, and the recipients have to view the communication content at their own choice. Intranet sites, e-learning, and knowledge repositories are examples of these methods.

The project manager determines what, how, and when communication methods will be employed in the project based on communication requirements.

Plan Communications: Outputs

- Communications Management Plan

The project management plan contains or is a component of the communications management strategy. The communications management strategy might be formal or informal, specific or wide, and tailored to the project's requirements.

Typically, a communications management plan includes:

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- Information should be communicated, including language, structure, substance, and amount of detail;
- Stakeholder communication requirements
- The purpose of disseminating that information;
- Distribution of needed information within a specific time range and on a regular basis;
- Person or groups who will receive the information;
- Person or groups who will be responsible for communicating the information;
- Person or groups who will be accountable for authorising the release of sensitive information;
- Memos, e-mail, and/or press releases are examples of methods or technology used to transmit information.
- Time and budget have been set aside for communication efforts.
- Time frames and the management chain (names) for escalation of issues that cannot be resolved at a lower staff level are identified in the escalation procedure.
- As the project evolves and develops, a method for updating and enhancing the communications management strategy;
- a glossary of commonly used terms;
- Communication restrictions, which are usually generated from special legislation or regulation, technology, and organisational rules, etc.
- Flow charts of the information flow in the project, workflows with possible order of authorization, list of reports, and meeting plans, etc.

Guidelines and templates for project status meetings, project team meetings, e-meetings, and e-mail can all be included in the communications management plan. If they are used in the project, a project website and project management software can also be included.

- Project Document updates

Project documents that may be updated include but are not limited to:

- o Project schedule,
- o Stakeholder register, and
- o Stakeholder management strategy.

Information Distribution

The process of making relevant information available to project stakeholders as planned is known as distribute information. It's done at every stage of the project's life cycle, as well as in all management activities. The execution process, which involves implementing the communications management plan as well as responding to unanticipated demands for information, is the main focus here. A variety of approaches are used to effectively distribute information, including:

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- Models with a sender and a recipient. Communication obstacles and feedback loops
- Media selection. When to communicate in writing vs. orally, when to write an informal note vs. a formal report, and when to communicate face-to-face vs. through e-mail, depending on the situation.
- Style of writing Active versus passive voice, sentence construction, and word choice are all important considerations.
- Techniques for meeting management. Creating a schedule and resolving problems
- Techniques of presentation Body language and visual aids design
- Techniques for facilitation Consensus-building and problem-solving

Distribute Information: Inputs

- Project Management Plan

The communications management plan is included in the project management plan.

- Performance Reports

Performance reports are intended to disseminate project performance and status information, and they should be accessible prior to project meetings and as accurate and current as feasible.

Forecasts are modified and published as the project progresses, based on work performance metrics. This data pertains to the project's previous performance that may have an impact on the project's future performance, such as estimates at completion and estimates to complete. Earned value methods are commonly used to create forecast information, but alternative methods such as analogy with previous projects, re-estimating remaining work, including the impact of external events in the timetable, and others may also be used. This information, together with performance data and other critical data that must be disseminated for decision-making, should be available.

- Organizational Process Assets

The following are examples of organisational process assets that can influence the Distribute Information process:

- Dissemination of information policies, procedures, and recommendations.
- Templates, as well as
- Historical data and learnt lessons

Distribute Information: Tools and Techniques

- Communication Methods: Information is distributed through individual and group meetings, video and audio conferences, computer chats, and other remote communication methods.
- Information Distribution: Tools A variety of tools can be used to transmit project information, including:

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- o Hard-copy document distribution, manual filing systems, press releases, and shared-access electronic databases;
- o Electronic communication and conferencing tools, such as e-mail, fax, voice mail, telephone, video and web conferencing, websites and web publishing; and
- o Electronic tools for project management, such as web interfaces to scheduling and project management software, meeting and virtual office support software, portals, and collaborative work management tools.

Distribute Information: Outputs

Organizational Process Assets Updates

The following are examples of organisational process assets that could be updated:

- Notifications to stakeholders. Stakeholders may be informed about addressed issues, approved changes, and the overall progress of the project.
- Reports on projects. Lessons learned, issue logs, project closing reports, and outputs from other Knowledge Areas are all included in formal and informal project reports that reflect project status.
- Presentations on a project. The project team communicates with any or all project stakeholders formally or informally. The information and presentation technique should be appropriate for the audience's demands.
- Records of the project. Correspondence, memos, meeting minutes, and other documents outlining the project are examples of project records. To the degree practicable and acceptable, this information should be kept in an organised fashion. Members of the project team can also keep track of things in a project notebook or register, which can be physical or electronic.
- Stakeholders' responses Information about project operations collected from stakeholders can be disseminated and used to adjust or improve the project's future performance.
- Documentation of the lessons learned. The causes of issues, the logic behind the corrective action selected, and other sorts of information distribution lessons learned are all documented. Lessons learnt are documented and disseminated so that they become part of the project's and performing organization's history databases.

1.3.7 Method of Performance Reporting

Performance reporting is another crucial technique for managing project communications. Stakeholders are kept informed about how resources are being used to meet project goals through performance reporting. It also encourages employees to report on their success.

a widely used tool that has been shown to boost project effectiveness. Progress or status reports are common formats for performance reporting. Many people confuse the two names, but some people differentiate between them as follows:

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- The project team's accomplishments over a given time period are described in progress reports. In many projects, each team member is required to submit a monthly or even weekly progress report. Team leaders frequently compile aggregated progress reports based on data provided by team members.
- Status reports describe the current state of the project at a certain moment in time. The project's status reports detail where it stands in terms of achieving the triple constraint of scope, time, and money. How much money has already been spent? How long did it take you to complete specific tasks? Is the job being completed according to the schedule? Depending on the demands of the stakeholders, status reports can take a variety of forms.

Report The process of gathering and disseminating performance data, such as status reports, progress measurements, and forecasts, is known as performance. The performance reporting process entails collecting and analysing baseline versus actual data on a regular basis in order to understand and convey project progress and performance, as well as forecast project outcomes.

For each audience, performance reports must include information at the right level. The format could be anything from a simple status report to a more detailed report. A simple status report could include performance data like percent complete or status dashboards for each region (i.e., scope, schedule, cost, and quality). The following are examples of more detailed reports:

- Analysis of past performance,
- Current status of risks and issues,
- Work completed during the period,
- Work to be completed next,
- Summary of changes approved in the period, and
- Other relevant information which must be reviewed and discussed.

A comprehensive report should also provide an estimate of when the project will be completed (including time and cost). These reports can be generated on a regular basis or on a case-by-case basis.

Report Performance: Inputs

- Project Management Plan: Project baselines are detailed in the project management plan. The performance measurement baseline is a project work plan that has been approved and against which the project execution is assessed, with variances measured for management control. The scope, schedule, and cost elements of a project are commonly included in the performance measurement baseline, although technical and quality parameters may also be included.
- Work Performance Information

Information on performance results is gathered from project activities, such as:

- Deliverables status,
- Schedule progress, and
- Costs incurred.

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- Work Performance Measurements

Work performance data is used to develop project activity metrics, which are used to compare actual progress to projected progress. Among these include, but are not limited to:

 o Planned versus actual schedule performance,

 o Planned versus actual cost performance, and

 o Planned versus actual technical performance.

- Budget Forecasts

The Control Cost budget projection information provides information on the additional monies that are estimated to be required for the remaining work, as well as estimates for the complete project work completion.

- Organizational Process Assets

The following are examples of organisational process assets that can influence the Report Performance process:

 o Report templates,

 o Policies and procedures that define the measures and indicators to be used, and

 o Organizationally defined variance limits.

Report Performance: Tools and Techniques

- Variance Analysis

Variance analysis examines what produced a difference between the baseline and actual performance after the fact. Depending on the application area, the standard utilised, and the industry, the process for performing variance analysis may differ. The following are typical steps:

- Check the accuracy of the data collected to make sure it's accurate, consistent with previous data, and reliable when compared to other project or status data.
- Determine variations by comparing actual data to the project baseline and noting any deviations that are beneficial or unfavourable to the project's success. To quantify deviations, earned value management employs specialised formulae.
- Determine the impact of project cost and schedule deviations, as well as variances in other project areas.

Analyse the trends in the variances, if appropriate, and record any discoveries concerning the causes of variation and the effect area.

- Forecasting Methods

Forecasting is the technique of estimating future project performance based on current results. Forecasting techniques can be divided into several categories:

 o Time series methods. Time series approaches rely on historical data to forecast future events. Earned value, moving average, extrapolation, linear

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prediction, trend estimate, and growth curve are examples of methods in this area.

- o Causal/econometric methods. Some forecasting approaches are based on the assumption that the underlying elements that may impact the variable being anticipated can be identified. Sales of umbrellas for example, may be linked to weather conditions. After understanding the reasons, projections of the affecting variables can be developed and used in the forecast. Regression analysis employing linear or non-linear regression, autoregressive moving average (ARMA), and econometrics are examples of methodologies in this category.
- o judgmental methods. Intuitive judgments, views, and probability estimations are all included in judgmental forecasting approaches. Composite predictions, surveys, the Delphi approach, scenario building, technological forecasting, and forecasting by analogy are examples of methodologies in this area.
- o Other methods. Simulation, probabilistic forecasting, and ensemble forecasting are examples of other methodologies.

- Communication Methods

Status review meetings can be used to share and assess project progress and performance information. To distribute performance reports, the project manager typically uses a push communication mechanism.

- Reporting Systems

A reporting system gives the project manager a common mechanism for capturing, storing, and disseminating information to stakeholders regarding the project's cost, schedule progress, and performance. Software packages enable the project manager to combine reports from many platforms and distribute them to project stakeholders more easily. Table reporting, spreadsheet analysis, and presentations are all examples of distribution forms. Visual representations of project performance data can be created using graphic skills.

Report Performance: Outputs

Performance reports organise and summarise the data gathered and show any analysis results in comparison to the performance measurement baseline. Reports should give status and progress information to diverse stakeholders at the level of detail specified in the communications management plan. Bar charts, S-curves, histograms, and tables are all common performance report types. Performance reporting frequently includes variance analysis, earned value analysis, and forecast data.

Periodically, performance reports are issued in a variety of formats, ranging from simple status reports to more comprehensive reports. A simple status report might merely provide performance data like percent complete or status dashboards for each region (e.g., scope, schedule, cost, and quality). The following are examples of more detailed reports:

- Analysis of past performance,
- Current status of risks and issues,
- Work completed during the reporting period,

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- Work to be completed during the next reporting period,
- Summary of changes approved in the period,
- Results of variance analysis,
- Forecasted project completion (including time and cost), and
- Other relevant information to be reviewed and discussed.

Organizational Process Assets updates

Report formats and lessons learned documentation, including the causes of difficulties, reasoning behind the corrective action taken, and other types of performance reporting lessons learned, are among the organisational process assets that can be changed. Lessons learnt are documented so that they can be added to the project's and the performing organization's history databases.

Change Requests

Change requests are frequently generated as a result of project performance analysis. The following is how the Perform Integrated Change Control process handles these requests:

- Changes that bring the project's predicted future performance in line with the project management plan are among the recommended corrective actions, and
- Preventive steps that are recommended can help to lessen the likelihood of future project failure.

1.3.8 Factors for Success and Failures of Project

There are numerous aspects and circumstances that influence whether or not your project will be successful. Learn how to avoid project failures and how to use project management success criteria to help your team succeed.

Learning project success factors and following some crucial success factor examples can help you obtain a better grasp of how effective project managers plan, communicate, manage risk, and close projects successfully.

Critical Success Factor

Intensive Planning

Take the time to sit down for an exhaustive planning session before beginning a project, set your performance targets, come to an agreement on what a completed project should look like, and finalise your plan with your clients. Inadequate planning at the start of a project may cause you to overlook underlying issues or details that may cause problems later.

Strategy

It's easy to get caught up in new technology or processes and lose sight of the company's strategic goals and why you're working on this project in the first place. Focus on project management best practices first, then create your plan from there.

Notes

Clear Communication

Without adequate communication, even the best project management success factors would fail. Shareholders and employees will buy in more if frank and meaningful talks are had. Take charge of the project and raise any difficulties that emerge. Don't wait for the client to point it out.

Actionable Results

Forget the rhetoric and provide your clients with tangible solutions that include measurable benchmarks, performance targets, and a clear road to success.

Collaboration

Maintaining contacts and reaching out to other professionals has never been easier thanks to online networking. As project managers, you should start using collaboration as early as the planning stage. As they strive toward project accomplishment, collaborative teams have stronger plans in place and are more engaged. Collaboration also entails working together and keeping track of the project so that everyone is on the same page.

Collaborative project management approaches enable all team members to be fully engaged and contribute meaningfully to the project's success. The methods are also useful for new and "accidental project managers" who do not have professional project management training.

Plan Together

It's better if the project's delivery team is involved in the planning process. The quality of the final plan will be improved, and all team members will be more engaged.

Act Together

On the project, having the team act in sync is highly desirable. We all want our project teams to be informed about what is going on and what they need to do to achieve project success.

Track Together

To contribute positively to the project outcome, the extended team (project manager, team members, senior executives, customers, etc.) will need to keep track of what is and is not happening on the project.

Main Causes of Project Failure

For a variety of reasons, projects fail to finish on time, on budget, or within plan. While not all of these are the project manager's responsibility, an experienced and well-prepared project manager can execute planning and encourage project management success factors to keep a project on track. As a project manager, you should avoid the following project failure factors.

Notes

Failure to Plan Effectively

Effective planning is a project management success aspect that simply cannot be missed, despite the fact that it is an obvious step. Writing out your strategy and setting a realistic time period, estimating costs, determining milestones, documenting deliverables, and defining project scope are all part of effective project planning. Using a project management platform to keep you organised is one technique to help you plan efficiently. You'll meet your deadlines, keep organised, and stay within your budget if you prepare ahead.

Disregarding Risk Management

When it comes down to it, we all know that initiatives do not always go according to plan and frequently fail. You're asking for disaster if you don't plan for setbacks. Make a risk log with an action plan and store it wherever your team members and stakeholders can see it. Keeping all of your data in one place can allow your team members to discover information quickly and assist in bringing new members up to speed on projects. Having a robust risk management strategy in place will also allow you to act quickly if you notice warning signals of impending collapse.

Inadequate Scope Document

A poor scope document, or no scope document at all, is a major cause of project failure, and it's more often than you might believe. Because of the continually altering scope, 75% of IT executives believe their initiatives are doomed from the start. Project managers are in charge of dealing with scope changes and determining whether they are necessary. When the scope of a project changes—and it will—project managers must evaluate how this will affect the final project's timetable and budget, and they may need to approach the client to revise the budget. Finally, establishing the scope of your project should be done with a scope document throughout the planning and goal-setting stages of your project. Defining how you'll handle scope adjustments and tracking them can help everyone stay on the same page when things eventually change.

Not Selecting the Right People

While your resource and recruitment departments are responsible for finding the proper individuals for the work, it is your role as a project manager to assign the correct responsibilities to the right people and maintain a cohesive team. Assign team members to roles where they will flourish, and make use of your core resources to keep everyone on the same page while you and your team work to complete your project. Projects might face difficulties or setbacks at any time, and if your team is not structured properly, your job as a project manager will be substantially more difficult.

Lack of Communication

Poor communication is a primary project failure factor that leads to disaster. You have the responsibility of keeping your team informed, fostering transparency, and encouraging team members to express their ideas and concerns as a project manager. When working on a project, sticking to your schedule is critical to your success. Proper communication between leaders and team members keeps everyone up to date on the project's progress and ensures that everyone understands what is expected of them.

If you've had problems with communication in the past, make sure to include a communication plan in your project plan to avoid problems from the start. Find a communication route that works for your team and stakeholders, and keep track of previous communications and mistakes to avoid them in the future. Don't allow your project break apart due to a lack of good communication.

No Management Support

Make sure you have management support and buy-in before you begin your project. Projects that lack managerial backing are unlikely to be approved, and even if they are, they are considerably more likely to fail. Uncertain project goals and a failure to articulate the value it contributes or the problem it addresses for the business are common causes of project failure. It will be tough to have enough cash allotted to your project if you can't describe the value it brings. Furthermore, other existing initiatives that require management assistance may make it more difficult for a certain project to receive the financial support it requires because resources are being allocated to other regions and projects.

Weak Project Closure

Projects aren't supposed to go on indefinitely, and if you don't define a set of parameters for project termination, they'll deplete your resources. When you finish a project, you must agree with your clients that you satisfied the project's important success elements and that the product was produced, tested, and released to their satisfaction. You might even ask your clients to fill out a satisfaction survey in order to gather feedback and help you finish the project.

Make sure you understand what "done" means and set up milestones to keep track of how a project is progressing. This will also keep you informed of any concerns or delays as they arise, as well as whether the project will be completed on time, well ahead of schedule. Another best practice for project closure is to address the project's challenging components as soon as possible. Don't put off tackling a mound of work that may have been completed earlier.

Summary

- Processes are the daily acts that firms take to produce goods and services. A process is a repeatable method of integrating efforts using current systems. In addition, it is part of the line organisation. A project, on the other hand, is distinct from ordinary or process-driven work. Unlike a process, a project has a definite beginning and end. Cost, time, and performance limits are usually set. Projects demand the use of many organisational abilities and talents.
- Project management is the process of planning, scheduling, and controlling a project to achieve its goals. This does not address critical post-project human relations and project evaluation responsibilities. Project management is the practice of efficiently managing project-induced change.
- A programme is a collection of interconnected projects that are mutually dependent. Projects are part of a programme that is coordinated and managed as a whole to get benefits and control that are not possible with individual management.

Notes

- "The application of knowledge, skills, tools, and procedures to project activities in order to achieve project requirements," according to project management. Project managers must not only aim to accomplish particular project scope, schedule, cost, and quality targets, but also to facilitate the entire process in order to meet the requirements and expectations of everyone involved in or affected by project operations, below are the nine knowledge categories.
  a) Project scope management
  b) Project time management
  c) Project cost management
  d) Project quality management
  e) Project human resource management
  f) Project risk management
  g) Project communication management
  h) Project procurement management
  i) Project integration management
- A project's life cycle is a series of discrete periods or stages that work towards achieving a goal. Stages of project development PLC depicts the project management logical framework. It helps us plan our strategy, allocate resources, and evaluate the project's success. The project lifecycle is divided into four stages,
  a) Starting the project
  b) Organising and preparing
  c) Carrying out the project
  d) Closing the project
- The application of information, skills, tools, and procedures to project activities in order to achieve project requirements is referred to as project management.
- A project is a sequence of interconnected actions meant to achieve a specific goal within a given timeframe, budget, and quality level. It involves coordinating group activities while keeping in mind time, cost, and product performance constraints. "Project management" combines the terms "project" with "management."
- Projects are not all alike. Each project is unique in its own way. The following are the distinguishing qualities of a project:
  a) Objectives
  b) Single entity
  c) Life span
  d) Require funds
  e) Life cycle
  f) Team spirit
  g) Risk and Uncertainty

Notes

h) Directions

i) Uniqueness

j) Flexibility

k) Sub-Contracting

l) Cost

- The SDLC is a process that is followed for a software project. It is a detailed strategy that explains how to build, maintain, replace, and change or improve certain software. The life cycle is a mechanism for enhancing software quality and the development process as a whole.
- The most essential and widely used SDLC models in the industry are as follows:

a) Waterfall Model

b) Prototyping or Prototype Model

c) Incremental Model

d) V-Model

e) Spiral Model

f) Agile process Model

- Project management is a crucial aspect of every project. Because project management binds all other project activities and processes together.
- There are several project management activities. There are five main procedures in project management.

a) Project Initiation

b) Project Planning

c) Project Execution

d) Control and Validation

e) Closeout and Evaluation

- One of the most significant inputs to the process is the project management plan, which directs and manages the project activities. Among the other inputs are approved change requests, enterprise environmental factors, and process assets. Execution consumes most of a project's time and resources.
- Project Scope Management refers to the procedures that must be followed to ensure that the project comprises all required work and only required work. Its major function is to define and manage the project's scope. A summary of key project scope management processes:

a) Initiation

b) Scope Planning

c) Scope Definition

d) Scope Verification

e) Scope Change Control

Notes

- In project management, there are a few other terms associated with dependencies.
    a) Blockers: are internal or external barriers to job flow.
    b) Bottlenecks: are structural flaws that restrict the workflow.
    c) Constraints and dependencies: are tightly intertwined in project management. A project constraint is a restriction, limitation, or setback within the current task.
- The techniques required to make the most effective use of the people and physical resources (facilities, equipment, materials, supplies, and so on) involved with a project are referred to as project resource management.
- Human Resource Outsourcing is the practice of hiring a third party to undertake HR functions. Some or all of a company's HR functions may be outsourced to nations like India, China, and the Philippines. Due to rapidly changing market dynamics and global competitive challenges, companies are spending more time on core business. Organizations are fast realising they can't please everyone. Companies today focus on their core competencies and outsource the rest to save time and money. As a result, more companies are outsourcing HR.
- The Five-Stage Team Development Model
    a) Forming
    b) Storming
    c) Norming
    d) Performing
    e) Adjourning
- A basic communication model is an action to acknowledge a message is built into the model. The receiver acknowledges that he or she has received the message, but does not necessarily agree with it. Another activity is a message response, which indicates that the receiver has decoded, comprehended, and is responding to the message.
- There three techniques of communication: Interactive, Push and Pull communication.
- Performance reporting is another essential project communication tool. Performance reporting keeps stakeholders informed about how resources are used to fulfil project goals. It also fosters success reporting.
- Factors for Success and Failures of Project:
    a) Critical Success Factor
        I. Intensive Planning
        II. Strategy
        III. Clear Communication
        IV. Actionable Results
        V. Collaboration

Notes

VI. Plan Together

VII. Act Together

VIII. Track Together

b) Causes of Failure

I. Failure to Plan Effectively

II. Disregarding Risk Management

III. Inadequate Scope Document

IV. Not Selecting the Right People

V. Lack of Communication

VI. No Management Support

VII. Weak Project Closure

Glossary

- PLC: Project Life Cycle
- SDLC: Software Development Product Life Cycle
- CPI: Cost Performance Index
- PMBOK: Project Management Body of Knowledge
- PMI: Project Management Institute
- PMIS: Project Management Information System
- WBS: Work Breakdown Structure
- SRS: Software Requirement Specification
- DDS: Data Distribution Service
- NASA: National Aeronautics and Space Administration
- COTS: Commercial, Off-the-self Software
- XP: Extreme Programming
- IEEE: Institute of Electrical and Electronics Engineers
- DOD: Department of Defence
- SPMP: Software Project Management Plan
- FS: Finish-To-Start
- SF: Start-To-Finish
- SS: Start-to-Start
- FF: Finish-To-Finish
- IPMA: International Project Management Association
- NIH: Not Invented Here
- ARMA: Autoregressive Moving Average

Notes

Check Your Understanding

1. A _ _ _ _ _ _ is a collection of interconnected projects that are mutually dependent.
   a. Project
   b. Model
   c. Programme
   d. None of the above
2. _ _ _ _ _ _refers to the actions through which the executing organisation creates and implements quality policies, objectives, standards, and responsibilities.
   a. Human Resource Management
   b. Risk Management
   c. Communication Management
   d. Quality management
3. As a process of working to attain a certain goal, a project goes through multiple distinct periods or stages, which are referred to as the_ _ _ _ _ _.
   a. Project Life Cycle
   b. SDLC
   c. both a and b
   d. None of the above
4. _ _ _ _ _ _is a detailed strategy that explains how to build, maintain, replace, and change or improve certain software.
   a. Life Cycle
   b. Project Life cycle
   c. SDLC
   d. Project Management
5. A_ _ _ _ _ is a collection of interconnected actions designed to accomplish a certain goal while adhering to a set of deadlines, budgets, and quality standards
   a. Product
   b. Program
   c. PLC
   d. Project
6. A Sequential model is an example of a_ _ _ _ _ _ _
   a. Spiral Model
   b. V-Model
   c. Waterfall model
   d. None of the above
7. The beginning of any project is called ___ _ _ _ _ _ _

Notes

a. Project initiation

b. Project Planning

c. Project Management

d. None of these

8. A sequence of processes called_ _ _ _ _ _ _ determines how to attain a certain community or corporate goal, or a collection of related goals.

a. Project Life Cycle

b. Project Cost

c. Project Planning

d. All of the above

9. The process of formally recognising the existence of a new project or the continuation of an existing project into its next phase is known as_ _ _ _ _ __ _ _

a. Initiation

b. Scope Planning

c. Verification

d. Change Control

10. _ _ _ _ _ _ _is a business practice in which a corporation hires a third party to handle its HR activities.

a. HR Management

b. HR services

c. Human Resource Outsourcing

d. Business Process Outsourcing

Exercise

1 Define basic concepts of project management.

2 Explain the importance of project management.

3 What are the characteristics of project?

4 Define software development product life cycle processes and activities.

5 What is the concept related to SDLC selection criteria?

6 What are the stages of project management?

7 What do you understand by developing project management plan components?

8 What are the tools and techniques for plan scope management?

9 What do you understand by dependency considerations during project management?

10 What are the key concepts of project resource management?

11 What are the trends and emerging practices in project resource management?

12 What do you mean by concept of developing and managing the team?

Notes

13 Explain the concept of communication planning.

14 What do you mean by need of communication requirement analysis?

15 Define different communication models, information distribution.

16 Explain method of performance reporting.

17 What are the factors for success and failure of a project?

Learning Activities

1 What are the recent trends in Project management?

2 Create a SDLC for e-commerce Company?

Check Your Understanding - Answers

1 c

2 d

3 a

4 c

5 d

6 c

7 a

8 c

9 a

10 c

Further Readings and Bibliography:

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3. Strategic Project Management Made Simple: Practical Tools for Leaders and Teams, Terry Schmidt
4. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Harold Kerzner
5. A Down-To-Earth Guide To SDLC Project Management (2nd Edition): Getting your system / software development life cycle project successfully across the line using PMBOK adaptively., Joshua Boyde
6. The Software Development Lifecycle - A Complete Guide, Richard Murch
7. Guide to Software Development: Designing and Managing the Life Cycle, Arthur M. Langer

Module - II: Work Definition

Learning Objectives:

At the end of this module, you will be able to understand:

- Tools and Techniques for Directing and Managing Project Work
- Tools and Techniques for Creating Work Break Down Structure
- Tools and Techniques for Estimating the Activity Durations
- Sequence Activities during Project Management
- Tools and Techniques for Sequence Activities during Project Management
- Gantt Chart, CPM Technique with Example
- Introductory Concept of Project Cost Estimation and Various Techniques of Project Cost Estimation
- Project Cost Management Concepts and Tools
- COCOCMO Cost Estimation Model
- Problem with Cost Estimation
- Introduction to Cost Budgeting
- Preparation of Budget Baseline
- Impact of Budget on Project Progress
- Input and Output to Control Project Cost
- Tools and Techniques to Control Project Cost
- Performance Index of Project Cost Management
- Introduction to Risk Management and Its Categories
- Different Risk Management Models
- Tools and Techniques to Identify Project Risks
- Process of Performing Quantitative Risk Analysis
- Basic Concept of Monitoring and Controlling Risks

Introduction

Accurate time estimation is critical to project management: knowing how long a certain portion of your job will take will allow you to plan and organise yourself much more effectively for the course of your project – which, as we all know, will have a significant impact on its success. While your estimates won't be perfect, utilising the appropriate procedure can help you enhance accuracy, as will having understanding or experience with the type of job you'll be undertaking.

With that in mind, it's a good idea to always be gathering relevant data to assist you get a clear picture of how long a task will take in general — project time tracking is more valuable than simply recording for billing purposes! Regardless of which time

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estimation approach you employ, the data you collect will help you - with time, your estimates will get more and more accurate.

Whether you're in the design, development, engineering, or other professional services industry, one of the most crucial aspects of effective project work is completing projects on time, within scope, and on budget. It necessitates exact forecasting, planning, and progress tracking. Project cost estimate is a method used by project managers to assist with these forecasts.

To correctly plan for tasks and figure out who will complete them, you must first figure out how much the project will cost and whether or not the price tag is within your client's budget. You'll need to know what deliverables your team is accountable for and how to track costs once the project is up and running to perfect this process.

Unfortunately, most organisations fail to accurately estimate the costs of their projects. According to PMI's 2018 Pulse of the Profession study, poor cost estimates cause 28 percent of all projects to fail.

Estimated Costs

Professionals use data from cost estimates to construct a cost budget. A cost estimate forecasts the overall costs of each project stage. Estimates for the following sorts of costs are included in a cost budget:

Direct costs are expenses related to the physical commodities and services used in the manufacturing process. This could comprise materials, production labour, and transportation fuel in a manufacturing company for example.

Indirect costs are expenses incurred as a result of regular business operations. Rent, supervisory salary, and communication services like as internet and phone charges are all included.

Financial professionals can add up indirect and direct costs when preparing a cost estimate for a company or project.

The majority of businesses will have a mix of fixed and variable costs. Fixed costs are a quantity that is known and stays the same for a specific length of time. Rent for example, is a fixed expense because the amount is predictable. A variable cost is one that varies depending on the amount of sales made. The cost of materials utilised in production for example, is changeable. The team will need to purchase more materials as the company produces more things, which will raise the cost. Both fixed and variable costs are included in a cost budget.

A risk is anything that, if it materialises, could have an impact on the project's performance, budget, or timeframe. As a result, risks are possible; a specific incidence could have an impact on the project.

In practice, dangers are frequently linked to issues that must be handled. As a result, risk management is the process of discovering, analysing, and responding to hazards before they become issues.

Despite the fact that project risk management is the same for all projects, it can take many distinct shapes. Risk management must be approached differently for different types and sizes of projects.

Notes

In many large-scale projects, detailed risk management and mitigation measures for when problems develop receive a lot of attention.

A simple prioritised list of high, medium, and low priority risks is sufficient for smaller projects.

2.1 Defining Work Context

The instance from which you enter a network of relationships between instances determines your work context. The design build route of the project to which this instance belongs defines this context.

This project serves as the starting point for resolving instance-to-instance relationships. If a link in the project isn't resolved, the design build path's hierarchy is investigated in an upward direction to find a solution.

Its work context is its definition project if you open or produce an instance from its definition project. When you open or generate a calling instance, however, its work context is the calling instance's context.

2.1.1 Tools and Techniques for Directing and Managing Project Work

Project Management and Direction Execution is the process of carrying out the tasks outlined in the project management plan in order to meet the project's goals. The following are examples of these activities; however, they are not exhaustive:

- Carry out tasks in order to meet the project's needs.
- Make a list of project deliverables.
- The project's team members must be hired, trained, and managed.
- Materials, tools, equipment, and facilities must all be obtained, managed, and used.
- Implement the techniques and standards that have been planned.
- Establish and manage project communication channels for the project team's external and internal audiences.
- To aid forecasting, generate project data such as cost, schedule, technical and quality progress, and status.
- Submit change requests and incorporate accepted modifications into the scope, plans, and environment of the project.
- Manage risks and put risk-reduction measures in place.
- Manage your sales and vendors; and
- Gather and document lessons learned, then put authorised process improvement efforts into action.

The project manager, along with the project management team, leads the execution of the project's scheduled activities and handles the project's many technological and organisational interfaces. The project application area has a direct

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impact on the Direct and Manage Project Execution process. Deliverables are the results of activities that are carried out to complete the project work that is planned and scheduled in the project management plan. As part of project execution, information on the completion status of deliverables and what has been accomplished is collected and fed into the performance reporting process. The information on job performance will also be fed into the Monitoring and Controlling Process Group.

In addition, Direct and Manage Project Execution necessitates the implementation of agreed changes in the following areas:

Corrective action. Documented instructions for carrying out the project work in order to align the project's predicted future performance with the project management plan. Preventive action. A written directive to carry out an activity that can lessen the likelihood of negative project risk implications.

Defect repair. The formally documented discovery of a fault in a project component, together with a suggestion to repair or replace the component entirely.

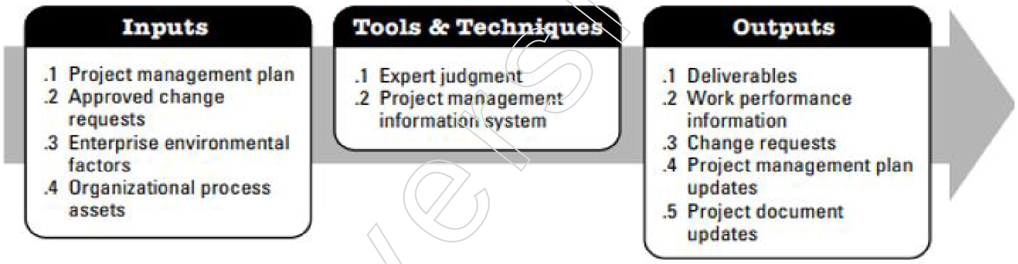

Figure: Shows the inputs, tools and techniques

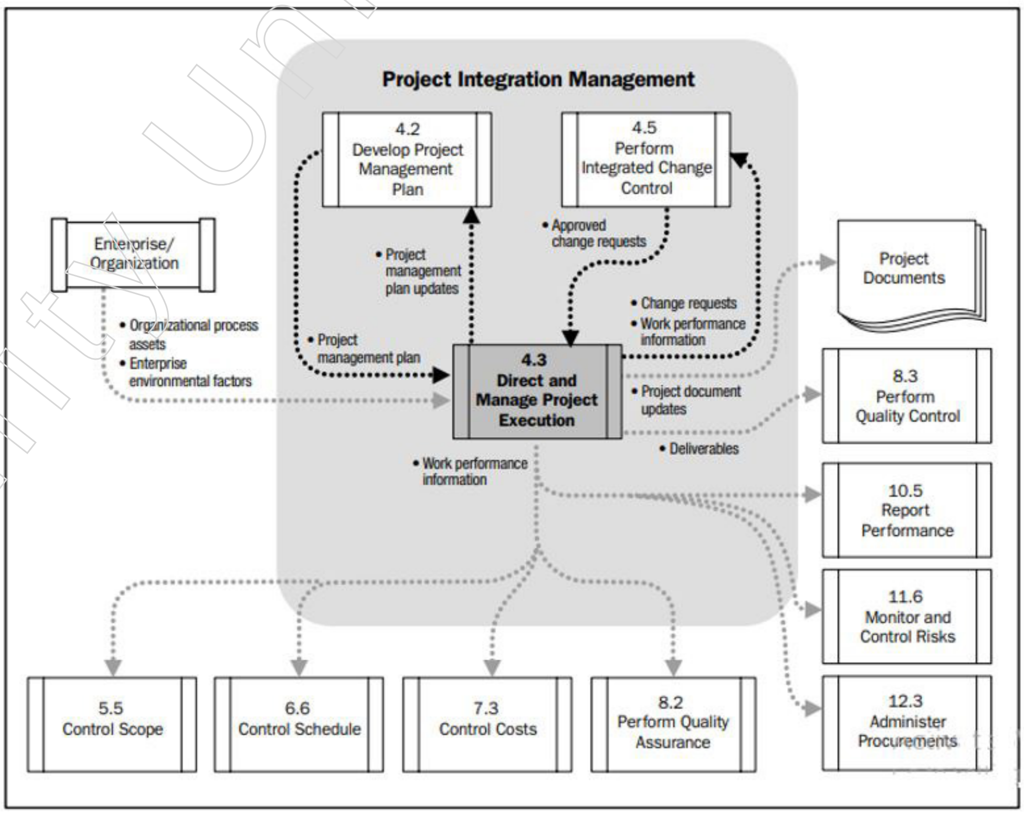

Figure: Outputs for this process and the data flow diagram

Notes

Direct and manage Project execution: Inputs

- Project management Plan

Project Management plan we already discussed in previous chapter.

Approve Change Request

A change control status update, which is part of the Perform Integrated Change Control process, will show which modifications have been accepted and which have not. The project team schedules the implementation of approved modification requests. Approved change requests are requests to expand or reduce the scope of a project that have been documented and approved. Change requests that have been accepted can include change policies, the project management plan, procedures, costs, or budgets, as well as revise schedules. Change requests that have been approved may necessitate the performance of preventive or corrective actions.

- Enterprise Environmental Factors

The following are some of the enterprise environmental aspects that can influence the Direct and Manage Project Execution process:

  - The culture and structure of an organisation, a firm, or a consumer.
  - Infrastructural development (e.g., existing facilities and capital equipment).
  - Administration of personnel (e.g., hiring and firing guidelines, employee performance reviews, and training records).
  - Risk tolerances of stakeholders, as well as.
  - Information systems for project management (e.g., an automated tool suite, such as a scheduling software tool, a configuration management system, an information collection and distribution system or web interfaces to other online automated systems).

- Organisational Process Assets

The following are some of the organisational process assets that can influence the Direct and Manage Project Execution process:

  - Standardised guidelines and work instructions;
  - Communication requirements defining allowed communication media, record retention, and security requirements;
  - Issue and defect management procedures defining issue and defect controls, issue and defect identification and resolution, and action item tracking;
  - Process measurement database used to collect and make available measurement data on processes and products;
  - Project files from previous projects (e.g., scope, budget, and schedule);
  - Process measurement database used to collect and make available measurement data on processes and products;
  - Process measurement database

Notes

Direct and Manage Project Execution: tools and techniques

Expert Judgment

Expert judgement is utilised to evaluate the inputs required to lead and oversee the project management plan's execution. During this procedure, such judgement and knowledge are applied to all technical and management elements. The project manager and the project management team use specialised knowledge or training to deliver this competence. Many sources of more knowledge are available, including:

- Consultants,
- Stakeholders, such as clients or sponsors, and
- Professional and technical associations are examples of other organisational units.

Project Management Information System

The project management information system, which is part of the enterprise environmental factors, gives you access to an automated tool like scheduling software, configuration management, information collection and distribution, or web interfaces to other online automated systems that you can use during the Direct and Manage Project Execution effort.

Direct and Manage Project Execution: outputs

Deliverables

Any unique and verifiable product, result, or capability to execute a service that must be generated to fulfil a process, phase, or project is an approved deliverable.

Work Performance Information

As the project continues, data from project activities is routinely collected. This data can be linked to a variety of performance outcomes, including but not limited to:

- eliverable status,
- Schedule progress, and
- Costs incurred.

Change Requests

When problems are discovered throughout the course of a project's work, change requests are submitted, which may include changes to project regulations or procedures, project scope, project cost or budget, project timetable, or project quality. Other requests for changes involve necessary preventive or corrective activities to avoid undesirable consequences later in the project. Change requests can be direct or indirect, launched externally or within, discretionary or legally/contractually mandated, and can include:

- Corrective action. Documented instructions for carrying out the project work in order to align the project's predicted future performance with the project management plan.

- Preventive action. A written directive to carry out an activity that can lessen the likelihood of negative project risk implications.
- Defect repair. The formally documented discovery of a fault in a project component, together with a suggestion to repair or replace the component entirely.
- Updates. Modifications to professionally controlled documents, plans, and other materials to reflect new or revised concepts or content.

Project management plan updates

The following are examples of project management plan elements that could be updated:

- Requirements management plan,
- Schedule management plan,
- Cost management plan,
- Quality management plan,
- Human resource plan,
- Communications management plan,
- Risk management plan,
- Procurement management plan, and
- Project baselines.

Project document updates

Updates to project documents may include, but are not limited to:

- Requirements documents,
- Project logs (issue, assumptions, etc.),
- Risk register, and
- Stakeholder register.

2.1.2 Tools and Techniques for Creating Work Break Down Structure

The next stage in project scope management is to design a work breakdown structure after gathering requirements and defining scope. A work breakdown structure (WBS) is a deliverable-oriented grouping of work that specifies the complete scope of a project. Because most projects involve a large number of people and a variety of deliverables, it's critical to arrange and split the work into logical sections based on how it'll be done. Because it provides the groundwork for planning and controlling project schedules, budgets, resources, and changes, the WBS is a foundation document in project management. Some project management professionals feel that work should not be done on a project if it is not included in the WBS because the WBS specifies the complete scope of the project. As a result, creating a comprehensive WBS is critical.

Subdividing project deliverables and project activity into smaller, more manageable components is the process of creating WBS. The work breakdown structure (WBS) is a deliverable-oriented hierarchical decomposition of the work to be carried out by

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the project team in order to achieve the project objectives and produce the required deliverables, with each descending level of the WBS representing a more detailed definition of the project work. The Tasks Breakdown Structure (WBS) organises and specifies the project's overall scope, as well as the work stated in the current authorised project scope statement.

The work packages, which are the lowest level WBS components, contain the planned work. A work package can be planned, budgeted, tracked, and controlled. Work refers to work items or deliverables that are the outcome of effort, not the effort itself, in the context of the WBS.

The major inputs for building a WBS are the project management plan, project papers, enterprise environmental factors, and organisational process assets. Decomposition—that is, breaking down project deliverables into smaller pieces—is the major instrument or approach, in addition to expert opinion. The scope baseline and project document updates are the outcomes of the WBS creation process. The scope baseline contains the authorised project scope statement, as well as the WBS and WBS glossary that go with it.

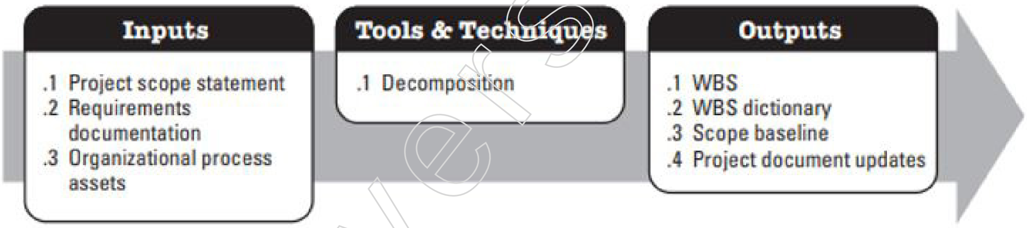

Figure: Create WBS: Inputs, Tools & Techniques, and Outputs

Create WBS: Inputs

- Project Scope Statement
- Requirements Documentation
- Organizational Process Assets

The following are examples of organisational process assets that can influence the Create WBS process:

- ○ Policies, procedures, and templates for the WBS,
- ○ Project files from previous projects, and
- ○ Lessons learned from previous projects.

Create WBS: Tools and Techniques

Decomposition

Decomposition is the process of breaking down project deliverables into smaller, more manageable pieces until the work and deliverables are defined down to the work package level. The work package level is the lowest level in the WBS, and it is at this level that the job's cost and activity durations may be accurately anticipated and managed. The level of information for work packages will vary depending on the project's size and complexity.

Notes

The following activities are typically included in the decomposition of the whole project work into work packages:

- Identifying and evaluating deliverables and associated work.
- Organizing and structuring the WBS.
- Taking the highest WBS levels and breaking them down into smaller, more detailed components.
- Creating and assigning WBS component identification codes, as well as
- Ensure that the work's degree of decomposition is both essential and sufficient.

The WBS structure can take a variety of forms, including:

- The first level of decomposition is the project life cycle phases, with the product and project deliverables introduced at the second level.
- The first level of deconstruction is using primary deliverables.
- Using subprojects, such as contractual work, that are generated by entities outside the project team. As part of the contracted job, the seller creates the supporting contract work breakdown structure.

The work for each of the deliverables or subprojects must be subdivided into its core components for decomposition of the upper level WBS components, where the WBS components represent verifiable products, services, or outcomes. An outline, an organisational chart, a fishbone diagram, or another method can be used to structure the WBS.

Verifying the decomposition's correctness necessitates establishing which lower-level WBS components are required and adequate for the accomplishment of the related higher-level deliverables. Different levels of breakdown can be found in different deliverables. Some deliverables merely need to be decomposed to the next level, while others require extra degrees of decomposition to get at a work package.

The ability to plan, manage, and control the task improves as the work is decomposed to higher degrees of detail. Excessive decomposition, on the other hand, can result in ineffective management, wasteful resource usage, and lower labour productivity.

For a deliverable or subproject that will be completed in the future, decomposition may not be viable. To construct the details of the WBS, the project management team normally waits until the deliverable or subproject is clarified. Rolling wave planning is a term used to describe this process.

All product and project work, including project management, is represented in the WBS. So that nothing is left out and no excess work is accomplished, the total of the work at the lower levels must roll up to the upper levels. This is commonly referred to as the "100% rule."

The PMI Practice Standard for Work Breakdown Structures - Second Edition offers advice on how to create, develop, and use work breakdown structures. This standard includes industry-specific WBS templates that can be customised for unique projects in a certain application area.

Notes

Create WBS: Outputs

WBS

The WBS is a deliverable-oriented hierarchical decomposition of the project team's work to achieve project objectives and provide needed deliverables, with each descending level of the WBS indicating a more precise specification of the project work. The WBS is completed by creating work package control accounts and a unique identification from a code of accounts. These identifiers give a system for summarising prices, schedules, and resources in a hierarchical manner. A control account is a management control point where the scope, cost, and schedule are all combined and compared to the earned value to determine performance. In the WBS, control accounts are assigned to certain management points. Each control account can have one or more work packages, but each work package must have only one control account connected with it.

WBS Dictionary

The WBS dictionary is a document that supports the WBS and is generated by the Create WBS process. The WBS glossary goes into greater depth about the WBS's components, such as work packages and control accounts. The WBS dictionary contains, but is not limited to, the following information:

- Code of account identifier,
- Description of work,
- Responsible organization,
- List of schedule milestones,
- Associated schedule activities,
- Resources required,
- Cost estimates,
- Quality requirements,
- Acceptance criteria,
- Technical references, and
- Contract information.

Scope Baseline

A component of the project management strategy is the scope baseline. The scope baseline includes the following elements:

- Project scope statement. The product scope statement, as well as the project deliverables and product user acceptance criteria, are all included in the project scope statement.
- WBS. Each deliverable is defined in the WBS, as is the decomposition of the deliverables into work packages.
- WBS dictionary: Each WBS element provides a full explanation of work as well as technical data in the WBS dictionary.

Notes

Project Document Updates

Updates to project documents include, but are not limited to, requirements documentation. If the Create WBS procedure yields approved change requests, the requirements documentation may need to be modified to reflect the approved modifications.

2.1.3 Activities during Project Management

You may believe that after planning scope management, every project work has been outlined in sufficient depth, but schedule management typically necessitates a more detailed description of operations. Defining activities entails specifying the precise actions that will result in the project deliverables in sufficient detail to estimate resource and schedule requirements. To begin identifying activities, the project team evaluates the project management plan, enterprise environmental variables, and organisational process assets. An activity list, activity attributes, a milestone list, modification requests, and project management plan changes are all examples of outputs from this procedure.

The activity list is a list of tasks that should be included in the project schedule. The name of the activity, an activity identification or number, and a brief description of the activity should all be included in the list. The activity attributes offer information about each activity's schedule, including predecessors, successors, logical linkages, leads and lags, resource requirements, limits, enforced dates, and assumptions. The WBS and WBS dictionary should match the activity list and activity attributes. As new information becomes available, it is added to the activity attributes; this information includes logical links and resource requirements that are established later in the process. To keep track of activity-related information, many project teams employ an automated system.

On a project, a milestone is a noteworthy occurrence that usually has no duration. A milestone is often the result of multiple activities and a great deal of effort, but the milestone itself serves as a guide to assist identify the tasks that must be completed. Milestones can also be used to create goals for the future and track progress. Completion and customer sign-off documents, such as design documents and test plans; completion of specific products, such as software modules or the installation of new hardware; and completion of important process-related work, such as project review meetings and tests, are examples of milestones on a project like the one in the chapter's opening case. Not every project product or outcome qualifies as a milestone. Milestones are the most significant and conspicuous events in a person's life. In the context of child development for example, parents and doctors look for milestones such as a child rolling over, sitting, crawling, walking, and talking for the first time.

Project initiation, project planning, project execution, and project closing are all part of the standard project cycle.

The project start-up is often referred to as project initiation. It is the most crucial step of project task planning. The problems or case studies are defined and analysed in this step. After that, a project proposal is presented for consideration. If higher management or the responsible party decides to set up a project to address the problems or test the solutions after conducting a feasibility study, project activities will begin. In this instance, an official project manager will be hired.

Notes

The party who raises or is familiar with the field difficulties and obstacles usually draughts the project initiative. This person is usually assigned to the project as the project manager or is heavily involved in the project management. In most cases, the project initiative will be amended and finalised as a project plan for documentation.

The project outline will be agreed upon by all stakeholders concerned at the end of the first phase. The project manager begins the process of assembling his team. After that, there will be a full planning step.

- reason for the project
- desired benefits
- objectives
- scope
- potential constraints
- known risks if any
- stakeholders
- deliverables
- estimated time
- estimated resources

The project organisation must be clarified before the daily project work can begin. It is necessary to document the responsibilities and accountabilities. The management is the responsibility of the project manager. However, issues like as who he should report to and whether or not a project assurance body is required must be addressed. The project sponsor, project board, project manager, and project team are all part of a typical project organisation. The project assurance body, such as a quality manager or quality auditor, may be added to the project organisation depending on the project's complexity.

A project's owner is known as the project sponsor. He is the one who is paying for the project and can be considered the customer. The following are some of its most important functions:

- "Lead and direct the other members of the Project Board as well as the Project Manager."
- Ascertain...that the necessary cash and other resources are accessible when needed.
- presiding over Project Board meetings"

The project board should include the project sponsor, the project's senior user, and the project's senior supplier.

It performs the following functions:

- "Determine the project's direction and approve critical milestones."
- make decisions as needed during the project's life cycle
- grant the Project Manager day-to-day project management authority"

Project Assurance is required to "evaluate the project's state and thereby acquire assurance that it is appropriately organised, planned, and controlled."

Notes

Project Planning is the stage at which specific plans are made. The project manager must complete the tasks of finding the suitable individuals, laying out the activities, and determining the timeline. A financial plan as well as resource allocation must be specified.

- Each team member's accountability, duties, and tasks should be defined.
- Create a list of deliverables, activities, and deadlines.
- Make a detailed resource plan.
- Make a detailed schedule.
- Determine the risks and constraints.
- Plan for monitoring and reporting a strategy for communicating
- Plan for documentation

The Project Action Plan is one tool that offers project planning a framework and assists you with it.

Project Execution The third stage of a project's lifespan. The major goal at this point is to put the planned activities into action in order to meet the deliverables within the time and resource constraints.

However, no matter how meticulously the project has been planned, it may follow a different path in practice. This does not imply that the project has failed. Controlling changes and adjusting the project plan properly is one of the most difficult responsibilities for the project manager at this point.

Project Closure The term "project completion" refers to the formal completion of a project. The deliverables will be given to the stakeholders at this point. The set objectives will be met by a successful project. In most cases, in addition to the project report to stakeholders, a project review report will be written for the project's documentation and evaluation. A lessons-learned workshop could be organised so that the project's experiences can be shared with all stakeholders.

The project manager is continually faced with the difficulty of balancing scope1, cost, and time during the project management process, which is known as the project triangle (see figure 3). Greater scope often indicates increased time and cost, a tight time constraint could imply increased costs and reduced scope, and a tight budget could mean increased time and reduced scope. If the project must be completed quickly and well, the cost will rise; conversely, if the project must be completed quickly and cheaply, the quality or scope will suffer. In project management, this idea is sometimes known as "choose any two."

2.2 Time Estimation Method

Successful project management requires a thorough understanding of time estimation. You can ensure that your estimates are accurate and hence of higher value to you and your team by using the correct method. Time estimation is the art of accurately 'guessing' how long a piece of work will take to complete. Using time estimation techniques can help you reduce the amount of guesswork in your estimates, giving you more confidence in your time management and the time frame in which your

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work can be completed. So, let's have a look at how to estimate project hours utilising a variety of ways.

2.2.1 Tools and Techniques for Estimating the Activity Durations

Project managers, sponsors, clients, end users, and even the project team are all asking themselves the same question: how long will this take? You must first determine the duration of each activity on the activity list before you can correctly answer that question. Estimating activity durations necessitates some knowledge of the type of work the project team will undertake. Determining the activity length will be practically impossible if you or the project team have never done the specific type of work required in the current project. Expert judgement, such as that of consultants and industry associations, can aid in the estimation, but the truth is that you won't know how long a task will take until it is completed.

Estimates of activity duration assist the project manager in determining when the project team and other resources will be required. The duration of an activity will assist the project manager in creating the plan and sequence of activities, identifying bottlenecks in the project schedule, managing risks, and many other tasks. It requires time and patience to forecast when an activity will be completed. This is a procedure that you and the project team will most likely go through several times during the project. The project team and project manager will be able to more precisely define the activities and their length as more information becomes available. The project manager does not need to rush through the estimate process, and the entire project team should be involved.

The next step in project schedule management is to estimate the time of activities after working with key stakeholders to define activities and determine their dependencies. It's vital to remember that duration comprises both the amount of time spent working on an activity and the length of time that has passed. Even though the actual task may take one workweek or five workdays, the duration estimate may be two weeks to account for extra time required to collect outside information. The number of persons or resources given to a task has an impact on the estimated work duration. For instance, if someone asked you when you plan to finish reading a certain book, you might say two months. Even if you only plan to spend 20 hours reading the book, two months is a reasonable estimate.

Do not mix length with effort, which refers to the number of workdays or hours needed to finish a task. (In software like Microsoft Project 2016, the duration is usually placed in the Duration column, whereas the effort is usually entered in the Work column. If numerous persons are working on a task that day, a day's duration estimate could be based on eight hours of labour or 80 hours of work. The term "duration" refers to a time estimate on a calendar, not an estimate of effort. In the previous example, you might aim to read a book for 20 hours (the effort estimate) over the course of two months (the length estimate).

Due to the fact that time and effort are linked, project team members must document their assumptions while estimating duration. Because their performance will be judged based on their ability to fulfil the estimates, the individuals who will actually do the task should have a lot of influence in duration estimations. It's also a good idea to look at similar projects and get expert guidance when determining activity durations.

Notes

As the project proceeds, members of the project team must update the estimations. If the project's scope changes, the duration estimates should be revised to reflect the new information.

The project management plan, project papers, enterprise environmental factors, and organisational process assets are all used to estimate activity duration. In addition to analysing previous project information, the team should double-check the accuracy of the project's current duration estimations. For example, if team members discover that all of their estimations were far too long or short, they should revise them to reflect their new knowledge.

The availability of resources, particularly human resources, is one of the most significant factors to consider when estimating activity length. What special talents are required for the job? What are the people assigned to the project's skill levels? At any given time, how many workers are expected to be available to work on the project?

The estimates themselves, the basis of estimates, and project document revisions are all examples of activity duration estimates outputs. Estimates of duration are frequently given as a single figure, such as four weeks; a range, such as three to five weeks; or a three-point estimate. A three-point estimate contains an optimistic, most likely, and pessimistic scenario, with the optimistic scenario taking three weeks, the most likely scenario four weeks, and the gloomy situation five weeks. The optimistic estimate considers the best-case situation, whereas the pessimistic estimate considers the worst-case scenario. As you may assume, the most likely estimate is based on a most likely or predicted situation. For performing PERT estimates, as explained later in this chapter, and Monte Carlo simulations, a three-point estimate is necessary.

Estimate Activity Durations – Tools and Techniques

The methods and approaches for estimating activities that work for all sorts of projects are listed below.

Expert Judgment

It is the most popular way for obtaining an estimate; therefore, it is critical for the Project Management team to have professionals with the most hands-on knowledge in utilising project requirements. It's also critical to make sure that everyone understands what has to be provided. Look for professionals who will be involved in the project as well.

Analogous Estimation

It is a way that allows a Project Management team to refer to similar and existing projects in order to analyse the present project's activity durations. A project manager can use an analogous estimation method to estimate the time it will take to complete the project. Ascertain that the prior efforts similar to the current task were successful. When only limited information regarding the project is available, a comparable method of estimating can be employed.

PERT Method

It's an example that might be statistically examined to assess the ERP project's execution and determine the project's duration. This strategy, however, may not

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provide an accurate prediction. When a few facts don't allow for a specific analysis, this strategy employs an expert's knowledge and experience to convey an essential date. The capacity to validate the estimated project length period in terms of its likelihood of meeting organised value justifies project managers' widespread use of the PERT technique. The method is simple to implement and can be beneficial in the case of complex projects. Its flaw, however, is that any precision of the strategy's parameters expectation will be dependent on the correctness of the assumptions made about single individual jobs run-time.

Three-Point Estimates

The PERT (Program Evaluation and Review Technique) is the most widely used statistical tool for determining the duration of a project under the three-point estimation procedures. The PERT technique is the most effective way to estimate a project's projected activity durations in project management. It calculates an approximate timeframe for the predicted activity durations using three-time estimates.

Parametric Estimating

Parametric estimating, like analogue estimation, analyses the estimated time of a project using historical data and a variety of characteristics. Actual links between recorded data and variables are also used in parametric estimation. It is more precise than a similar method.

Alternative Analysis

It lets you to experiment with multiple ways to resource allocation by altering the number of resources and selecting the best one.

Published Estimating Data

This is a method for estimating activity resources. Articles, books, journals, and publications from various firms that have presented knowledge on similar initiatives are included in this strategy. The Project Managers can make an approximate estimate of how many assets they'll need for the project using the published estimating data.

Vendor Bid Analysis

When a project team is assigned to work on a project with external vendors or contractors to fulfil project activities, they employ this technique. This method aids project managers in determining the project cost based on vendor proposals and estimating the value of deliverables.

The precision of the length of the entire project activities is critical to the stability of the scheduled activities. The reasons why estimation procedures such as estimating, parametric assessing, and three-point estimating are comparable are extremely important.

Benefits of Estimating Activity Durations in Project Management

The work's output is seen as essential. Employees with greater experience can afford to be more productive than those with less experience. Employees with irrelevant talents produce less, which reduces the project's productivity and decision-making process.

The benefits of estimating activity durations in project management are as follows:

- It specifies how long each task will take to complete, which is an important factor in developing the scheduling process.
- It specifies the amount of time that each action will take to finish.
- To come up with a reasonable estimate for each work included in the project lifecycle, inputs such as the schedule management plan, activity list, activity attributes, resource calendars, project scope statement, risk register, and resource breakdown structure are required.
- Project managers can use Estimate Activity Durations in Project Management to establish accurate and precise estimates of project activities.
- The procedure of estimating Activity Duration will ensure that everything runs smoothly.

How to Calculate Estimate Activity Durations?

The three most important estimations for a project are effort, duration, and cost. Once you have the criteria, calculating the project's projected activity length is a simple task.

To estimate the overall time required for your project, follow the steps below:

- Examine previous projects that are similar to the one the team is now working on.
- Contact the experts with the most hands-on experience and knowledge of the project's requirements.
- In Project Management, techniques such as Work Breakdown Structure and analogies can be used to predict activity durations.
- Determine how precise you want your estimate to be. If the project must be detailed, the time frame will likely grow, and you will need to devote a significant amount of effort to fully comprehend the procedure.
- Include hours for contingencies. This is used to reflect any risk or uncertainty that may be present in the estimate.

2.2.2 Sequence Activities during Project Management

The next phase in project schedule management is to sequence or determine the dependencies between project tasks after they have been defined. The project management plan, project papers (such as the activity characteristics activity list, assumption log, and milestone list), enterprise environmental factors, and organisational process assets are all inputs to the activity sequencing process. The sequencing process include assessing the causes of dependencies as well as the various types of dependencies.

The project team can sequence the tasks in the order in which they should be completed once the activity list has been generated. The network diagram, also known as a project network diagram (PND), depicts the flow of activities necessary to finish a

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project or a project phase. It decides which activities can be scheduled sequentially vs in tandem by identifying the sequencing of activities mentioned in the WBS.

The approach of differentiating and authenticating affiliates in the midst of project activities and sequencing activities exemplifies continuous work planning to maximise project restrictions' efficacy. The execution plan is used throughout the project to improve performance.

The activities in the sequence are organised into Project Management process groups and knowledge areas. The project schedule development defines sequence activities, estimates activity resources, and estimates activity durations utilising the findings from the procedures in conjunction with the scheduling tool to build the schedule model. The schedule management plan defines the task's scheduling method and device, as well as how the activities will be arranged.

Sequencing can be done using Project Management software, as well as manual or automated techniques. The sequence activities method focuses on turning project activities from a list to a graphic, which serves as a pre-requisite for publishing the schedule baseline.

Process of Sequence Activities in Project Management

The practice of finding and documenting linkages between project tasks is known as sequence activities. As a result, the primary goal of the sequence activities process is to complete the project scope and meet the task objectives by finishing the interdependence of activities.

A Network Diagram is a significant outcome of the sequence activities process. The activities in a project's network diagram are represented in boxes with activity IDs, and the interconnectedness of activities is shown with bolts.

Except for the first and last, each activity should have at least one predecessor and at least one successor activity with a logical relationship between them. By establishing logical relationships, a realistic project timeline can be created. To help create a reasonable and achievable project plan, it may be necessary to use lead or lag time between activities. Sequencing can be done with project management software, manual techniques, or computerised procedures. As an early stage in distributing the schedule baseline, the sequence activities method focuses on transforming the project activities from a list to a graphic.

Why is it Important to Determine Activity Sequencing on Projects?

On projects, it's critical to concentrate on planning and identifying activity sequencing. Otherwise, you'll find yourself depleting your resources on the first activities only to discover that bigger and more important activities have taken their place, rendering them obsolete.

If you don't sequence actions, you won't be able to determine the toughest method for a project. Project network diagrams are similar to a number of other diagrams. For example, in transportation modelling, you aim to identify the quickest route between two places. You just need to take one way, as shown in the illustrations. All activities in a project network diagram must be done in order for the project to be completed.

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Leads and Lags in Sequence Activities

Sequencing Project Activities requires the use of leads and lags.

It is important to Finish-to-Start type support, which is the most basic connection between activities, that successor activity can begin early. A Lead permits follow-up work to begin as soon as possible.

Lag, which is related to Start-to-Start and is a type of dependence relationship between exercises, causes successor action to be postponed. For example, suppose you decide to postpone the purchase of building supplies until three days after the plan's designs are completed. Three days of spare time appears to be the starting point.

2.2.3 Tools and Techniques for Sequence Activities during Project Management

Sequence The process of finding and recording linkages between project activities is known as activities. Logic linkages are used to order the activities. Except for the first and last, every activity and milestone has at least one predecessor and successor. To ensure a realistic and achievable project schedule, it may be required to use lead or lag time between activities.

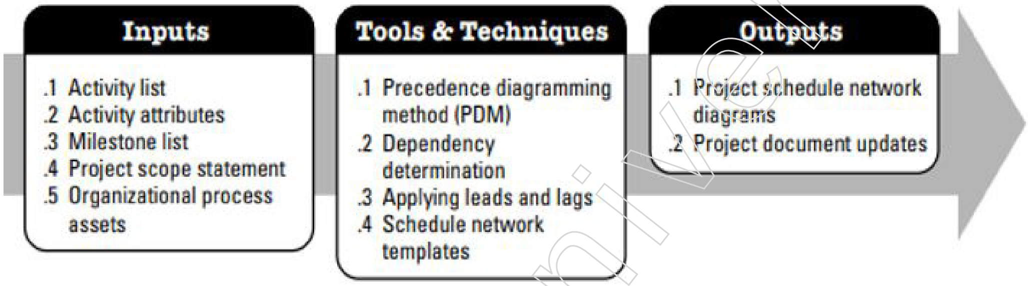

Figure: Sequence Activities: inputs, Tools & Techniques, and outputs

Dependencies

The sequence of project activities or tasks is referred to as a dependency or relationship. Is it necessary for example, to complete one activity before beginning another? Is it possible for the project team to work on multiple tasks at the same time? Is it possible for some to overlap? For the development and management of a project schedule, determining these linkages or dependencies among activities is critical.

Among project activities, there are numerous sorts of dependencies:

- he nature of the work being done on a project necessitates the existence of mandatory dependencies. Hard logic is a term used to describe them. You can't test code until it's been written for example.
- The project team defines discretionary dependencies. For example, a project team might follow best practices by deferring full design of a new information system until all of the analysis work has been approved by the users. Soft logic is another term for discretionary dependencies, which should be utilised with caution because they can constrain later scheduling options.

Notes

- Relationships between project and non-project activity are examples of external dependencies. For example, the supply of new hardware from an external source may be required for the installation of a new operating system and other software. Even if the supply of the hardware is not part of the project's scope, you should include it as an external requirement because late delivery will harm the project's timetable.
- Internal dependencies are connections between project activities that are normally under the authority of the project team. If a team develops software for example, they can construct dependencies such as unit testing before system testing.

It's worth noting that dependencies can be internal and required, external and optional, and so forth. It's critical that project stakeholders collaborate to establish the activity dependencies in their project, just as they did with activity definition. If you don't establish the sequence of activities, you won't be able to employ network diagrams or critical path analysis, two of the most effective scheduling tools accessible to project managers.

Network Diagrams

For depicting activity sequencing, network diagrams are the best method. A network diagram is a schematic representation of the logical links and sequencing of project operations. Network diagrams are often known as project schedule network diagrams or PERT charts.

On this network diagram, take note of the most important elements. The letters A through J denote activities with dependencies that must be completed in order for the project to be completed. These activities are the result of the previously stated WBS and activity definition process. The arrows indicate the order in which activities are completed or the links between tasks. Activity A for example, must be completed before Activity D, and Activity D must be completed before Activity H.

This network diagram follows the activity-on-arrow (AOA) or arrow diagramming method (ADM) format, which is a network diagramming methodology in which activities are represented by arrows and joined at nodes to show the sequence of events. A node is just the location where an activity begins and ends. The initial node denotes the beginning of a project, while the last node represents its completion.

Keep in mind that the network diagram depicts the actions that must be completed in order for the project to be completed. The journey from the first to the last node is not a race. To complete the project, each activity on the network diagram must be accomplished. It's also worth noting that not every item on the WBS must be represented on the network diagram; only activities with dependencies must be included. Some people, on the other hand, prefer to have start and end dates as well as a detailed description of all activities. It's a personal preference. It may be easier to put only activities with dependencies on a network diagram for large projects with hundreds of activities. Putting summary tasks on a network diagram or breaking down the project into multiple smaller network diagrams can sometimes suffice.

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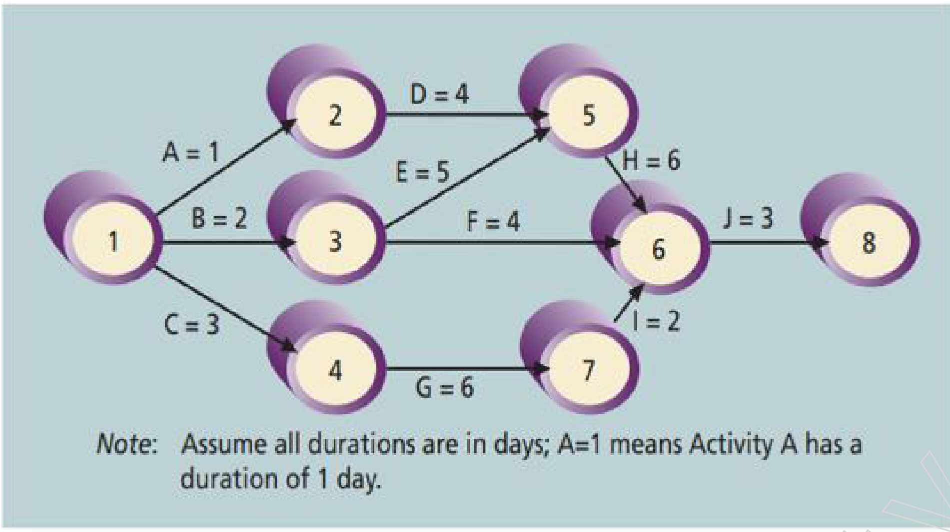

Figure: Network diagram for project X

Following these steps to generate an AOA network diagram, assuming you have a list of project activities and associated start and finish nodes:

- All of the activities that begin at Node 1 can be found here. Draw arrows between Node 1 and each of the finish nodes, as well as between Node 1 and each of the finish nodes. Put the letter or name of the activity on the arrow that corresponds to it. If you know how long the activity will take, write it next to the letter or name of the activity, as illustrated in Figure 6-2. A 5 1 indicates that Activity A will last one day, one week, or another standard unit of time. Make sure that all of the arrows have arrowheads to indicate the direction of the relationships.
- Working from left to right, continue sketching the network diagram. Keep an eye out for explosions and mergers. When two or more activities follow a single node, bursts occur. When two or more nodes come before a single node, it's called a merging. Node 1 in Figure 6-2 for example, is a burst since it connects to Nodes 2, 3, and 4. Node 5 is the result of a merger between Nodes 2 and 3.
- Continue building the AOA network diagram until you've incorporated all of the activities.
- On an AOA network diagram, all arrowheads should point to the right, and no arrows should cross. To make the diagram look decent, you may need to redraw it.

Despite the fact that AOA or ADM network diagrams are relatively simple to comprehend and produce, a different method is more typically used: precedence diagramming.

The precedence diagramming method (PDM) is an activity-based network diagramming approach. It's very handy for visualising certain time correlations.

Based on a Microsoft Project help screen, the figure below depicts the various sorts of interdependence that might exist among project activities. After you've figured out why there's a dependency between activities (required, discretionary, or external), you'll need to figure out what kind of dependency it is. It's worth noting that the terms activity and task, as well as relationship and reliance, are interchangeable. The following are the four types of interactivity dependencies or relationships:

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Task dependencies

The nature of the relationship between two linked tasks. You link tasks by defining a dependency between their finish and start dates. For example, the "Contact caterers" task must finish before the start of the "Determine menus" task. There are four kinds of task dependencies in Microsoft Project.

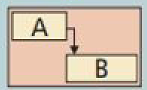
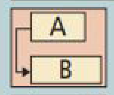
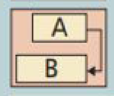
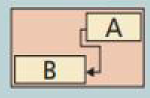
Task dependency	Example	Description
Finish-to-start (FS)		Task (B) cannot start until task (A) finishes.
Start-to-start (SS)		Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)		Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)		Task (B) cannot finish until task (A) starts.

Figure: Task dependency types

1. Finish-to-start dependency: A relationship in which the "from" or predecessor activity must be completed before the "to" or successor activity may begin. You can't provide user training until software or a new system has been installed for example. The most frequent sort of relationship or dependency is finish-to-start, and AOA network diagrams only employ finish-to-start relationships.

2. Start-to-start dependency: A relationship in which the "from" action cannot begin until the "to" or successor activity has begun. On IT projects for example, a number of activities may begin at the same time, such as the several tasks that occur when a new system goes live.

3. Finish-to-finish dependency: In a relationship, the "from" activity must be completed before the "to" activity may be completed. One task cannot be completed before the other. Quality control for example, cannot be completed before manufacturing, despite the fact that the two operations can be completed concurrently.

4. Start-to-finish dependency: In this relationship, the "from" activity must begin before the "to" activity may be completed. Although this form of partnership is uncommon, it is appropriate in specific circumstances. For example, a company may seek to have raw materials on hand just when the manufacturing process begins. The stocking of raw materials should be delayed if the production process is delayed. Another example is a babysitter who needs to complete monitoring a little child but is awaiting the arrival of the parents. Before the babysitter can complete the work, the parent must appear or "start."

The precedence diagramming method is more commonly used than AOA network diagrams, and it has several advantages over AOA. To begin, the majority of project management software employs the precedence diagramming technique. Second, this strategy eliminates the usage of dummy activities. Dummy activities are activities with no duration or resources that are used in AOA network diagrams to highlight logical relationships between activities. These actions are depicted with dashed arrow lines and duration estimates of zeros. Third, whereas AOA network diagrams employ only finish-to-start relationships, the precedence diagramming method illustrates different dependencies across activities.

2.2.4 Gantt Chart, CPM Technique with Example

Gantt chart is a graphic representation of schedule-related data. Schedule activities or work breakdown structure components are listed down the left side of the chart, dates are indicated across the top, and activity durations are displayed as date-placed horizontal bars in a standard bar chart.

The most common methods for communicating project schedule status are Gantt charts (bar charts) and control charts. The Gantt chart, is the most popular, widely used, and easily understood. A tracking Gantt chart is a typical name for this type of chart. The use of Gantt and control charts to track and trend schedule performance is a good idea. Their simple visual representations make them popular tools for communicating project schedule status, particularly to upper management, who rarely have time for specifics. Adding actual and revised time estimates to the Gantt chart provides a rapid snapshot of project status as of the report deadline.

By listing project activities and their accompanying start and finish dates in calendar form, Gantt charts provide a consistent method for showing project schedule information. Because the start and finish dates of the activities are depicted as horizontal bars, Gantt charts are sometimes referred to as bar charts.

The deliverables on the WBS drive the activities on the Gantt chart, which should correspond to the activity list and milestone list. There are milestones, summary tasks, specific task durations, and arrows demonstrating task dependencies on the Gantt chart for the software launch project.

On the Gantt chart for the software launch project, take note of the various symbols (see below figure)

Figure: Gantt chart for project X

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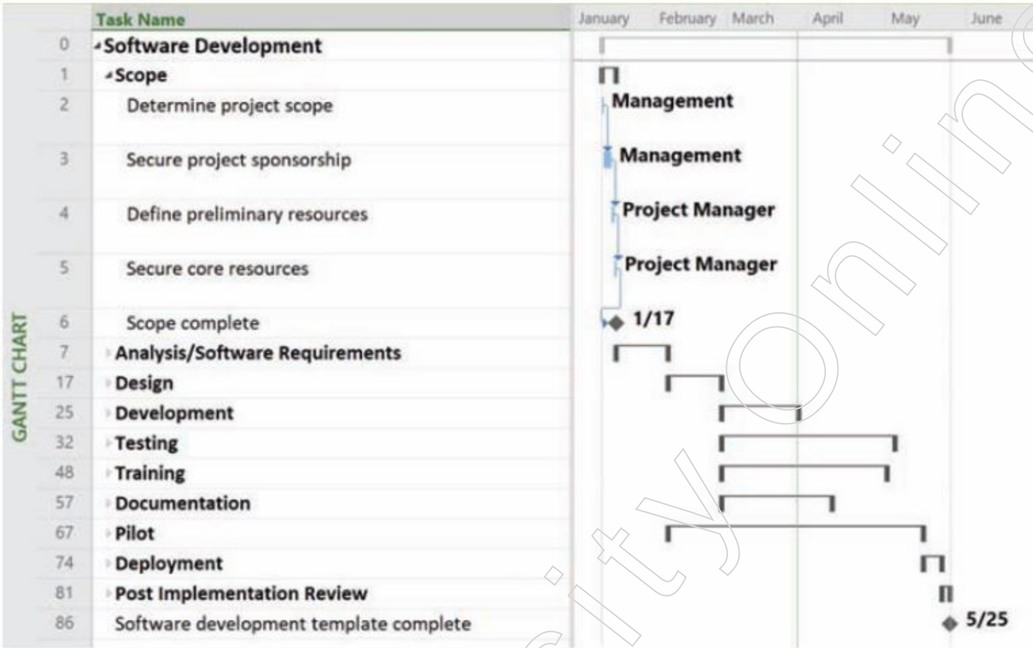

Figure: Gantt chart for software launch project

- The black diamond is a symbol of achievement. Task 6, “Scope complete,” is a January 17 milestone in the diagram above. Top managers may choose to see only milestones on a Gantt chart for very large projects. Microsoft Project allows you to filter the information presented on a Gantt chart so that specific tasks, such as milestones, may be easily displayed.
- Summary tasks are represented by the thick black bars with rectangles at the beginning and end. The actions indicated in rows 2-5 for example, are all subtasks of Task 1’s summary task, “Scope.” In most project management software, WBS activities are referred to as tasks and subtasks.
- Tasks 2, 3, 4, and 5 have light blue horizontal bars that reflect the duration of each activity.
- Relationships or dependencies between tasks are shown by arrows linking these symbols. Gantt charts frequently fail to indicate dependencies, which is one of its fundamental flaws. Dependencies are automatically displayed on the Gantt chart if they have been set in Microsoft Project.

Adding Milestones to Gantt Charts

Milestones, especially for major projects, can be critical components of timetables. Many individuals enjoy focusing on achieving goals, so you may use them to highlight major events or project accomplishments. Normally, milestones are created by inserting tasks with no duration. By ticking the relevant option in the Advanced tab of the Task Information dialogue box in Microsoft Project, you may label any task as a milestone. The task’s length will not alter to zero, but the Gantt chart will display a milestone symbol based on the task’s start date. Some people use the SMART criteria to help establish milestones in order to make them more meaningful. The SMART criteria are recommendations on how milestones should be set:

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- Specific
- Measurable
- Assignable
- Realistic
- Time-framed

Distributing a marketing strategy for example, is defined, quantifiable, and assignable if everyone knows what should be in it, how it should be delivered, how many copies should be given and to whom, and who is responsible for the actual delivery. If it is a feasible event that is scheduled at an opportune time, distributing the marketing plan is reasonable and can be time framed.

Using Tracking Gantt Charts to Compare Planned and Actual Dates

A unique type of Gantt chart can be used to assess project progress by displaying actual scheduling information. A Tracking Gantt chart—a Gantt chart that compares planned and actual project schedule information—is shown in the diagram below. The baseline dates are the scheduled schedule dates for activities, and the schedule baseline is the whole approved planned schedule. The Tracking Gantt chart has columns labelled “Start” and “Completion” that indicate the task’s actual start and finish dates, as well as columns labelled “Baseline Start” and “Baseline Finish” that represent the task’s anticipated start and finish dates. (In the below figure, these columns are hidden.) The project is finished in this case, however numerous jobs were late in starting and finishing.

A Tracking Gantt chart employs a few more symbols to act as a progress evaluation tool:

- Why The Gantt chart in Figure below frequently shows two horizontal bars for tasks. Each task’s scheduled or baseline time is represented by the top horizontal bar. The real duration is represented by the bar below it. This type of display is demonstrated in subtasks 1.2 and 1.3. If these two bars are the same length, that is, they begin and conclude on the same dates, the actual timetable for that task was the same as the planned schedule. This scheduling occurred for Subtask 1.1, which began and finished on March 4 as anticipated. The actual timetable deviated from the planned or baseline schedule if the bars did not start and end on the same dates. As you can see for Subtask 1.2, if the top horizontal bar is shorter than the bottom one, the task took longer than expected. The task took less time than expected if the top horizontal bar is longer than the bottom one. The planned duration for summary tasks is shown by a striped horizontal bar, as shown in Main Tasks 1 and 2. The progress for summary tasks is shown by the black bar next to it. Main Task 2 for example, clearly demonstrates that the actual duration was longer than anticipated.

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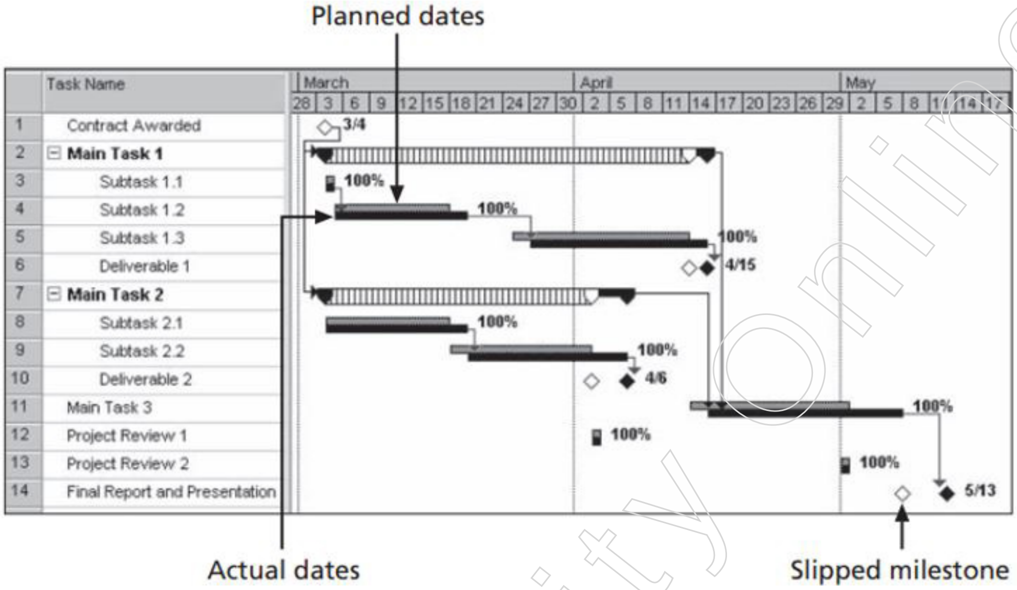

Figure: Sample tracking Gantt chart

- A slid milestone is represented by a white diamond on the Tracking Gantt chart. A slipped milestone refers to an action that was completed later than expected. The final report and presentation were finished later than expected, resulting in a slipped milestone in the last task.
- The percentage of work accomplished for each task is displayed to the right of the horizontal bars as percentages. For example, 100% indicates that the task is completed, whereas 50% indicates that the task is still in progress but 50% accomplished.

A Tracking Device The percentage of work accomplished for project tasks or the actual start and finish dates are used to create a Gantt chart. It enables the project manager to track the progress of individual tasks as well as the entire project. The project is finished for example, as shown in the diagram above. It began on time, but ended a day late, on May 13 (5/13) rather than May 8.

The fundamental benefit of utilising Gantt charts is that they give a uniform structure for displaying project schedule information, both planned and actual. They are also simple to design and comprehend. The fundamental problem of Gantt charts is that they rarely reveal task linkages or dependencies. The dependencies will be displayed differently than they would be on a network diagram if Gantt charts are made using project management software and tasks are linked. It is a matter of personal preference whether you display dependencies on a Gantt chart or a network diagram.

Critical Path Method

Many initiatives fail to reach their deadlines. The critical path method (CPM), also known as critical path analysis, is a network diagramming methodology for estimating project duration. This useful tool aids in the prevention of project schedule overruns. A project's critical path is a set of events that determine when the project will be completed. It is the longest and has the least amount of slack or float in the network

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diagram. The amount of time an activity can be postponed without affecting the next action or the project's completion deadline is known as slack or float. On most projects, numerous jobs are completed in parallel, and most projects have multiple paths through a network diagram. The project's completion date is determined by the longest path or the path that contains the most crucial activities. You are not finished with the project until all of the tasks have been completed.

Calculating the Critical Path

To determine a project's critical route, you must first create a decent network diagram, which requires a strong activity list based on the WBS. To establish the critical path, you must first design a network diagram and then estimate the time of each action. The critical path is calculated by combining the durations of all activities along each path in the network diagram. The essential path is the one that is the longest.

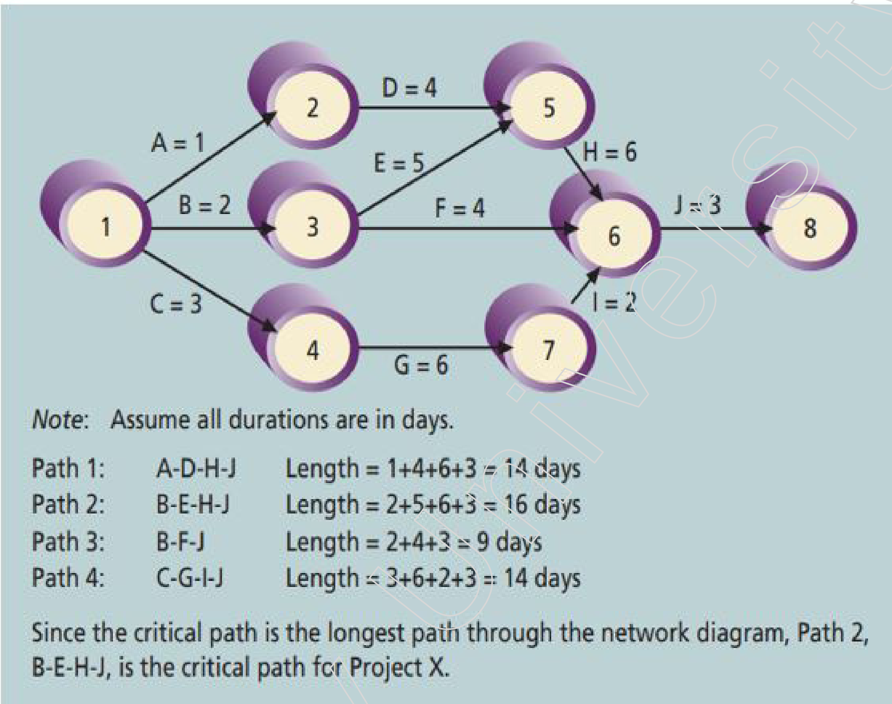

Figure: Determining the critical path for project X

The AOA network diagram for Project X is shown in the above Figure once again. To establish the critical route for projects, you can use either the AOA or the precedence diagramming technique. Figure 6-8 depicts the four paths that lead via the network design. On the AOA network diagram, each path begins at the first node (1) and ends at the last node (8). The length or total duration of each path through the network diagram is also shown in this graphic. The lengths of the path are calculated by adding the durations of each activity along the way. The crucial path for the project is B-E-H-J, which has the longest duration of 16 days.

What does it mean to be on the crucial path? Despite being the longest road, the critical path represents the lowest time to finish a project. If one or more key route tasks take longer than expected, the entire project timetable will be pushed back until the project manager intervenes.

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When it comes to managing the critical path, project teams can be inventive. For example, Joan Knutson, a well-known project management author and speaker, frequently recounts how a gorilla assisted Apple Inc. in completing a project on time. Team members worked in a cubicle area, with a stuffed gorilla on top of the cubicle of whoever was in charge of the current critical path task. Everyone understood that person was pressed for time and didn't require any distractions. When a critical task was done, the gorilla was given to the person in charge of the next critical task.

Growing Grass Can Be on the Critical Path

People are frequently perplexed as to what a project's crucial path entails. Some people believe that the critical path includes the most critical activities, however it is only concerned with the project's temporal dimension. The fact that it has the word critical in its name does not imply that it covers all critical operations. In a keynote talk at a PMIISSIG Professional Development Seminar for example, Frank Addeman, Executive Project Director at Walt Disney Imagineering, revealed that cultivating grass was a necessary step for developing Disney's Animal Kingdom theme park! For the animals in the 500-acre park, special grass was necessary, and some of it took years to develop. Another misperception is that the critical path is the network diagram's shortest path. The purpose of some fields, such as transportation modelling, is to find the shortest path in network diagrams. However, in order to complete a project, each task or activity on the critical path, as well as other paths, must be completed. It's not a case of taking the shortest route.

Other elements of critical path analysis could be perplexing. Is it possible for a project to have more than one critical path? Is there ever a change in the critical path? Assume that Activity A in Project X has a three-day estimate rather than a one-day estimate. Path 1 would be 16 days long based on this updated duration estimate. There are now two crucial pathways in the project, each of which is the longest and lasts the same amount of time. As a result, a project can have multiple critical paths. To avoid a late project completion, project managers should closely monitor the performance of activities in the critical path. Project managers must keep an eye on all critical paths if there are more than one.

The critical route of a project can shift as it moves along. Assume that everything goes according to plan at the start of the project. Assume that Activities A, B, C, D, E, F, and G all begin and end on schedule. Assume that Activity I encounters difficulties. If Activity I takes longer than four days, path C-G-I-J will be longer than the other paths, providing everything goes according to plan. Path C-G-I-J would become the new crucial path as a result of this alteration. As a result, the critical path of a project can shift.

Using Critical Path Analysis to Make Schedule Trade-Offs

It's crucial to understand the key path throughout the project's life cycle so that the project manager may make trade-offs. If a critical route item is running late, the project manager must be aware of the issue and decide what to do about it. Is it necessary to revise the schedule with stakeholders? Should greater resources be directed to other important path items to compensate for the lost time? Is it permissible for the project to be completed late? The project manager and team take a proactive role in maintaining the project timeline by keeping track of the key path.

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Determining the free slack and total slack for each project activity is a strategy that can assist project managers in making scheduling trade-offs. The amount of time an activity can be postponed without delaying the early start date of any immediately following activities is known as free slack or free float. Based on the project network logic, the early start date is the earliest possible time for an activity to begin. Total slack, also known as total float, refers to the amount of time an activity can be postponed from its scheduled start date without affecting the project's completion date.

A forward and backward trip across a network diagram is used by project managers to quantify free slack and total slack. Each activity's early start and early conclusion dates are determined by a forward pass. Based on the project network logic, the early finish date is the earliest possible time for an activity to be completed. The project's start date is the same as the first network diagram activity's early start date. The early start date plus the duration of the first activity equals the first activity's early finish date. Unless an activity has numerous antecedents, it is also equal to the early start date of each succeeding activity. When an activity has many predecessors, its early start date is the most recent of those predecessors' early finish dates. Tasks D and E for example, come right after Task H in the diagram above.

As a result, Task H's early start date is the early finish date of Task E, which is later than Task D's early finish date. In a similar approach, a backward trip around the network diagram determines the late start and late finish dates for each activity. The late start date is the earliest that an activity can start without delaying the project's completion deadline. The late finish date is the latest time an activity can be performed without causing the project's completion date to be pushed back.

Each activity's early and late start and conclusion dates can be determined by hand by project managers. A simple network diagram with three tasks, A, B, and C, is shown in Figure below. Tasks A and B are both completed before Task C. Assume that all estimates of length are in days. Task A has a 5-day estimated duration, Task B has a 10-day estimated duration, and Task C has a 7-day projected duration. There are just two options available.

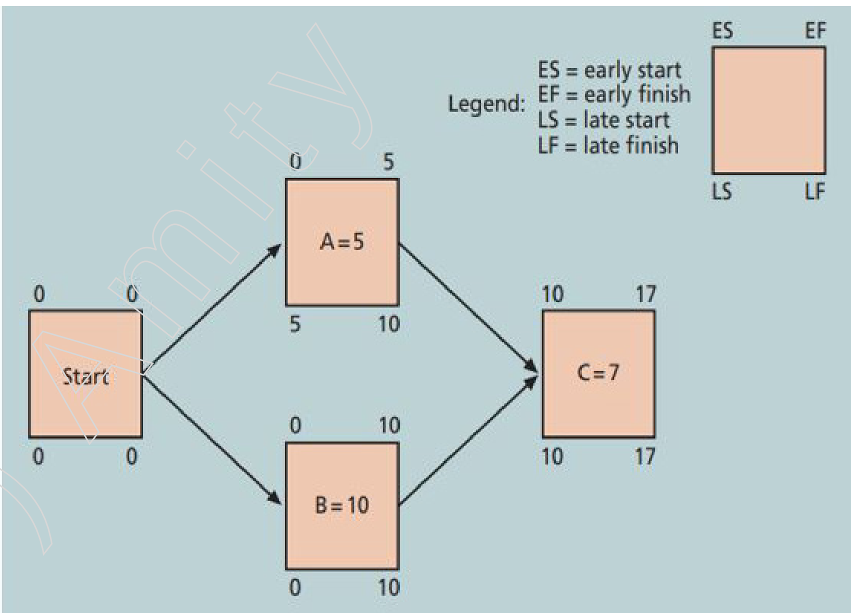

Figure: Calculating early and late start and finish dates

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Using the Critical Path to Shorten a Project Schedule

Stakeholders frequently request that a project timetable estimate be shortened. By identifying tasks, determining sequencing, and predicting resources and durations for each activity, a project team may have done its best to develop a project schedule. Although the findings of this study may indicate that the project team will need 10 months to finish the project, the sponsor may inquire if the project can be completed in eight or nine months. (It's uncommon for people to request that the project team take longer than originally planned.) The project manager and team can employ many duration compression approaches to shorten the project timetable if they know the crucial path. One method is to shorten the time of critical path activities. By allocating extra resources to criticalpath tasks or modifying their scope, the project manager can reduce the length of criticalpath activities. According to some experts, cutting a realistic project timeline by more than 25% is extremely tough.

Remember how Sue Johnson had scheduling issues with the online registration project in the first scenario because multiple users skipped critical project review meetings and one of the senior programmers resigned. Sue and her team could assess their progress toward meeting the May 1 deadline if they built a realistic project schedule, made reliable duration estimates, and defined relationships between tasks. They would have to take corrective actions to finish the project on time if some critical route tasks had already slipped and they had not built in extra time at the end of the project. In order to make up time, Sue might request that her firm or the institution offer more personnel to work on the project. She could also ask for a reduction in the scope of tasks in order to finish the project on time. Sue might potentially shorten the project schedule by employing project schedule management strategies like as crashing or fast tracking.

Crashing is a method for balancing cost and schedule trade-offs in order to get the most schedule compression for the least amount of money. Assume that entering course data for the new semester into the new system was one of the critical path items for the online registration project. If this activity has not yet been completed and was originally projected to take two weeks due to the college's provision of a part-time data entry clerk, Sue could recommend that the clerk work full-time so that the task can be completed in one week rather than two. Sue's company would not incur any more costs as a result of this modification, and the project's completion schedule might be shortened by one week. If the college is unable to meet this requirement, Sue may wish to hire a temporary data entry employee for one week to assist her in completing the assignment more quickly. The project timetable can be shortened by focusing on items on the critical route that could be completed faster for no additional cost or at a low cost.

The biggest benefit of crashing is that it reduces the amount of time it takes to complete a project. Crashing has the primary downside of increasing total project expenses.

Fast tracking is another method for reducing the length of a project's timetable. Fast tracking entails performing operations in simultaneously that would ordinarily be completed in order. Sue Johnson's project team for example, may have decided not to begin coding for the online registration system until all of the analysis was completed. Instead, they might consider beginning some coding work before the analysis is finished. The key benefit of fast tracking, like crashing, is that it can reduce the amount of time it takes to complete a project. The biggest negative is that it might raise costs and delay the project schedule because commencing some tasks too early raises project risk and leads to rework.

Importance of Updating Critical Path Data

It's crucial to update the schedule with actual data after determining the critical path at the start of a project. The project manager should capture the real durations of activities after the project team has completed them. The project manager should also keep track of updated estimates for tasks that are currently underway or that have yet to begin. These adjustments frequently lead a project's critical path to shift, resulting in a revised project completion date. Again, proactive project managers and their teams maintain track of changes so that they may make educated decisions and keep stakeholders informed about significant project decisions.

2.3 Project Cost Estimation

When a company estimates the overall cost of a project by precisely defining the scope of work, it is known as project cost estimating. To forecast a project's overall cost to deliver, it's necessary to look at the activities, length, and resources required. The closer a project's estimate is to the actual cost, the more probable it is that spending will remain in the black after it begins. Although project cost estimation isn't the most thrilling aspect of your job, getting the budget right might make the difference between a successful project and one that fails. With the number of projects suffering from scope creep on the rise, team leaders must be vigilant during the planning and forecasting stages to ensure that their project cost estimates are correct and that they are only taking on work that is financially viable.

Because project cost estimate is based on relating costs to a scope of work, it is necessary to describe how long tasks will take and who will complete them, as well as keep a close eye on the project. Cost estimating for a project does not end when it begins; it must be monitored and altered as the project develops.

2.3.1 Introductory Concept of Project Cost Estimation

If project managers want to finish projects on time and on budget, they must take cost estimates seriously. Following the creation of a good resource requirements list, project managers and their teams must create numerous cost estimates for these resources. For example, if a project's activity is to conduct a specific type of test, the list of activity resource requirements would include the skill level of the people required to conduct the test, the number of people and hours recommended to conduct the test, the need for special software or equipment, and other considerations. To produce a good cost estimate, you'll need all of this information. This section discusses several types of cost estimates, cost estimation tools and approaches, common problems with IT cost estimates, and a thorough example of a cost estimate for an IT project.

Types of Cost Estimates

Cost estimates and foundation of estimates are the primary outputs of project cost management. For most projects, project managers prepare a variety of cost estimates. The following are three primary categories of estimates:

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- A rough order of magnitude (ROM)estimate gives a rough estimate of how much a project will cost. A rough estimate, a guesstimate, a swag, or a broad gauge are all terms used to describe a ROM estimate. This type of estimate is completed very early in a project, often even before it has officially begun. This estimate is used by project managers and high management to make project selection decisions. This type of estimate is usually made three or more years before the project is completed. The accuracy of a ROM estimate ranges from 250 percent to 1100 percent, implying that the project's real expenses might be 50 percent lower or 100 percent higher than the ROM estimate. The real cost of a project with a $100,000 ROM estimate for example, could range from $50,000 to $200,000. This accuracy range is generally significantly wider for IT project estimates. Because of the history of IT project cost overruns, many IT professionals instinctively quadruple software development estimates.
- A budgetary estimate is a method of allocating funds to a company's budget. Many organisations plan their budgets at least two years ahead of time. One to two years before the project's completion, budgetary estimations are established. Budgetary projections are normally 210 percent to 125 percent accurate, which means real expenses could be 10% less or 25% greater than the budgetary estimate. A project with a budgeted estimate of $100,000 for example, could cost anywhere from $90,000 to $125,000 in actual cost.
- A definitive estimate gives a realistic cost estimate for the job. Definitive estimates are used to make a variety of purchase decisions that require precise estimates, as well as to estimate ultimate project costs. For example, if a project requires the purchase of 1,000 personal computers from an outside supplier within the next three months, a firm estimate is necessary to aid in the evaluation of supplier proposals and the allocation of funds to pay the chosen supplier. One year or less before the project's completion, definitive estimates are made. The most accurate of the three sorts of estimations should be a definite estimate. The accuracy of this type of estimate ranges from 25% to 110 percent, implying that actual expenses could be 5% lower or 10% higher than the final estimate. For example, the true cost of a project with a firm estimate of $100,000 could be anywhere between $95,000 and $110,000. The three fundamental types of cost estimates are summarised in the table below.

Table: Types of cost estimates

Type of Estimate	When Done	Why Done	Typical Range
Rough order of magnitude (ROM)	Very early in the project life cycle, often 3–5 years before project completion	Provides estimate of cost for selection decisions	−50% to +100%
Budgetary	Early, 1–2 years out	Puts dollars in the budget plans	−10% to +25%
Definitive	Later in the project, less than 1 year out	Provides details for purchases, estimates actual costs	−5% to +10%

The number and type of cost estimates varies depending on the application. The Association for the Advancement of Cost Engineering (AACE) International for example, distinguishes five types of construction cost estimates: order of magnitude, conceptual, preliminary, definitive, and control. The essential point is that estimates are frequently made at different stages of a project and should improve in accuracy as time goes on.

It's necessary to offer supporting details for the estimates and revisions to project papers, in addition to establishing cost estimates for the overall project and activity cost estimates. The supporting elements include the estimate's ground rules and assumptions, a description of the project (such as a scope statement and WBS) that served as the estimate's foundation, and information on the cost estimation tools and methodologies used to construct the estimate. These supporting details should make preparing a revised estimate or a similar estimate easier in the future.

Another factor to consider when preparing cost estimates is labour expenditures, which typically account for a considerable portion of total project costs. Over the course of a project's life cycle, many businesses estimate the number of people or hours required by department or talent. Northwest Airlines for example, estimated the maximum number of full-time equivalent (FTE) workers it could deploy to the project each year by department while developing early cost estimates for their reservation system project, ResNet. FTE is a typical way to refer to the total workforce necessary for a project, regardless of whether employees work full-time or part-time, as detailed in more depth under establishing the budget. It's worth noting that Northwest Airlines planned to hire a small number of contractors. Contractor labour costs are frequently substantially greater, so it's critical to distinguish between internal and external resources.

Cost Estimation Tools and Techniques

As you may expect, determining a reasonable cost estimate is tough. Fortunately, there are various tools and strategies that can help you create one. Expert judgement, similar cost estimation, bottom-up estimating, three-point estimating, parametric estimating, the cost of quality, project management estimating software, vendor bid analysis, and reserve analysis are some of these tools and techniques.

Maximum FTE by department by year

Department	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
Information systems	24	31	35	13	13	116
Marketing systems	3	3	3	3	3	15
Reservations	12	29	33	9	7	90
Contractors	2	3	1	0	0	6
Totals	41	66	72	25	23	227

Analogous estimates, also known as top-down estimates, use the actual cost of a previous, similar project to estimate the present project's cost. This method necessitates a lot of expert judgement and is often less expensive than other methods, but it is also less precise. When past projects are similar in truth, not merely in

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appearance, analogous estimates are the most dependable. Furthermore, the teams preparing cost estimates must have the necessary experience to decide whether particular aspects of the project will cost more or less than similar projects.

Estimators for example, frequently seek for a similar project to tailor or alter for known variances. However, if the project to be evaluated requires the use of a new programming language or the use of a new sort of hardware or network, the similar estimation technique might easily result in an estimate that is too low.

Bottom-up estimates entail assessing the costs of individual work items or activities and adding them up to arrive at a final project cost. Activity-based costing is a term used to describe this method. The accuracy of the estimates is determined by the size of the individual work items and the estimators' experience. If a project's detailed WBS is available, the project manager may require that each person responsible for a work package generate a cost estimate for that work package, or at the very least an estimate of the resources required.

Resource cost rates, such as labour rates or costs per pound of commodities, are frequently provided by someone in an organization's financial department and can be entered into project management software to compute costs. The software generates cost estimates for each level of the WBS, and then for the entire project, by automatically calculating data. Using smaller work items improves the accuracy of the cost estimate since the cost estimate is developed by the individuals who will be doing the work rather than someone who is unfamiliar with the task. Bottom-up estimates have the disadvantage of being time-consuming and hence costly to create.

Three-point estimates consist of calculating the most likely, optimistic, and pessimistic costs for objects.

Parametric estimating: To estimate project expenses, a mathematical model is used to incorporate project characteristics (parameters). For example, based on the programming language being used, the level of skill of the programmers, the number and complexity of the data involved, and other factors, a parametric model would predict $50 per line of code for a software development project. When the historical data used to develop the model is accurate, the parameters are easily quantifiable, and the model is adaptable in terms of project size, parametric models are the most dependable.

In many building construction projects, parametric estimates based on cost per square foot are used. The cost depends on the construction quality, location, materials, and other considerations. In fact, many individuals find that combining analogous, bottom-up, three-point, and parametric estimating with a hybrid technique yields the best cost estimates.

2.3.2 Key Concept in Project Cost Management

Estimating, budgeting, and controlling expenses are all part of project cost management, which ensures that the project is completed within the allocated budget.

The practices required to ensure that a project team completes a project within an established budget are included in project cost management. This definition has two key phrases: "a project" and "an agreed budget". Project managers must ensure that

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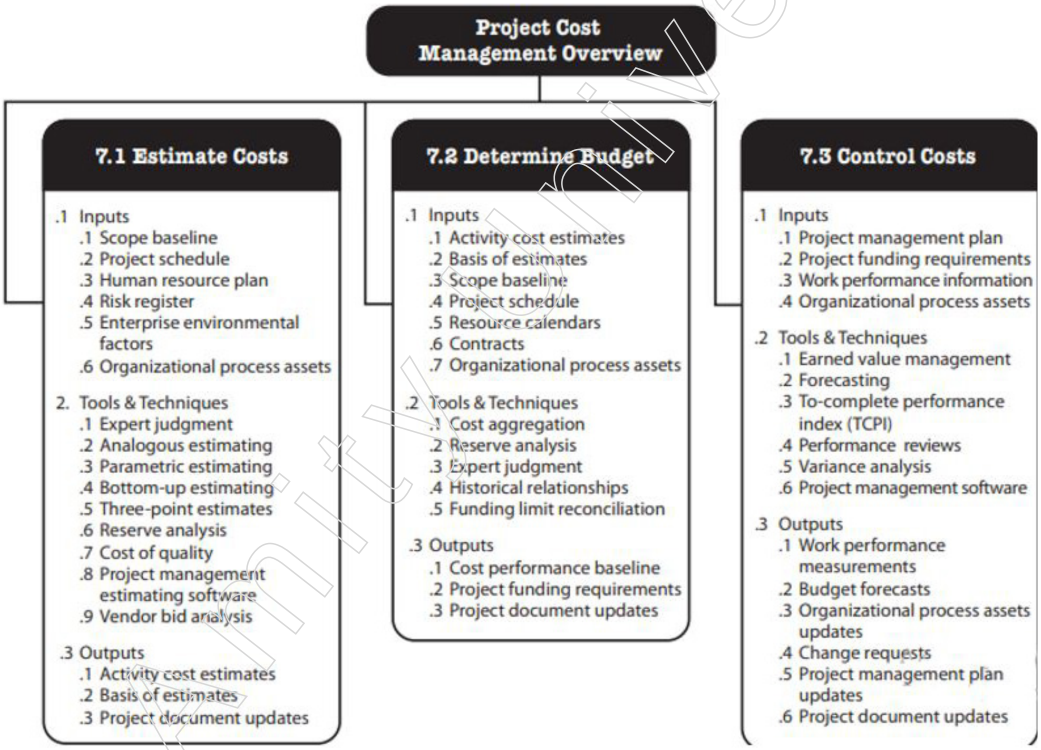
their projects are adequately defined, that precise schedules and cost estimates are in place, and that a realistic budget was approved with their input. The project manager's role is to keep project stakeholders happy while also lowering and controlling costs. Project cost management is divided into four steps:

- Cost management planning entails identifying the policies, methods, and documentation that will be utilised for project cost planning, execution, and control. A cost management strategy is the key product of this approach.
- Developing an approximation or estimate of the expenses of the resources required to complete a project is known as cost estimation. Activity cost estimates, foundation of estimates, and project document updates are the key outputs of the cost estimating process.
- Allocating the total cost estimate to individual work items to establish a baseline for monitoring performance is part of determining the budget. A cost baseline, project financing requirements, and project document changes are the major outcomes of the cost budgeting process.
- Controlling costs entails keeping tabs on the project's budget. Work performance information, cost predictions, change requests, project management plan updates, and project document updates are the major outputs of the cost control process.

Table: Project Cost Management Overview



Basic Principles of Cost Management

Many IT initiatives never get started because IT experts don't know how to make a business case for them. In Chapter 4, Project Integration Management, important concepts such as net present value analysis, return on investment, and payback analysis were presented. Similarly, many initiatives begin but never conclude due

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to expense management issues. Most members of an executive board are more engaged in finance and have a better command of financial words than IT terms. IT project managers must therefore be able to present and discuss project information in both financial and technical terms. Project managers must be familiar with a variety of cost management principles, concepts, and terms in addition to net present value analysis, return on investment, and payback analysis. Profits, life cycle costing, cash flow analysis, tangible and intangible costs and benefits, direct expenses, sunk costs, learning curve theory, and reserves are all covered in this section. Another essential topic is earned value management, which is one of the most important tools and approaches for reducing project costs and is covered in full in the cost control section.

Profitsare the income minus the expenses. A corporation can boost profits by increasing sales, lowering expenses, or attempting to accomplish both. Profits are more important to most executives than other concerns. It is critical to focus on the influence on profits, not merely revenues or expenses, when justifying investments in new information systems and technology. Consider an e-commerce application that you believe will boost a $100 million company's revenue by 10%. Without knowing the profit margin, you can't assess the application's prospective benefits. The profit margin is the percentage of revenue that is made up of profits. A profit margin of 2% means that $100 in revenue generates $2 in profit. There is a 22 percent profit margin if the corporation loses $2 for every $100 in revenue.

Life cycle costing provides a big-picture view of a project's cost over its entire life cycle. This aids in the development of an accurate financial cost and benefit prediction for a project. The entire cost of ownership, or development plus support costs for a project is considered in life cycle costing. For example, a corporation may complete a project to build and install a new customer service system in one or two years, yet the system may remain in place for ten years. Project managers should produce estimates of the project's costs and benefits for its whole life cycle with the help of financial specialists in their businesses (10 years in the preceding example). Remember from Chapter 4 that the project's net present value analysis would cover all costs and benefits for the whole 10-year timeframe. When making financial decisions, top management and project managers must consider the life cycle costs of projects.

Organizations have a history of underinvesting in the early stages of projects, which has an impact on the total cost of ownership. Spending money on creating user needs and early testing on IT projects for example, is far more cost-effective than waiting for problems to arise after implementation. Remember from Chapter 5 that repairing a software issue late in a project is far more expensive than addressing it early. Because businesses rely on reliable IT, downtime incurs significant expenses.

- On September 3, 2014, when Facebook was down for 20 minutes, they lost a little more than $22,453 per minute, or more than $500,000.
- Amazon.com was down for around 30 minutes on August 19, 2013, costing them $66,240 each minute, or nearly $2 million.
- An infrastructure failure costs $100,000 per hour on average for Fortune 1000 organisations, whereas a major application failure costs $500,000 to $1 million per hour, or $8,300 to $16,600 per minute.

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- In 2014 fortune 1000 organisations spent an average of $1.25 billion to $2.5 billion on unplanned application downtime.

Cash flow analysis: The approach of determining the projected annual expenses and benefits for a project, as well as the resulting annual cash flow, is known as cash flow analysis. To calculate net present value, project managers must undertake a cash flow analysis. Most people grasp the basic concept of cash flow: they can't buy something if they don't have enough money in their wallets or bank accounts. When deciding which initiatives to invest in, top management must consider cash flow considerations. If top management chooses too many projects with high cash flow requirements in the same year, the company will be unable to support all of its projects while still remaining profitable. It's also crucial to provide the year in which the dollar values were calculated. When predicting costs and benefits in future-year dollars for example, if a corporation bases all costs on 2018 predictions, it must account for inflation and other factors.

Costs and benefits can be classified as tangible or intangible, depending on how effectively a company can identify the expected costs and benefits for a project. In dollars, tangible costs or advantages are straightforward to calculate. Consider the Surveyor Pro project from the beginning of the chapter, which includes a preliminary feasibility analysis. The tangible cost of this study is $100,000 if it was finished for $100,000. If a government agency projected that the study could be completed for $150,000, the study's tangible benefits to the government would be $50,000: It could fund the research and then reassign the government employees who would have completed it to other initiatives.

Intangible costs and benefits, on the other hand, are difficult to quantify in money. Assume Juan and a few others used their personal time to explore areas pertinent to the study using government-owned computers, books, and other resources. Their time and the supplies controlled by the government would not be billed to the project, but they could be considered intangible costs. Intangible project benefits often include things like goodwill, prestige, and general declarations of increased productivity that are difficult to quantify in dollars. Intangible costs and benefits are generally more difficult to justify since they are difficult to measure.

Direct costs can be directly linked to the creation of the project's products and services. Direct costs might be assigned to a specific project. Direct costs for example, include the pay of full-time project employees as well as the cost of gear and software purchased particularly for the project. Direct costs can be controlled, thus project managers should concentrate on them.

Indirect costs are not directly tied to the project's products or services but are indirectly related to the project's completion. In a huge building with 1,000 employees working on multiple projects, indirect costs may include the cost of energy, paper towels, and other essentials. Project managers have very limited control over indirect expenditures, which are given to projects.

Sunk cost is money that has already been spent. As if it were a sunken ship that could never be raised. Sunk expenses should not be considered when determining which initiatives to invest in or continue. Assume for example, that Juan's office had spent $1 million on a project to construct a geographic information system during the

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previous three years but had never produced anything useful. If his government was deciding which projects to finance next year, and an official proposed continuing to fund the geographic information system project because $1 million had already been spent on it, the official would be mistaken in considering sunk cost as a major component in the decision. Because so much money has already been spent on a failing project, many people fall into the trap of continuing to spend money on it. This is analogous to gamblers who keep betting despite the fact that they have already lost money. Sunk costs should be forgotten, despite the fact that it is often impossible to do so.

Learning curve theory asserts that when a large number of products are produced repeatedly, the unit cost of those items declines in a predictable fashion as the number of units produced increases. Consider the possibility that the Surveyor Pro project may generate 1,000 handheld devices capable of running the new software and accessing data through satellite. The price of the first portable unit would be significantly higher than the price of the thousandth. The learning curve hypothesis can aid in cost estimation for projects involving the manufacturing of large quantities of goods.

The learning curve idea also refers to how long it takes to finish certain jobs. For example, when a new employee does a given activity for the first time, it will most likely take longer than when the employee performs a precisely same task for the tenth time. As a result, estimates of effort for more experienced personnel should be lower.

Reserves are financial amounts added in a cost estimate to mitigate cost risk by accounting for unforeseeable future events. Contingency reserves are included in the project cost baseline to account for future scenarios that can only be partially anticipated (also known as known unknowns). For example, if a business knows its IT worker turnover rate is 20%, it should set aside contingency funds to cover the costs of recruiting and training IT personnel. Unpredictable future situations are accommodated by management reserves (sometimes called unknown unknowns). For example, if a project manager is out of commission for two weeks or a key supplier goes out of business, a management reserve could be set aside to cover the expenditures.

2.3.3 Trends and Emerging Practices in Project Cost Management

The expansion of earned value management (EVM) to encompass the idea of earned schedule is one of the latest trends in Project Cost Management (ES).

ES is a development of EVM's theory and practice. Earned schedule theory substitutes the usual EVM (earned value vs. planned value) schedule variance measures with ES and actual time (AT). If the amount of earned schedule is more than 0, the project is considered ahead of schedule using the alternate equation for computing schedule variance ES AT. In other words, at a certain point in time, the initiative earned more than expected. The earned schedule metrics-based schedule performance index (SPI) is ES/AT. This metric reflects the speed with which work is completed. Using earned schedule, actual time, and predicted length, earned schedule theory also provides methods for estimating project completion dates.

Tailoring Considerations

Because each project is different, the project manager may need to customise the Project Cost Management techniques. Tailoring considerations include, but are not limited to:

- Management of information: Is there a formal knowledge management and financial database repository in place that a project manager must utilise and that is easily accessible?
- Budgeting and estimating: Is there a formal or informal cost estimation and budgeting policy, practice, or guideline in place at the company?
- Management of earned value: Is earned value management used by the company to manage projects?
- The application of an agile strategy: Is the company using agile project management methodologies? What effect does this have on cost estimation?
- Governance: Is there a written or informal audit and governance policy, practice, or guideline in place?

Considerations for agile/adaptive environments

Due to frequent changes, thorough cost calculations may not be beneficial for projects with a high degree of uncertainty or where the scope is not yet fully specified. Instead, lightweight estimation methods can be used to quickly provide a high-level prediction of project labour costs that can be easily changed as changes occur. In a just-in-time manner, detailed estimates are reserved for short-term planning horizons.

When high-variability projects have tight budgets, the scope and timetable are frequently changed to stay inside the budget limits.

2.3.4 Comparison between Various Techniques of Project Cost Estimation

The process of predicting the effort required to construct a product framework is known as programming cost estimation. Models can be classified as algorithmic or non-algorithmic, each with its own set of advantages and disadvantages. Precision requires a high level of determination. The evaluations are based on effort, duration, cost, and so forth. Cost estimate will remain a difficult task, and researchers should enjoy devising novel approaches to this task. For more precise estimation, models based on Artificial Intelligence technologies should be used. In this way, programming expense estimation, also known as programming exertion estimation, is a method of estimating the amount of effort required to construct a product framework.

Software cost estimation methods and model

2CEE Cost Estimation Model

It is the first model that can be calibrated using data mining approaches to calibrate software engineering. 2CEE (21st Century Effort Estimation) is both a data mining system and an effort estimation tool for generating new software cost models. It proposes the most accurate software cost model using a range of data mining and machine learning approaches such as nearest neighbour, feature subset selection, and bootstrapping local calibration. It analyses historical project data with the use of data mining and can produce new patterns based on past project data.

It's made to investigate ambiguity or uncertainty in the model and estimate, to allow estimates early in the lifecycle by expressing new projects as a set of values, and to

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provide a variety of calibration methods. 2CEE has been encoded in a Windows-based programme that can be used to generate estimates as well as calibrate and develop models utilising various machine learning, data mining, and statistical techniques by the model creator. It improves cost analyst efficiency by automating several operations for the user. As a measure of model performance, 2CEE employs leave-one-out cross validation.

Expert Judgment Method

In a specific domain, expert judgement is the capacity to make forecasts and steer away from or avoid issues. It is the most practical way for estimating software costs. This method was commonly used by businesses to calculate the cost of a product. How can you put someone on your team's conclusion to the test? You may keep track of them over time or jumpstart the process by asking them about a topic they care about. Expert judgement procedures entail consulting with a software cost estimating expert or a group of experts to determine the cost of a proposed project based on their knowledge and expertise with the project.

In general, the Delphi technique, which is a group consensus technique, is the best way to go. The virtues and weaknesses of the algorithmic method are complementary to one other. A wideband Delphi technique is used instead of the normal Delphi technique to provide a sufficiently broad communication bandwidth for the experts to communicate the volume of information required to calibrate their estimates with those of the other experts.

This method's estimation steps are as follows:

- A specification and an estimation form are given to each expert by the coordinator.
- Forms are filled out anonymously by experts.
- The coordinator convenes a meeting in which the experts address estimation difficulties with the coordinator and one another.
- On an iteration form, the coordinator creates and distributes a summary of the estimation.
- Experts, once again, anonymously fill out forms.

Following that, the wideband Delphi Technique was employed in a lot of investigations and cost estimation operations. It has been extremely successful in combining the free discussion benefits of group meetings with the anonymous estimating benefits of the regular Delphi Technique.

The advantages of this method are:

- Experts can account for variances in past project experience and the proposed project's requirements.
- Experts can take into account project impacts from new technologies, structures, applications, and languages that will be used in the future project, as well as exceptional personnel qualities and interactions, among other things.

The disadvantages include

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- This procedure is impossible to quantify.
- The experts' or experts' group's factors are difficult to document.
- Even though the group consensus has reduced prejudice, optimism, and pessimism, experts may still be biased, optimistic, and pessimistic.
- Expert judgement is always used in conjunction with other cost estimating approaches, such as the algorithmic method.

Estimating by Analogy

It is one of the most useful strategies for estimating software costs. On the basis of analogous methods, a number of cost estimation models have been constructed. Analogy Based Software Estimation is based on the idea that real values attained inside the company in a previous and similar project are better predictors of future project success and forecast future project performance significantly better than an estimate produced from scratch. It also makes it easier to apply organisational knowledge to new projects. Estimating by analogy is comparing the planned project to a similar project that has already been completed and where the project development information is available. To estimate the planned project, actual data from completed projects is extrapolated. This approach can be utilised at both the system and component levels.

The process of estimating through analogy is quite simple. In some ways, it's a methodical type of expert judgement, because specialists frequently seek for identical instances to inform their judgement.

The steps for estimating via analogy are as follows:

- Defining the scope of the proposed project.
- Selecting completed projects with the most similar features that have been saved in the historical data base.
- By analogy, calculating the cost of the proposed project from the most similar completed undertakings.

The main advantages of this method are:

- The calculation is based on real-world project characteristics.
- The estimator's previous experience and knowledge, which is difficult to quantify, can be utilised.
- It is possible to identify and assess the discrepancies between the finished and projected projects.

However, there are certain drawbacks to this approach:

- We must identify how to best describe projects using this way. The variables that can be used must be limited to information that is accessible at the time the prediction is needed. The type of application domain, the number of inputs, the number of separate entities referenced, the number of screens, and other factors are all possibilities.
- Even after we've defined the project, we need to figure out how comparable it is and how much faith we can put in the comparisons. Too few comparisons may lead to the employment of maverick projects, while too many may dilute

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the effect of the closest analogies. The approach of identifying similarities by measuring Euclidean distance in n-dimensional space, where each dimension corresponds to a variable, was introduced by Martin Sheppard and others. The values are standardised such that each dimension gives the same amount of weight to the analogy-finding process. The most powerful analogies are, in general, two.

- Finally, we must estimate the new project's effort based on known effort levels from previous initiatives. Means and weighted means are possibilities, with the closer analogues having more influence.

The selection of the appropriate group of previous projects is the most important part of Analogy Based Estimation's effectiveness. In some cases, it has been calculated that estimating by analogy is a better strategy than estimating using an algorithmic model. It is a more intuitive strategy, making the reasoning behind a forecast easier to comprehend.

Top-Down and Bottom-Up Methods

Top-Down Estimating Method

The top-down method of estimating is based on the software project's overall uniqueness. Beginning at the topmost level, the project is divided into lower-level components and life cycle phases. When only global attributes are known, this method is better appropriate for early cost estimations. Macro Model is another name for top-down estimating. The overall cost estimation for the project is obtained from the global attributes of the software project using the top-down estimating method, and then the project is partitioned into several low-level mechanisms or components. The Putnam model is the most popular method that employs this strategy. When only global attributes are known, this method is better appropriate for early cost estimation. Because there is no precise information accessible in the early stages of software development, it is quite valuable.

Other estimate approaches may overlook system-level operations (integration, documentation, project control, configuration management, and so forth), which are often overlooked in compensation. The top-down approach is typically quicker, easier to implement, and involves less project detail. However, it has drawbacks, such as being less accurate and overlooking lower-level components and potential technical issues. It also gives very little information to back up decisions or projections.

The advantages of this method are:

- It focuses on system-level activities like integration, documentation, and configuration management, which are often overlooked by other estimate approaches, and it does not overlook the expense of system-level tasks.
- It necessitates the least amount of project details, therefore it is usually quicker and easier to implement.

The disadvantages are:

- It frequently fails to recognise complex low-level issues that are likely to escalate expenses, and it occasionally overlooks low-level components.

- It gives no specific justification for decisions or estimations.

Bottom-up Estimating Method

It's also a crucial part of the cost estimation process. Bottom-up estimation is identifying and estimating each component separately, then merging the data to obtain a total project estimate. Because the necessary information may not be available early in the life cycle process, performing a bottom-up estimate can be difficult. This method is also more time-consuming, and it may not be feasible when time or staffs are limited. The cost of each software component is calculated using the bottom-up estimating method, and the findings are then combined to arrive at an estimated cost of the total project. Its goal is to build a system estimate using the knowledge gathered about minor software components and their interactions. The dominant method employing this approach is COCOMO's detailed model.

The advantages:

- It allows the software team to manage an estimate in a more traditional manner, as well as handle estimate components that they are familiar with.
- Because the estimation mistakes in the various components have a chance to balance out, it is more stable.

The disadvantages:

- Many system-level costs (integration, configuration management, quality assurance, and so on) related with software development may be overlooked.
- Because the essential information may not be available in the early stages, it may be erroneous.
- It is usually more time consuming.
- When both time and manpower are limited, it may not be possible.

Algorithmic Method

The first cost estimating model was created using an algorithmic method, demonstrating the usefulness of an algorithm-based model in software cost estimation files. Equations are used to perform software estimates in the algorithmic process. The equations are based on research and historical data, and they take into account factors like the number of source lines of code (SLOC), the number of functions to run, and other cost drivers like language, design approach, skill levels, risk assessments, and so on. The algorithmic method is intended to provide a set of mathematical equations that may be used to estimate software. These mathematical calculations are based on research and historical data, and they take into account factors like the number of source lines of code (SLOC), the number of functions to run, and other cost drivers like language, design approach, talent levels, risk assessments, and so on. Algorithmic approaches have been extensively investigated, and many models, such as COCOMO models, Putnam models, and function point-based models, have been produced.

The ability to provide reproducible findings, the ease of updating input data, the ease of refining and customising formulas, and a better knowledge of the overall estimating procedures since the formulas can be evaluated are all advantages of this method.

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Advantages

- It is capable of producing repeatable estimates.
- It's simple to change input data, update calculations, and customise them.
- It's quick and can handle a series of estimations or a sensitivity analysis.
- It is based on previous experience and is objectively calibrated.

Disadvantages

- It is incapable of dealing with extraordinary circumstances, such as outstanding persons in any software cost estimation activities, exceptional teamwork, and exceptional skill-levels and task matching.
- Incorrect estimation will come from poor sizing inputs and imprecise cost driver ratings.
- Some experiences and variables are difficult to quantify.

Table: Bird eye view of various cost estimation technique

S.No	Method	Type	Strengths	Weakness
1	COCOMO	Algorithmic	Clear results, it's very common	A lot of data is required, it is not suitable for any project
2	Function Point	Algorithmic	Language free, it's results are better than source line of code	Mechanization is hard to do, it is not considered for quality output
3	Putnam Model	Algorithmic	A Probabilistic model used in a very large projects	Only use large projects
4	Seer–Sem Model	Algorithmic	Used in a very large projects	It's required 50 input parameters which are increases the complexity and uncertainty
5	Linear Model	Algorithmic	It's a best method of prediction using linear regression technique	Little difference between actual and predicted results and error is also needed to calculate
6	Expert Judgment	Non-Algorithmic	Fast prediction, adapt for a special project	Success depends on expert, usually done incomplete
7	Analogy	Non-Algorithmic	Works based on actual experience and special exp	Much information is required about past projects, in some situations there are no similar projects
8	Parkinson	Non-Algorithmic	Correlates with some experience	Reinforces poor practice
9	Price to win	Non-Algorithmic	It often gets the contract	Generally, produces large over runs

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10	Top – Down	Non-Algorithmic	Require minimal project details, usually faster and easier to implement and system level focus	Less detailed basis and less stable
11	Bottom – down	Non-Algorithmic	More detailed basis, more stable and encourage individual commitment	May overlook system level costs, requires more effort, a lot of time consuming

2.3.5 Tools related to Project Cost Management

Project Cost Management is primarily concerned with the cost of the resources required to complete project activities, but it should also take into account the impact of project decisions on the recurring costs of using, maintaining, and supporting project deliverables.

Project expenses will be measured in a variety of ways and at various periods by various stakeholders. Stakeholder requirements for cost management should be explicitly considered.

Predicting and analysing the project's product's future financial performance can be done outside of the project or as part of Project Cost Management.

Cost Estimation

Cost estimation, which is the activity of projecting the price of a complete project with a stated scope, is one of the most significant parts of a project cost management tool.

Fixed, variable, direct, and indirect cost estimation are all types of cost estimation used in project management. Because the project scope, timing, and other elements can change, it's critical to use cost management software to update pricing estimates so you know exactly how much the project will cost.

Use software with advanced estimate features like bottom-up estimation and project portfolio history.

These tools will enable your team to track their progress and make any necessary adjustments. Furthermore, as you learn more about the variables and actual costs, your project estimates will get more refined.

Budgeting

The software you use should allow you to complete and approve the project's budget once you've produced an accurate cost estimation in your project management plan. The best cost management software sends project managers weekly and monthly expense reports, ensuring that your project never goes over budget, potentially costing you thousands of dollars in unforeseen costs.

Furthermore, these tools enable teams to create budget constraints depending on time or cost. When a project's budget is approaching its limit, the programme will notify you so you can change the scope of the project.

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Regular updates on a project's spending can provide crucial information regarding the direction your project is taking and whether or not extra action is required.

Project Performance Measuring

The performance of your project is measured to see if you're on track and on budget. A dashboard that refreshes data in real time is the most convenient way to keep track of your project's progress. Your cost baseline, projected and actual project costs, schedule variance, and percentage of completion should all be included on your dashboard.

Easy Reporting

Find a cost management application that gives a choice of simple reporting options to keep projects operating smoothly. Continue your search if creating a report necessitates the use of a handbook or the assistance of an outside specialist. When it comes to reporting, secure cloud sharing for entire visibility is also critical.

User-Friendly Interface

Because cost accounting is already complex, a user-friendly cost management application is essential. In fact, according to a survey of users, the most significant aspect of project management is ease of use. 1 A user-friendly interface can help your team work more efficiently and reduce project delays. If you're having trouble using your tool, you should probably find another.

Affordability

Small businesses require functional cost accounting solutions to succeed—but not at a cost of a hundred dollars. Fortunately, many of these technologies are inexpensive or even free, allowing you to boost production while lowering expenditures. Even though money is a big factor, examine the advantages and disadvantages carefully.

Third-party integrations

By providing smooth third-party interfaces, project cost management systems should provide you an edge. Your entire project management process will be streamlined as a result of this.

Key Components of a Cost Management Plan

A cost management plan outlines how to manage, control, and communicate the costs of a project so that it is completed on time and on budget. Creating these strategies is often made easier with project cost management software. Although you can tailor a cost management plan to your own requirements, it usually follows a conventional pattern that contains items such as these:

- Cost variance plan
- Cost management approach
- Cost estimation
- Cost baseline

- Cost control and reporting process
- Change-control process
- Project budget

Cost Control Techniques

Project managers are in charge of ensuring that project objectives are met and that costs are kept under control. The following are some cost-cutting measures that can help you improve your bottom line:

- Budget planning
- Cost tracking
- Time management
- Project change controlling
- Earned value use

2.3.6 COCOMO Cost Estimation Model

Barry W. Boehm created the Constructive Cost Approach (COCOMO), an algorithmic software cost estimation model. The model employs a simple regression method that incorporates factors generated from historical project data and current project features.

The COCOMO model, or Constructive Cost Estimation Model, predicts the labour and time required to construct a model based on the size of the source code. It incorporates 15 multiplication factors derived from various project variables, and then uses this information to determine time and effort.

COCOMO was first published in Boehm's book Software Engineering Economics in 1981 as a model for evaluating software project effort, cost, and schedule. It was based on a review of 63 projects conducted by Boehm while he was Director of Software Research and Technology at TRW Aerospace. The research looked at projects with 2,000 to 100,000 lines of code and programming languages ranging from assembly to PL/I. These projects followed the waterfall model of software development, which was the standard at the time.

The Cocomo (Constructive Cost Model) regression model is based on the number of lines of code, or LOC. It is a procedural cost estimate model for software projects that is frequently used as a method of accurately estimating numerous project factors such as size, effort, cost, duration, and quality. Barry Boehm proposed it in 1981, and it is based on a study of 63 projects, making it one of the most well-documented models.

Effort & Schedule are the primary characteristics that define the quality of any software product, which is also an output of the Cocomo:

- Effort: The amount of time it will take to execute a task. It is expressed in person-months.
- Schedule: Simply expressed, it refers to the quantity of time necessary to complete a task, which is related to the amount of effort expended. It is expressed in time units such as weeks and months.

Notes

Various Cocomo models have been presented to anticipate cost estimation at various levels, depending on the level of accuracy and correctness required. All of these models can be utilised on a wide range of projects, the characteristics of which define the constant value to be used in later calculations. The following table lists the characteristics of several system kinds.

Organic, semidetached, and embedded systems are defined by Boehm as follows:

- Organic – If the team size necessary is adequate small, the problem is well understood and has been solved in the past, and the team members have minimal experience with the problem, the software project is said to be organic.
- Semi-detached— A software project is classified as semi-detached if key qualities including team size, experience, and understanding of several programming environments fall somewhere between organic and embedded. Semi-detached projects are less familiar and difficult to produce compared to organic initiatives, and they demand more experience, better supervision, and inventiveness. Compilers or various Embedded Systems for example, can be classified as Semi-Detached.
- Embedded – This category includes software projects that need a high level of complexity, creativity, and experience. To design such sophisticated models, a larger team is required than for the other two models, and the developers must be sufficiently experienced and imaginative.
- Different values of the constants used in Effort Calculations are employed in each of the following system types.

Basic COCOMO

Basic COCOMO calculates the effort (and cost) of software development as a function of programme size. The size of a programme is measured in thousands of source lines of code (SLOC)

COCOMO is a software project classification system that applies to three types of software projects:

- Organic initiatives entail -"small" teams with "excellent" experience working with "less-than-rigid" specifications.
- Semi-detached projects – "medium" teams with a variety of experience dealing with a mix of rigid and less stringent standards.
- Embedded projects- are those that are created under a set of "tight" constraints. It's a mix of organic and semi-detached projects as well. (hardware, software, and operational, to name a few)

The basic COCOMO equations take the form

Effort Applied (E) = a_b (KLOC)^b b [man-months]

Development Time (D) = c_b (Effort Applied)^b b [months]

where, KLOC is the estimated number of delivered lines (expressed in thousands) of code for project.

The coefficients a_b , b_b, c_b and d_b are given in the following table:

Notes

Software project	a_b	b_b	c_b	d_b
Organic	2.4	1.05	2.5	0.38
Semi-detached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

Basic COCOMO is useful for estimating software expenses quickly. It does not, however, take into consideration differences in hardware limits, people quality and expertise, and the adoption of contemporary tools and methodologies, among other things.

Intermediate COCOMOs

Intermediate COCOMO calculates software development effort based on programme size and a set of "cost drivers" that comprise subjective evaluations of product, hardware, personnel, and project attributes. This extension takes into account a set of four "cost drivers," each of which has a number of sub-attributes: -

- Product attributes
  - Required software reliability
  - Size of application database
  - Complexity of the product
- Hardware attributes
  - Run-time performance constraints
  - Memory constraints
  - Volatility of the virtual machine environment
  - Required turnabout time
- Personnel attributes
  - Analyst capability
  - Software engineering capability
  - Applications experience
  - Virtual machine experience
  - Programming language experience
- Project attributes
  - Use of software tools
  - Application of software engineering methods
  - Required development schedule

The formula for Intermediate Cocomo now looks like this:

E = a_i (KLoC)^bi. EAF

where EAF is the factor determined above, SLoC is the projected number of thousands of delivered lines of code for the project, and E is the effort invested in person-months. The next table shows the coefficient a_i and the exponent b_i.

Notes

Software project	a_i	b_i
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

E is used in the same way in the Development time D calculation as it is in the Basic COCOMO.

Detailed COCOMO

Detailed COCOMO comprises all of the features of the intermediate version, as well as an assessment of the cost driver's impact on each step of the software engineering process (analysis, design, and so on).

For each cost driver attribute, the detailed model employs multiple effort multipliers. These Phase Sensitive effort multipliers are used to calculate how much effort is needed to finish each phase.

COCOMO calculates effort as a function of programme size and a set of cost drivers assigned to each phase of the software life cycle.

The schedule for a detailed project is never static.

The following are the five phases of detailed COCOMO:

- plan and requirement.
- system design.
- detailed design.
- module code and test.
- integration and test.

2.3.7 Problem with Cost Estimation

Typical Problems with IT Cost Estimates

Although various tools and methodologies can aid in the creation of project cost estimates, many IT project cost estimates, particularly those for new technologies or software development, are still extremely wrong. Tom DeMarco, a well-known software development author, proposes four explanations for these mistakes, as well as possible solutions.

Estimates are done too quickly. Creating an estimate for a major software project is a difficult process that takes a lot of time and effort. Many estimates must be completed rapidly and without the presence of defined system requirements. The Surveyor Pro project for example, entails a significant amount of specialised software development. Someone would have to generate a ROM estimate and financial estimates for this project before fully understanding what information surveyors require in the system. For IT projects, the more detailed, later cost estimates are rarely lower than the earlier projections. It's crucial to keep in mind that estimates are made at

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different stages of the project, and project managers must explain why each estimate was made.

- People lack estimating experience. People who create software cost estimates frequently lack cost estimation skills, especially for large projects. They also lack sufficient accurate and trustworthy project data on which to build estimations. If a company employs effective project management procedures and has a track record of keeping accurate project data, including estimates, the company's estimates should increase. Allowing IT personnel to obtain cost estimating training and coaching will also enhance cost estimates.
- Human beings are biased toward underestimation. Senior IT experts or project managers for example, may set estimates based on their own talents forgetting that the project would involve many younger employees. Estimators may also overlook the additional costs of integration and testing on major IT projects. To ensure that estimates are not biased, project managers and top management should review estimates and ask important questions.
- Management desires accuracy. Management may request an estimate, but what they actually want is a more precise figure to assist them develop a bid to win a large contract or secure internal funds. This issue is comparable to the one mentioned in Chapter 6, Project Schedule Management, in which senior managers or other stakeholders desire project timetables to be shorter than expected. It is critical for project managers to assist in the development of accurate cost and schedule estimates and to use their leadership and negotiation abilities to ensure that those estimates are adhered to.

It's also crucial to be cautious while making first estimates. The first estimate is never forgotten by top management, while accepted adjustments are rarely, if ever, remembered. Keeping senior management informed about changing cost projections is a never-ending and critical activity. It should be a formal, albeit perhaps painful, procedure.

2.4 Project Cost Budgeting

The process of constructing a financial strategy and budget using cost estimates is known as cost budgeting. A budget is a financial tool that can be used by professionals to manage their finances. Cost budgeting is a sort of budget in which all predicted costs for a certain period are totalled. When planning new projects, project managers frequently employ cost budgeting. When generating budgets for the quarter or year, business executives and financial experts might employ cost budgeting. A cost budget can be used by these experts to analyse their project performance and spending habits.

2.4.1 Introduction to Cost Budgeting

The process of combining the projected costs of different activities or work packages to generate a permitted cost baseline is known as determine budget. The primary advantage of this method is that it establishes a cost baseline against which project performance can be measured and regulated. This procedure is carried out only once or at predetermined intervals during the project.

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To develop a total cost baseline for monitoring project performance, cost budgeting entails combining the expected costs of different schedule activities or work packages.

Although the project manager may be able to compute a total budget based on assigned resources early in the project's life cycle, it is critical to define when money will be spent. The timing of these expected costs will necessitate coordination from other elements of the company in order for the costs to be properly funded and paid for on time.

After cost estimate, cost budgeting takes place. Many projects begin with a total budget before the specifics of the project are specified, but these budgets are frequently revised following cost estimation. The iterative nature of the project management process is demonstrated by the regular adjustment of cost estimates in response to other project management activities.

On some smaller projects, cost estimating and cost budgeting are so closely linked that they are considered as a single process that can be completed in a short period of time by a single person. However, the processes are separate since the inputs, tools, procedures, and outputs for each are different. The power to impact project cost is highest at the early stages of the project, therefore early scope definition is crucial to both processes.

Cost budgeting is aggregating the expected costs of work activities at the work package level or above, based on the project's requirements and the performing organization's regulations. If bottom-up estimating was used to estimate activity costs, a time-phased budget at the activity level can be created by allocating the costs of the activities to the time periods specified in the project schedule. It's thus simple to roll activity expenses up to the work package level.

Allocating the project cost estimate to specific material resources or work items across time is part of determining the budget. These material resources or work items are based on the project's WBS's activities. The budget is determined using the project management plan, project documentation, business documents, agreements, enterprise environmental elements, and organisational process assets. The cost budgeting process' principal purpose is to create a cost baseline for monitoring project performance and determining project funding requirements. The process may also result in changes to project documents, such as additions, deletions, or modifications to the scope statement or project timeline.

To assign expenditures for each month, the Surveyor Pro project team would use the cost estimate from the below Figure, as well as the project timeline and other information. A cost baseline for this project is shown in the second figure below. A cost baseline is a time-phased budget used by project managers to track and measure costs. Contingency reserves are included, while management reserves are not. Remember that contingency reserves are set aside for known unknowns, whereas management reserves are set aside for unknown unknowns.

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Surveyor Pro Project Cost Baseline Created October 10*

	Months												
WBS Items	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1. Project Management													
1.1 Project manager	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	96,000
1.2 Project team members	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	144,000
1.3 Contractors		6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	66,300
2. Hardware													
2.1 Handheld devices				30,000	30,000								60,000
2.2 Servers				8,000	8,000								16,000
3. Software													
3.1 Licensed software				10,000	10,000								20,000
3.2 Software development		60,000	60,000	80,000	127,000	127,000	90,000	50,000					594,000
4. Testing			6,000	8,000	12,000	15,000	15,000	13,000					69,000
5. Training and Support													
5.1 Trainee cost									50,000				50,000
5.2 Travel cost									8,400				8,400
5.3 Project team members							24,000	24,000	24,000	24,000	24,000	24,000	144,000
6. Reserves				10,000	10,000	30,000	30,000	60,000	40,000	40,000	30,000	3,540	253,540
Totals	20,000	86,027	92,027	172,027	223,027	198,027	185,027	173,027	148,427	90,027	80,027	53,567	1,521,240

*See the lecture slides for this chapter on the Instructor website for a larger view of this and other figures in this chapter. Numbers are rounded, so some totals appear to be off.

Figure: Surveyor Pro project cost baseline

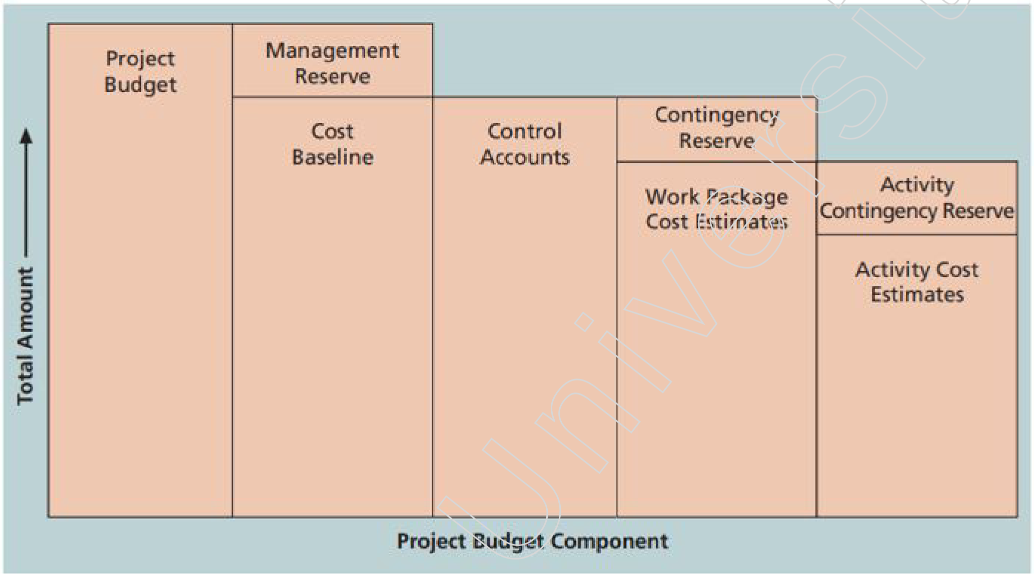

Figure: Project budget components

The various components of the project budget are depicted in the diagram above. The cost baseline plus the management reserve make up the project budget. Control accounts are cost estimates for work packages plus a contingency reserve. Activity cost estimates with activity contingency reserve make up work package cost estimates.

The majority of businesses have a well-defined budgeting process. Many businesses for example, demand that budget estimates reflect the number of FTE for each month of the project. A full-time employee (FTE) typically works 40 hours a week. One FTE could be provided by one person working full-time on a project, or two FTEs could be provided by two persons working half-time on a project.

This figure serves as the foundation for calculating overall compensation expenditures each year. Many businesses also want to know how much money they'll have to pay suppliers for labour or other items and services they've ordered. Travel, depreciation, rentals and leases, and other supplies and expenses are all popular budget components. To ensure that data is collected appropriately, it is critical to

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understand these budget categories before producing an estimate. This data is used by businesses to track expenditures between projects and non-project activity, as well as to seek for methods to cut costs. They use the data for legal and tax purposes as well.

Estimating costs for each major project activity over time not only provides a cost baseline, but it also provides project managers and top management with a foundation for project cost control, as described in the next section. Updates to the cost management plan, which is a subsidiary portion of the project management plan, may result from cost budgeting, as well as desired adjustments or clarifications. For information on using Project 2016 for cost control, see Appendix A (available on the Companion website for this text).

Budgeting for costs also offers information on project finance needs. Some projects start with all money available, while others must rely on recurring funding to avoid cash flow issues. If the cost baseline indicates that more funds are necessary in certain months than are anticipated to be available, the organisation must make modifications to avoid financial difficulties.

2.4.2 Preparation of Budget Baseline

A cost breakdown structure, unit pricing analysis, overhead costs, and cash flow may all be included in a baseline budget. It can be prepared at any level of detail depending on the size and scope of the project. Cash flow and time-phased plans for the baseline budget are established once a complete baseline schedule is created and authorised.

The scope of work, work breakdown structure, indirect expenses, project duration, and risks must all be considered when developing a baseline budget. Direct costs include labour, materials, subcontractor, and machinery costs. Indirect costs include things like operating costs, insurance, depreciation, administration, security charges, and employee pay. In order to control risks, management and contingency reserves should also be included in the budget.

Money is the fuel that projects run on. The budget is determined by the project's scope. If you're working on a little project, the budget will be minimal as well, and there may or may not be a small variation between the intended and real budget.

However, if you're working on a project with a long lifecycle and a lot of resources or manpower, remember Uncle Ben's advice to Spiderman: "With Great Power Comes Great Responsibilities." Similarly, such a fantastic endeavour necessitates a fantastic and massive money. Spiderman's job description is to manage duties, and your job description here is to manage responsibilities in the form of a budget.

Projects costing more than $1 million have a 50% higher failure rate than those costing less than $350,000.

This occurs as a result of bad budget management. Budgeting isn't something you prepare and then expect things to go according to plan. You must manage the budget throughout the project's lifecycle, which is accomplished through controlling the project baseline.

Project Baseline:

A baseline budget is a time-phased plan that incorporates all direct and indirect cost estimates. This can be used as a starting point for all future operations, as well as a tool for analysing performance and projects.

Estimates of duration, revenue, and spending are included in the baseline. It includes a breakdown of the estimated contract expenses for various deliveries. It also contains indirect costs and an estimate of how long particular tasks and activities will take to complete.

Prepare the budget according to the stakeholder's true needs and wants:

What the project's stakeholders say they need and want isn't as straightforward as it appears. If a greater understanding of how to meet these needs and wants is not achieved, both parties may have undefined aspirations and expectations.

It is nearly impossible to determine the project's needs if the Project Manager or anyone else in charge of the project is unable to comprehend the genuine aspirations of the stakeholders. You must devote as much time as is necessary to thoroughly comprehend the stakeholders' requirements and the output they anticipate from you. Only until you're certain about this can you begin planning the project's budget.

Many initiatives begin with the needs of the stakeholders in mind, but changes must be made as the needs of the stakeholders evolve. Understanding the needs and wants is critical; otherwise, the project would be disrupted for everyone involved, resulting in a budget overrun.

Prepare a surprise ready budget:

Make a list of all the potential issues. This is a really important phase.

There are many aspects over which we have no control, thus no budget can be completely designed. We all know that external environmental conditions have an impact on supply, labour, and resource pricing. Changes in finance, product or service shortages, currency exchange, and other factors, according to the project description, can all have an impact on the budget.

Because today's pricing or rates will not be the same throughout the project duration, inflation must be factored into the budgeting process. You should also have some backup plans in case something goes wrong.

Ascertain that all stakeholders have given their input. Obtaining input from stakeholders such as suppliers and vendors ensures the preparation of a more realistic budget, even if there are any unanticipated factors that may affect the pricing.

You cannot be blind sighted by such things if you are prepared for the surprises ahead of time.

Develop Relevant KPIs:

Without creating Key Performance Indicators, no budget can be managed (KPI).

The Key Perform indication shows the difference between what was planned and what was really accomplished. A baseline budget is a form of KPI that shows how

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far off the planned budget is from the actual budget. To have good project budget management, include these critical KPIs.

Cost Variance (CV) - This reflects whether the actual budget exceeds or falls short of the projected baseline.

Actual Cost (AC)or Actual Cost of Work Performed (ACWP) - This figure reveals how much money has been spent on the project so far, and it can be compared to the baseline budget.

Earned Value (EV) or Budgeted Cost of Work Performed (BCWP) - This indicates the budget that has been approved for the activities that have been completed up to a certain point in time.

Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS) - As of the reporting date, this is the expected cost of scheduled activities.

Return On Investment (ROI) - This demonstrates the project's profitability.

Follow the 3 R's (Revisit, Review, Re-forecast):

Uncertainty has become a part of Project's personality. There would undoubtedly be some difficulty or uncertainty. As a result, it's critical to keep an eye on the project budget to ensure that it doesn't slip too far out of our control or too far into our pockets. As a result, review your budget on a regular basis to identify and eliminate any variances.

A 5% budget overrun would be less difficult to fix than a 50% budget overrun. If you don't keep an eye on it and re-forecast it, it will almost certainly become a 50% budget overrun before you realise it.

The goal of a baseline budget is to maintain track of the original budget while managing and comparing it to the budget that has been planned. You'll be able to maintain the project on budget significantly better if you conduct frequent budget reviews rather than forecasting and forgetting about it.

Other resources, such as those that will be used in the project, should also be monitored in addition to the budget. If you are late in arranging resources, it will cost you billable hours, which will result in a budget overrun. Task Management Software can be used to manage resources by creating tasks for them and assigning them to the appropriate people.

Keep Everyone Informed and Accountable:

Employees are bound by limits to labour for only the amount of money that is allowed. An efficient employee would do his best job on all assignments, but with a restricted budget, he would use his inventiveness to complete his tasks and activities as efficiently as possible. Limits ensure that we get the most out of our ingenuity.

However, it is the project manager's or whoever is in charge of the project's responsibility to ensure that everyone is educated and aware of the budget and their responsibilities. Only a well-informed team can be a responsible and empowered team, both of which are critical to the project's success.

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Use Project Management Software to keep your team informed and on track with their deliverables and objectives.

2.4.3 Impact of Budget on Project Progress

Money is at the heart of any enterprise. You could certainly get more people to work on your project faster and provide more if you had a larger budget. That is why no project plan is complete unless a budget has been established. But, regardless of how big or little your project is, or how many resources and activities are involved, the process for calculating the bottom line is the same.

It's critical to develop detailed estimates for all project costs. After that, you compile the cost estimates into a budget plan. It is now feasible to track the project's progress against that budget while it is being completed.

The project budget is an important part of the entire project plan because it estimates all of the expenditures that will be incurred and when they will be incurred. The budget for the project is crucial for the following reasons:

Planning validator Because the project schedule is a major determinant of the project budget, the budget can be used to check the validity of the schedule and vice versa. When you examine the timetable from a cost standpoint, you may notice resource or budget difficulties that were previously unnoticed. In contrast, because the budget must account for all of the time a resource is required on the project, the schedule input is critical for validating the project budget.

Performance measurement You can better gauge the true performance of your project along the way and, in most situations, uncover difficulties and risks far sooner by measuring project progress against a cost baseline. This is the foundation for earned value management, a more advanced project management technique.

Managing expectations Stakeholder expectations are influenced by the budget in numerous ways. The initial budget establishes the assumption for total project costs. If the budget isn't correctly prepared, you're likely to have a problem with expectations. When the project budget is pre-determined and serves as a cost ceiling for the project, it aids in setting stakeholder expectations for the project schedule and scope.

Cash flow management Tool: The timing of your resource requirements is determined by your schedule. The accuracy of the timetable is critical to efficient resource management, especially in organisations where resources are pooled between projects or handled centrally.

Justifying Project Investment: With more projects subject to a project selection process and financial return on investment requirements, it's more critical than ever to create a cost baseline for the project and regularly monitor it.

Consequences of Improper Budgeting

All project procedures are inextricably linked to project finances. The duration and type of utilised resources, processes, and activities within the domain of a project are usually dictated by the quantity of available or required cash. When it comes to project finances, a miscalculation, bad judgement, or a lack of sufficient oversight could spell the end of the project.

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When it comes to underestimating project costs, there are numerous scenarios that could occur, all of which have negative effects. The consequences on meeting the client's expectations are first and foremost. Not being able to meet the project's agreed-upon deliverables and quality requirements may have a severe impact on your own credibility and future professional development. Furthermore, this could harm your company's reputation and have a bad impact on all members of your team.

Negative repercussions may come early in the project's life cycle, but in most situations, these issues arise unexpectedly and unexpectedly, resulting in a significant influence on the project's progress. When they are discovered, it is frequently too late to react quickly and effectively to rescue the day by making the necessary changes and adjustments to the project's initial budget.

2.4.4 Input and Output to Control Project Cost

Controlling costs is the practice of keeping track of the project's progress in order to update project costs and manage changes to the cost baseline. The cost baseline is maintained throughout the project, which is a major advantage of this method. Throughout the project, this procedure is followed.

Cost control entails (a) influencing the causes that cause changes to the cost baseline in order to ensure that the changes are beneficial, (b) recognising that the cost baseline has changed, and (c) managing the actual changes as they occur. Controlling costs entails:

- Cost performance is being tracked to see if there are any deviations from the budget.
- Assuring that all necessary modifications are appropriately reflected in the cost baseline.
- Preventing modifications to the cost baseline that are erroneous, improper, or unauthorised.
- Notifying appropriate stakeholders of changes that have been approved.

Searching into the "whys" of both positive and negative variations is part of cost control. It needs to be well-integrated with the other control processes (scope change control, schedule control, quality control, and others). Inappropriate responses to cost fluctuations for example, might result in quality or schedule issues, as well as an excessive degree of risk later in the project.

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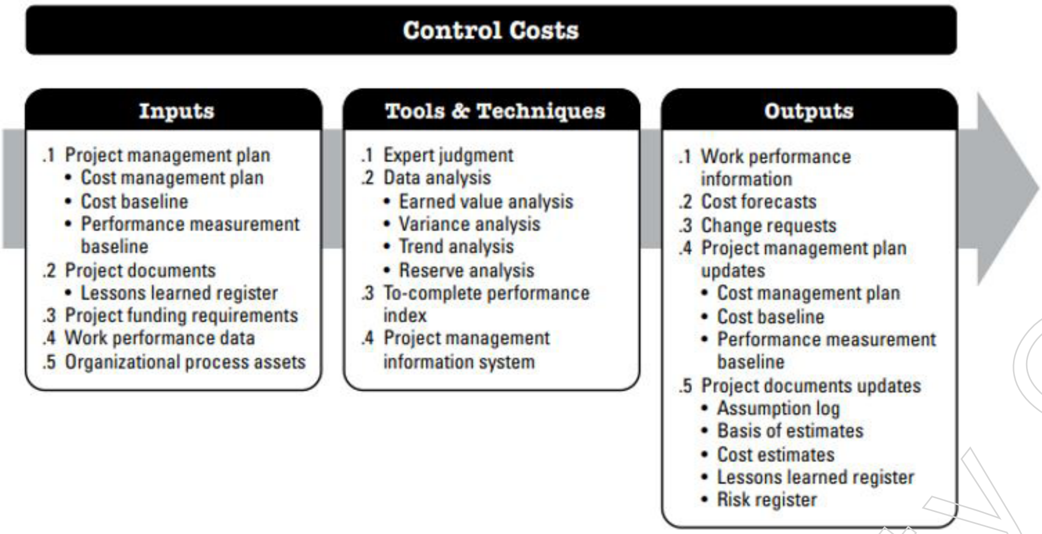

Figure: Control Costs: Inputs, Tools & Techniques, and Outputs

Monitoring cost performance, ensuring that only approved project adjustments are included in a revised cost baseline, and informing project stakeholders of authorised changes to the project that will affect costs are all part of controlling project costs. Inputs for cost control include the project management plan, project papers, project finance requirements, work performance data, and organisational process assets. Work performance data, cost predictions, modification requests, project management plan updates, and project document changes are all examples of outputs from this procedure.

Expert judgement, data analysis, project management information systems, and the to-complete performance index are some of the tools and strategies that can help with project cost control.

Updating the budget necessitates knowledge about the actual expenses incurred thus far. Any increase in the allowed budget must go through the Perform Integrated Change Control process to be approved. Other than tracking the outflow of cash, monitoring the expenditure of funds without consideration to the value of work completed for such expenditures adds little value to the project. The analysis of the relationship between the consumption of project funds and the work completed for such expenditures makes up a large part of the cost-control effort. The administration of the agreed cost baseline is crucial to effective cost control.

Project cost control includes:

- Changing the circumstances that cause the allowed cost baseline to change.
- Assisting in the timely completion of all change requests.
- Taking care of the real changes when they happen.
- Assuring that project cost expenditures do not exceed permitted financing by period, WBS component, activity, or overall.
- Cost performance is being tracked to isolate and explain deviations from the approved cost baseline.

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- Work performance is being compared to the amount of money that has been spent.
- Preventing unauthorised modifications from being reflected in cost or resource consumption reports.
- All authorised changes and associated costs will be communicated to appropriate parties.
- and
- Keeping projected cost overruns to a manageable level.

Control Costs: Inputs

Project management plan

- Plan for cost control. The cost management strategy explains how project expenses will be managed and controlled.
- The starting point for cost.
- To assess if a change, corrective action, or preventative action is required, the cost baseline is compared to actual results.
- Baseline for performance evaluation. The performance measurement baseline is compared to actual results when utilising earned value analysis to evaluate if a change, corrective action, or preventive action is required.

Project documents

The lessons learned register for example, is an example of a project document that can be used as an input in this procedure. To increase cost control, lessons learnt early in the project can be used to later phases.

Project funding requirements

The project's funding requirements include anticipated expenses as well as liabilities.

Work performance data

Data about project status, such as which costs have been authorised, incurred, invoiced, and paid, can be found in work performance data.

Organizational process assets

The following are examples of organisational process assets that can influence the Control Costs process:

- Cost control plans, processes, and guidelines, both official and informal;
- Cost control tools; and
- Monitoring and reporting systems to be employed.

Control Costs: Outputs

Work performance information

Information on how the project work is performing in comparison to the cost

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baseline is included in the work performance information. At the work package and control account levels, variations in the work produced and the cost of the work are reviewed. CV, CPI, EAC, VAC, and TCPI are documented for inclusion in work performance reports for projects utilising earned value analysis.

Cost forecasts

Stakeholders are informed about either a computed EAC value or a bottom-up EAC value.

Change requests

Following a review of the project's performance, a request for changes to the cost and schedule baselines, as well as other aspects of the project management plan, may be made. The Perform Integrated Change Control procedure is used to review and respond to change requests.

Project management plan updates

Any update to the project management plan is submitted as a change request to the organization's change control mechanism. Components of the project management plan that may necessitate a change request include, but are not limited to:

- Cost management plan: Adjustments to the cost management plan are implemented in response to feedback from key stakeholders, such as changes to control thresholds or stated levels of accuracy required in managing the project's cost.
- Cost baseline: Changes to the cost baseline are made in reaction to changes in scope, resources, or cost projections that have been accepted. Cost fluctuations might be so significant in some circumstances that a new cost baseline is required to give a meaningful basis for performance monitoring.
- Performance measurement baseline: In response to approved modifications in scope, schedule performance, or cost predictions, updates to the performance measurement baseline are made. Performance variations can be so extreme in some circumstances that a modification request is submitted to adjust the performance measurement baseline in order to give a more realistic basis for performance measurement.

Project documents updates

The following are examples of project documents that may be altered as a result of this process:

- Assumption log. Cost performance may indicate that assumptions about resource productivity and other cost-influencing factors need to be revised.
- Basis of estimates. The cost performance may indicate that the initial basis of estimates has to be revisited.
- Cost estimates. Cost estimates may need to be revised to reflect the project's actual cost efficiency.
- Lessons learned register. Techniques that were effective in sustaining the budget, variance analysis, earned value analysis forecasting, and corrective

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actions that were utilised to respond to cost deviations can all be added to the lessons learned register.

- ○ Risk register. If the cost variances have crossed, or are likely to cross, the cost threshold, the risk register may be updated.

2.4.5 Tools and Techniques to Control Project Cost

- Cost change control system. The methods for changing the cost baseline are defined by a cost change control system. It includes all of the necessary paperwork, tracking systems, and approval levels for making changes. The cost change management system should be linked to the overall change management system.
- Performance measurement. Performance measurement approaches aid in determining the degree of any differences that do arise. Earned value analysis is particularly beneficial for cost management. Determine what is generating the variance and whether or not it requires corrective action is a key aspect of cost control.
- Additional planning. Only a few projects go according to plan. Changes in the future may necessitate new or amended cost estimates, as well as an examination of alternative alternatives.
- Computerized tools. To track projected vs. actual costs and forecast the implications of cost changes, computerised tools such as project management software and spreadsheets are frequently employed.

Expert judgement, data analysis, project management information systems, and the to-complete performance index are some of the tools and strategies that help in project cost control (described in the next section on earned value management).

Expert judgment Examples of expert judgment during the Control Costs process include but are not limited to:

- ○ Variance analysis,
- ○ Earned value analysis,
- ○ Forecasting, and
- ○ Financial analysis.

Data Analysis

The following are some examples of data analysis approaches that can be used to control costs:

Earned value analysis (EVA) The baseline for performance measurement is compared to the actual schedule and cost performance using earned value analysis. To create the performance measurement baseline, EVM combines the scope baseline, cost baseline, and schedule baseline.

Earned value management (EVM) is a technique for measuring project performance that takes into account scope, time, and cost. Project managers and their teams can use a cost performance baseline to determine how well the project is meeting scope, time, and cost goals by entering real data and comparing it to the baseline. A baseline is a starting point, a measurement, or an observation that is recorded in order to be compared in the future. Actual data comprises whether or not a WBS item was finished, roughly how much of the work was accomplished, when the work began and ended, and how much the completed work cost.

Earned value management entails determining three values from a project's WBS for each activity or summary activity.

- The planned value (PV)is the budget that has been set aside for scheduled work. An example of earned value computations is shown in Table 7-3. Assume that a project included the purchase and installation of a new web server as a summary activity. Assume that, according to the plan, it will take one week to complete and will cost $10,000 in labour hours, hardware, and software. As a result, the activity's projected value (PV) for that week is $10,000.
- The actual cost (AC)is the actual cost incurred for work done on an activity over a given time period. Take for example, the purchase and installation of a new web server, which took two weeks and cost $20,000. Assume $15,000 in real costs were incurred in Week 1 and $5,000 in Week 2. These figures represent the weekly real cost (AC) of the activity.
- The earned value (EV)is a metric that expresses the amount of work completed in terms of the budget allocated to it. Because it is calculated as the sum of the PV of the finished job, it cannot be larger than the approved PV budget for a component. After one week, the earned value in Table 7-3 is $5,000.

Earned value calculations for one activity after week 1

Activity	Week 1
Earned value (EV)	5,000
Planned value (PV)	10,000
Actual cost (AC)	15,000
Cost variance (CV)	−10,000
Schedule variance (SV)	−5,000
Cost performance index (CPI)	33%
Schedule performance index (SPI)	50%

Table Earned value formulas

Term	Formula
Earned value (EV)	EV = PV of all completed work
Cost variance (CV)	CV = EV − AC
Schedule variance (SV)	SV = EV − PV
Cost performance index (CPI)	CPI = EV/AC
Schedule performance index (SPI)	SPI = EV/PV
Estimate at completion (EAC)	EAC = BAC/CPI
Estimated to Complete (ETC)	ETC = EAC − AC

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The earned value calculations in above Table are carried out as follows:

CV = 5,000-15,000 = -10,000

SV = 5,000-10,000 = -5,000

CPI = 5,000/15,000 = 33%

SPI = 5,000/10,000 = 50%

The formulas utilised in EVM are summarised in the table above. The earned value (EV) is used in the formulae for variances and indexes. Indexes are computed by dividing EV by the actual cost or intended value, while variances are generated by subtracting the actual cost or planned value from EV. After totalling the EV, AC, and PV data for all project activities, you can use the CPI and SPI to estimate how much it will cost and how long it will take to complete the project based on past performance. You can determine the estimate at completion (EAC) and estimated time to complete by dividing the budget at completion and original time estimate by the appropriate index, assuming that performance remains constant. The terms estimated time to complete and original time estimate have no standard acronyms.

Cost variance (CV)is the difference between the earned value and the real cost. If the cost variance is negative, it suggests that the task was more expensive than anticipated. If the cost variance is positive, the work was completed at a lower cost than anticipated.

Schedule variance (SV)is the difference between the earned and planned values. A negative schedule variance indicates that the job took longer than expected, whereas a positive schedule variance indicates that the work took less time than expected.

The cost performance index (CPI)is the ratio of earned value to actual cost; it can be used to calculate the estimated project cost. When the CPI is one, or 100 percent, the anticipated and actual expenses are the same—the expenditures are precisely what was budgeted. The project is over budget if the CPI is less than one or less than 100 percent. The project is under budget if the CPI is larger than one or greater than 100 percent.

The schedule performance index (SPI)is the ratio of earned to planned value; it can be used to calculate the project's estimated completion time. An SPI of one, or 100 percent, indicates that the project is on track, similar to the cost performance index. The project is ahead of schedule if the SPI is greater than one or 100 percent. The project is behind schedule if the SPI is less than one or one hundred percent.

Negative scores for cost and schedule variance, in general, imply issues in those areas. Negative figures indicate that the project is costing more or taking longer than expected. A CPI and SPI of less than one or less than 100 percent, on the other hand, signal difficulties.

The estimate at completion (EAC)—an estimated cost of completing a project based on performance to date—can be calculated using the cost performance index. Similarly, the schedule performance index can be used to estimate the project's completion time. You can also compute the to-complete performance index (TCPI), which is a measure of the cost performance that must be accomplished with remaining resources in order to reach a given target, such as the BAC or EAC. Based on each goal, there are two formulas:

To complete on plan or meet the BAC: TCPI = (BAC EV)/(BAC- AC)

To meet the current EAC: TCPI = (BAC- EV)/(EAC- AC)

Earned value data can be graphed to track project progress. After five months, the earned value chart for a one-year project is shown below. Because the data was collected or estimated at that point, the real cost and earned value lines terminate at five months. Three lines and two points are depicted in the diagram:

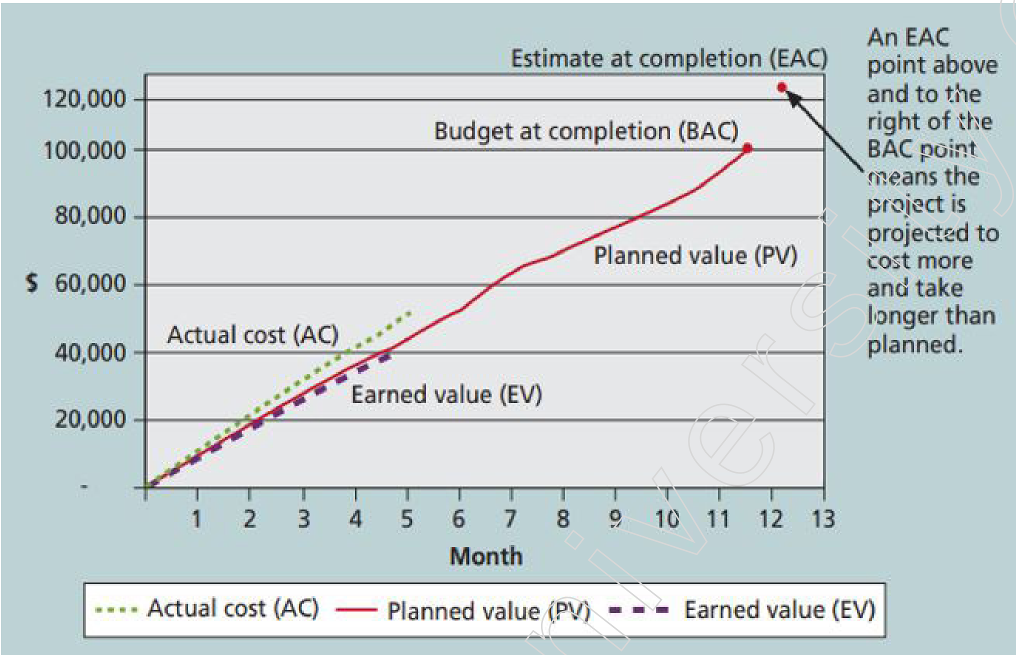

Figure: Earned value chart for project after five months

- PV stands for planned value, which is the total amount of money that has been budgeted for all activities in a given month. The projected value line stretches for the project's estimated duration and terminates at the BAC point.
- Actual cost (AC) is the total cost of all activities for each month.
- Earned value (EV) is the total earned value for all actions in a given month.
- The initial total budget for the project, or $100,000 in this case, is known as the budget at completion (BAC). On the chart, the BAC point is drawn at the original time estimate of 12 months.
- In this case, the estimated at completion (EAC) is $122,308 dollars. This figure is arrived at by dividing the BAC, in this example $100,000, by the CPI, which was 81.761 percent. This EAC point is shown on the graph with a completion time estimate of 12.74 months. This value is computed by dividing the original time estimate, in this case 12 months, by the SPI, which was 94.203 percent in this case.

Viewing earned value data as a graph allows you to see how the project is progressing. You can view the planned performance by glancing at the planned value line for example. If everything goes according to plan, the project will be completed in

Notes

12 months and cost $100,000. The actual cost line is always on or above the earned value line in the example above, indicating that costs are equal to or greater than expected. The planned value line is nearly identical to the earned value line, and it is slightly higher in comparison to the previous month. This association indicates that the project was on track until the previous month, when it slipped behind schedule.

Top managers in charge of several projects frequently like to see performance data in a graphical manner, such as the earned value chart shown in the preceding Figure. In the first scenario for example, government officials were analysing earned value charts and EACs for a variety of projects. Earned value charts help you to easily assess the performance of initiatives. Top management may opt to discontinue projects or take other remedial measures if there are substantial cost and schedule performance issues. Budget decisions rely heavily on the EACs, especially when total finances are restricted. When utilised properly, earned value management is a significant approach that aids top management and project managers in evaluating progress and making informed management decisions.

More information and calculations about earned value may be found in the PMBOK® Guide – Sixth Edition and other sites.

Trend analysis. Trend analysis looks at how a project performs over time to see if it's improving or degrading. In the form of BAC versus estimate at completion (EAC) and completion dates, graphical analysis tools are useful for analysing current performance and comparing it to future performance targets. Trend analysis approaches include, but are not limited to, the following:

- Charts. The three characteristics — intended value, earned value, and actual cost— can be monitored and reported on a period-by-period (usually weekly or monthly) and cumulative basis in earned value analysis.
- Forecasting. The project team may generate a projection for the estimate at completion (EAC) as the project develops, which may differ from the budget at completion (BAC) based on project performance. The project manager should examine the anticipated EAC if it becomes clear that the BAC is no longer realistic. Forecasting the EAC entails making predictions about future circumstances and occurrences based on current performance data and other information available at the time of the forecast. Forecasts are created, modified, and reissued based on work performance data collected as the project progresses. The project's past performance as well as any facts that could have an impact on the project in the future are covered in the work performance information.
- EACs are usually calculated using actual costs for finished work and an estimate to complete (ETC) the remaining work. Based on previous experience, the project team must foresee what it would face while doing the ETC. Manual predictions of the required EAC costs perform well in conjunction with earned value analysis. A manual, bottom-up summing by the project manager and project team is the most prevalent EAC forecasting method.
- The project manager's bottom-up EAC technique is based on the real costs and experience incurred for the finished work, and it necessitates a new estimate for the remaining project work. EAC = AC + Bottom-up ETC is the equation.

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- The manual EAC of the project manager is rapidly compared to a set of calculated EACs that represent various risk situations. The cumulative CPI and SPI numbers are commonly used to calculate EAC values. While EVM data quickly generates a large number of statistical EACs, only three of the most typical approaches are presented below:
  - Work on the ETC is expected to be completed at the planned rate, according to the EAC estimate. This EAC technique accepts the project's actual performance (whether good or negative) as indicated by actual expenses, and forecasts that all future ETC work will be completed at the budgeted rate. When actual performance is poor, the presumption that future performance will improve should only be accepted if project risk analysis supports it. EAC = AC + (BAC – EV) is the equation.
  - At the current CPI, the EAC forecasts ETC work. This approach presupposes that the project's current state may be expected to continue in the future. The ETC work is expected to be completed at the same cumulative cost performance index (CPI) as the project's previous costs. EAC = BAC / CPI is the equation.
  - Both SPI and CPI components are considered in the EAC forecast for ETC work. The ETC work will be completed at an efficiency rate that considers both the cost and schedule performance metrics in this prediction. When the project schedule is a factor affecting the ETC effort, this strategy is most useful. The CPI and SPI are weighted at varying ratios (e.g., 80/20, 50/50, or any other ratio) depending on the project manager's assessment. EAC = [(BAC – EV) / (CPI – SPI)] + [(BAC – EV) / (CPI – SPI)].

Reserve analysis. Reserve analysis is performed during cost control to assess the state of the project's contingency and management reserves to see if they are still needed or if additional reserves are required. These reserves may be used as intended as the project advances to cover the cost of risk responses or other eventualities. When opportunities are recognised and cost reductions are realised, funds may be deposited to the contingency account or deducted from the project as margin/profit.

If the indicated risks do not materialise, the project budget's unused contingency reserves may be withdrawn to free up resources for other projects or operations. During the project, new risk analysis may reveal the need to propose that more reserves be included to the project budget.

2.4.6 Performance Index of Project Cost Management

The to-complete performance index (TCPI) is a measure of the cost performance that must be achieved with remaining resources in order to reach a particular management goal, represented as the cost to finish outstanding work divided by the remaining budget. The computed cost performance index (TCPI) is obtained on the remaining work in order to reach a certain management target, such as the BAC or the EAC. The project manager should examine the anticipated EAC if it becomes clear that the BAC is no longer realistic. The EAC may replace the BAC in the TCPI calculation after it has been approved. (BAC – EV) / (BAC – AC) is the TCPI calculation based on the BAC.

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The TCPI equation is the work remaining (defined as the BAC minus the EV) divided by the funds remaining (given in the lower left) (which can be either the BAC minus the AC, or the EAC minus the AC).

The Future Cost Performance Index (FCPI) is calculated using the To Complete Performance Index (TCPI). To finish the project on time and on budget, you must adhere to it for the remaining tasks.

“TCPI is the calculated Cost Performance Index that is accomplished on the remaining work to fulfil the defined management target, such as the BAC or the EAC,” according to the PMBOK Guide.

The To Complete Performance Index is a forecast of future cost performance that you’ll need to finish the project on time and on budget. This budget could be your original approved budget (BAC) or one that you’ve just computed (Estimate at Completion).

Divide the remaining work by the remaining cash to arrive at the

TCPI=(Remaining Work) / TCPI (Remaining Funds)

Subtracting the Earned Value from the overall budget will give you the remaining work.

Total budget – Earned Value = (BAC – EV) = Remaining Work

To Complete Performance Index Table

Estimate at Completion (EAC)	Estimate to Complete (ETC)	To Complete Performance Index (TCPI)
EAC is a method to calculate the total cost of a project at its completion.	ETC is the additional cost required to complete the remaining part of the project.	To Complete Performance Index estimates how efficiently the project has to proceed to achieve the target.
Estimate at Completion is defined in the PMBOK Guide as "The expected total cost of completing all work expressed as the sum of the actual cost to date and the estimate to complete."	Estimate to Complete is defined in the PMBOK Guide as, "Estimate to Complete is the anticipated cost to finish all the remaining project work."	To Complete Performance Index is defined in the PMBOK Guide as "The measure of the cost performance that is required to achieve with the remaining resources to meet a specified management goal."
Case 1: EAC = BAC / CPI Case 2: EAC = AC + (BAC – EV) Case 3: EAC = AC + [(BAC – EV) / (CPI * SPI)] Case 4: EAC = AC + Bottom-up Estimate to Complete	ETC = EAC – AC	TCPI = (Remaining Work) / (Remaining Funds) TCPI = (BAC – EV) / (BAC – AC) Or TCPI = (BAC – EV) / (EAC – AC)

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2.5 Project Risk Management

Project risk management is the process through which project managers manage potential hazards that could have a positive or negative impact on a project. The goal is to reduce the severity of these dangers.

Any unforeseen incident that has the potential to affect people, technology, resources, or processes is referred to be a risk (including projects). Risks, unlike a recurrent problem, are accidents that might come abruptly and completely unexpectedly.

2.5.1 Introduction to Risk Management and Its Categories

The art and science of recognising, analysing, and responding to risk throughout the life of a project in the best interests of accomplishing project objectives is known as project risk management. Risk management, a usually overlooked area of project management, can often result in considerable increases in project success. Risk management can help with project selection, scope determination, and the development of realistic schedules and cost estimates. It assists project stakeholders in comprehending the project's nature, including team members in defining strengths and weaknesses, and aids in the integration of other project management knowledge areas.

Unlike crisis management, which indicates an evident threat to a project's success, good project risk management generally goes unreported. In turn, the dilemma piques the interest of the entire project team. Successful risk management does not have the same level of visibility as resolving a crisis, which is generally rewarded by management. When risk management is effective, however, fewer problems arise, and those that do arise are resolved more quickly. Outside observers may find it difficult to determine if risk management or luck played a role in the smooth creation of a new system, but project teams always know that strong risk management contributed to the success of their projects. Managing project risks necessitates a team of motivated and competent individuals. In 2008, PMI established the PMI Risk Management Professional (PMI-RMP) SM certificate to meet this demand. (For further information, go to PMI's website.)

All initiatives are dangerous because they are one-of-a-kind endeavours of varied degrees of complexity with the goal of delivering rewards. They do so while dealing with limits and assumptions, as well as conflicting and changing stakeholder expectations. In order to produce value while balancing risk and reward, organisations should choose to assume project risk in a controlled and planned manner.

The goal of project risk management is to identify and manage risks that aren't covered by other project management techniques. These risks, if left unmanaged, have the potential to cause the project to diverge from the plan and fail to meet the project's established goals. As a result, the success of a project is directly proportional to the effectiveness of Project Risk Management.

Every endeavour contains two levels of risk. Each project has its own set of dangers that can jeopardise the project's success. It's also crucial to examine the entire project's riskiness, which is determined by the combination of particular project hazards and other sources of uncertainty. Both levels of risk in projects are addressed by project risk management processes, which are defined as follows:

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- Individual project risk is an unforeseeable event or circumstance that, if it occurs, has a positive or negative impact on one or more project goals.
- Overall project risk is the impact of uncertainty on the project as a whole, resulting from all sources of uncertainty, including individual risks, and represents the exposure of stakeholders to the consequences of both positive and bad project outcomes.

If project risks exist, they might have a positive or negative impact on project objectives. Positive risks (opportunities) should be exploited or enhanced, whereas negative risks should be avoided or mitigated (threats). Unmanaged threats can cause challenges or problems such delays, cost overruns, performance shortfalls, and reputational damage. Capturing opportunities can result in time and cost savings, increased performance, or a better reputation.

Project risk can be both positive and bad. Overall project risk management strives to keep project risk exposure within an acceptable range by lowering negative variation drivers, encouraging positive variation drivers, and optimising the likelihood of meeting overall project objectives.

The need of project risk management is often overlooked in all industries, particularly in the software development business. Young H. Kwak and William Ibbs investigated project management maturity in 38 businesses across a variety of industries. Engineering and construction, telecommunications, information systems/ software development, and high-tech manufacturing were grouped into four industry groups. Participants in the survey answered 148 multiple-choice questions about their company's project management maturity in the areas of scope, time, cost, quality, human resources, communications, risk, and procurement. The maturity rating scale varied from 1 to 5, with 5 being the highest. The survey results are shown in the table below. It's worth noting that risk management was the only expertise category with a total score of less than 3. This survey revealed that all enterprises, particularly those in the information systems and software development industry, which had the lowest grade of 2.75, should put more effort into project risk management.

Maturity of project management by industrial group and knowledge area

KEY: 1 = Lowest Maturity Rating, 5 = Highest Maturity Rating				
Knowledge Area	Engineering/ Construction	Telecommunications	Information Systems	High-Tech Manufacturing
Scope	3.52	3.45	3.25	3.37
Time	3.55	3.41	3.03	3.50
Cost	3.74	3.22	3.20	3.97
Quality	2.91	3.22	2.88	3.26
Human resources	3.18	3.20	2.93	3.18
Communications	3.53	3.53	3.21	3.48
Risk	**2.93**	**2.87**	**2.75**	**2.76**
Procurement	3.33	3.01	2.91	3.33

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In Mauritius, South Africa, a similar survey was conducted with software development companies. On a scale of 1 to 5, with 5 being the highest maturity rating, the average maturity rating for all knowledge categories was only 2.29. Like the study by Ibbs and Kwak, the lowest average maturity rating, 1.84, was in the field of project risk management. The survey authors highlighted that firms in the study were frequently concerned with cost overruns and had measures in place to help control costs, giving cost management the highest maturity rating of 2.5. The authors also discovered that project maturity was directly associated to project success, and that a low-risk management rating was a common cause of project issues and failures.

To investigate software risk management strategies, the KLCI Research Group polled 260 software companies throughout the world. Some of their conclusions are summarised in the following points:

- Ninety-seven percent of the participants reported they have risk identification and assessment procedures in place.
- The key benefit of risk management, according to 80% of respondents, is anticipating and averting issues.
- Seventy percent of the companies have software development processes in place.
- A Project Management Office was found in 64% of the companies.

The key benefits of software risk management strategies stated by survey respondents are shown in the graph below. Risk management approaches enabled software project managers avoid surprises, improve negotiations, satisfy customer commitments, and reduce schedule slippages and cost overruns in addition to anticipating and preventing difficulties. Although many businesses recognise that they do a poor job managing project risk, little progress appears to have been achieved in improving risk management on a project or enterprise level during the last decade. On the subject, several books and articles have been written. Dr. David Hillson, PMP® for example, talked about the necessity of project risk management shortly after the October 2008 stock market meltdown.

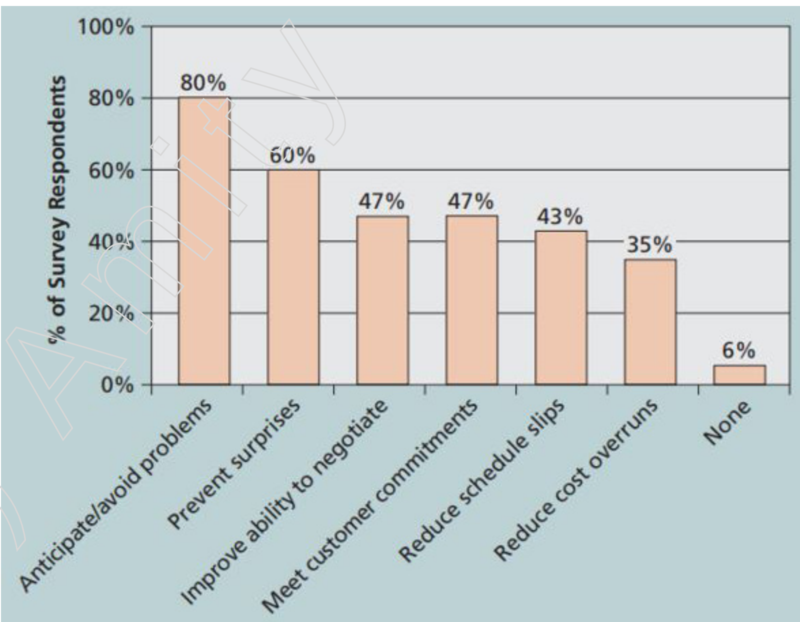

Figure: Benefits from software risk management practices

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Hillson said:

There is little doubt that dealing with the current aftermath from the credit crunch is posing significant problems to all areas of industry and society. Risk management, on the other hand, should not be viewed as a non-essential cost that may be minimised in these difficult circumstances. Instead, businesses should use the risk process' insights to ensure that they can deal with the inevitable uncertainties and emerge in the best possible position in the future. Risk management is more important than ever, with high levels of volatility enveloping us on all sides, and reducing it would be a false economy. Rather of seeing risk management as a problem, we should consider it as a critical component of the solution.

Negative risk management entails a variety of options for project managers to prevent, mitigate, change, or accept the potential effects of hazards on their projects. Positive risk management is similar to making an investment in a business opportunity. It's crucial to remember that risk management is an investment that comes with price. The amount of money a business is willing to invest in risk management activities is determined by the project's nature, the project team's experience, and the limits imposed on both. In any event, risk management costs should not outweigh the possible advantages.

Why do firms undertake IT initiatives when they are so risky? Many businesses exist today as a result of risky decisions that resulted in lucrative opportunities. When companies seek chances, they have a better chance of surviving in the long run. IT is frequently a critical component of a company's strategy; without it, many enterprises would perish. Given that all projects have risks that might result in either positive or negative results, the question is how to choose which projects to pursue and how to detect and manage project risk throughout the project's life cycle.

Several risk experts believe that in all parts of projects and personal lives, businesses and individuals should aim to strike a balance between risks and possibilities. The concept of achieving balance implies that various companies and people have varied risk attitudes. Some businesses or individuals have a risk tolerance that is neutral, some have a risk aversion, while yet others are risk takers. The utility theory of risk includes these three preferences.

Risk categories

Risk categories are the classification of hazards based on the organization's business activities, and they provide a structured picture of the underlying and prospective dangers they confront. Strategic, financial, operational, personnel, regulatory, and financial risk classifications are the most popular.

- Risk categories aid in the identification of dangers while also allowing them to become more robust and practical.
- It ensures that consumers may trace the source of an organization's underlying and possible threats.
- These categories aid in determining the effectiveness of a company's control systems across all departments.
- It guarantees that risk identification is thorough, taking into account all possible components of the underlying and future risk situations.

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- Users can utilise these categories to identify regions that are particularly vulnerable to dangers, as well as to identify standard and probable causes.
- Users can even create appropriate risk-handling procedures using risk categories.

Operational Risk

The risks of loss stemming from incorrect process execution, external challenges (weather concerns, government rules, political and environmental pressures, and so on), and other factors are referred to as operational risks. Operational hazards are defined as a sort of risk that arises from inefficiencies in an organization's business operations. Inadequate resources, failure to resolve disagreements, and other operational hazards are examples.

Budget Risk

Budget risk is a risk that emerges from an incorrect estimate of a budget allotted to a specific project or activity. Budget risk is also known as cost risk, and the consequences of this risk include delays in project completion, premature project handover, failure to provide a quality project or a compromise in project quality in comparison to what was promised to the customer, and so on.

Schedule Risk

The schedule risk occurs when the project's release or completion is not properly reviewed and addressed. Such a risk can have an impact on a project and may even be the cause of its failure, resulting in financial losses for the organisation.

Technical Environment Risk

The risk associated with the technical environment in which both customers and clients operate can be defined as the risk associated with the environment in which both customers and clients work. This risk can arise as a result of the testing environment, regular manufacturing fluctuations, and so on.

Business Risk

Business risks might arise as a result of the non-availability of a purchase order, contracts in the early stages of a project, delays in obtaining inputs from clients and customers, and so on.

Programmatic Risk

These are risks that aren't under the control of a programme or aren't covered by the operational parameters. Programmatic risks include changes in product strategy or government laws.

Information Security Risk

The violation of the confidentiality of a company's or clients' sensitive data is what information security threats are all about. A breach of such data poses a significant danger to an organisation, and it may result in not just financial losses but also a loss of goodwill.

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Technology Risk

Technology hazards can arise as a result of a rapid or full shift in technology, or even as a result of the installation of new technology.

Supplier Risk

Supplier risks arise when a third-party supplier interferes with the progress of a project because of his involvement in it.

Resource Risk

The incorrect management of a company's resources, such as its employees, budget, and so on, causes resource risk.

Infrastructure Risk

Infrastructure risk arises as a result of inadequate infrastructure or resource planning, which is why it is critical to have proper infrastructure planning in place so that the project is not harmed.

Technical and Architectural Risk

Technical and architectural risks are the kind of risks that cause an organization's entire operation and performance to fail. These dangers develop as a result of the failure of software and hardware tools and equipment used in a specific project.

Quality and Process Risk

Quality and process risk arises from the wrong application of tailoring a process and the appointment of inexperienced employees to the process, both of which undermine the process's conclusion.

Project Planning

Project planning risks are those that develop as a result of a project's lack of effective planning. This lack of project planning might lead to the project sinking and failing to meet the clients' expectations.

Project Organization

Another danger connected with the wrong organisation of a project is project organisation. This lack of project organisation may cause the project to sink and fail to achieve the clients' expectations.

2.5.2 Different Risk Management Models

Software project success rates are lower than expected in the actual world. One of the most important causes for the poor success rates is software risks that occur during the software development life cycle. Risk is a situation that has the potential to produce loss or jeopardise a project's success but has yet to occur. These issues could have a negative impact on the project's cost, schedule, or technical success, as well as the quality of the software products and project team communication. Software risk management consists of preventive critical activities taken prior to the launch of new software projects in order to improve project success rates. These preventive essential actions define software risks, as well as the impact of these risk variables, with the goal of resolving ambiguous software issues. Uncertainty might be linked to time, budget, labour, or any other risk element that arises during the software development life cycle. As a result, risk management procedures for the software project should be followed.

The goal of risk management is to limit the harm caused by risks. Risk management, like any other type of management, uses strategies and plans to achieve its goals. There are two types of risk management advantages: direct and indirect benefits. The significant risk, people, product, and cost are all addressed in direct (primary) benefits. Optimization, pragmatic decision making, better process management, and alternative techniques are among the indirect (secondary) benefits. Risk management's major goal is to prevent and control hazards before they become corrupting, hence risk mitigation, monitoring, and maintenance procedures are used throughout the process.

Several classical mechanisms of software risk management model

Barry Boehm Theory

Boehm created the concept of risk management software industry in the 1980s. The risk management process for Boehm software projects is separated into two main steps: risk assessment and risk control. The first step is risk assessment, which includes risk identification, risk analysis, and risk prioritisation; the second step is risk control, which includes risk management plans, risk and risk control resolution. We must first develop a response plan for each major risk and risk mitigation in accordance with the practical implementation of the program's activities, and in a process that will be monitored in this step.

The most common IT risks, according to Boehm, are:

- project team members are poorly trained,
- temporary planning and project budgets are not realistic,
- wrong product features are developed,
- interfaces are not user oriented,
- testing in real life situation fails.

Not all dangers should be treated in the same way. Some of the dangers highlighted are more likely to occur, while others, if realised, would have a greater impact. The categories of hazards being evaluated influence risk analysis and management. Three key factors of software risk can be differentiated from a technological and business perspective: technical, schedule/scope, and cost.

- Technical risks are related to the software product's performance, including difficulties with functionality, quality, reliability, and timeliness. Unexpected technical issues can potentially turn the project upside down, even if there are no scope adjustments in the middle of the project. Even though project managers are quite familiar with the technologies being used in the project, they can still be surprised — this component has always worked perfectly, but suddenly when you connect it with another component, it's a total mess. The lesser the chance

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of unforeseen technological constraints, the more experienced the technical personnel are, yet this risk is always present.

- Schedule and scope risks are related with the software product's development timetable and scope. Changes in scope are common in IT projects, and they're understandable in some ways: no matter how comprehensive your specification is, there will always be ideas once you've begun implementing it. Frequently, these proposals necessitate drastic revisions and change requests, which can throw any timetable into disarray. To handle the holistic view of risks, software managers should look at the risks from a new perspective and then gather all relevant data. Technical difficulties can also have an impact on the scope. If a certain functionality can't be implemented because it's technically impossible, the simplest option is to skip it, but this isn't a good idea if other components rely on it.
- Cost risks are associated with the cost of the software product during development and delivery, which covers budget, nonrecurring costs, recurring costs, fixed costs, variable costs, profit/loss margin, and realism. Once the risks have been identified, they should be evaluated on two levels: probability and impact. The project team will multiply these two dimensions together to get a risk score, which will allow the team and sponsors to discuss how to respond to each risk. The Risk Score assists us in determining the relative importance of the dangers. If the first risk has a score of \$100K and the second has a score of \$160K, the second risk poses a greater danger to the project's baselines and should be given higher priority.

SEI's Continuous Risk Management (CRM) Model

SEI (Software Engineering Institution), as a software engineering and application of authority, creates the CRM (Continuous Risks Management) model based on years of software project management expertise in the field. The CRM model proposed in the software project life cycle should pay attention to risk identification and management at all phases. Risk management is separated into five areas that repeat themselves: identification, analysis, planning, tracking, and control.

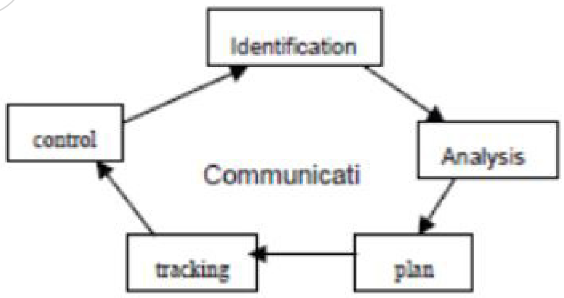

Figure: Continuous risk management model

Seven software risk management concepts are included in SEI's CRM model: (1) global vision; (2) active strategy; (3) open communication environment; (4) integrated management; (5) continuous process; (6) a unified perspective on the product; and (7) team coordination and cooperation.

The information flow direction in software risk management goes from risk identification to risk control, then back to risk identification, and so on, in a continuous cycle and flow. The characteristics of this cycle will not stop till the project is completed,

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which means risk management will continue. First, identify the issue prior to the risk into risk assessment, then identify the impact, probability, and time-consuming, risk classification and prioritisation of risk; next, risk information to make decisions on the basis of action; and real-time monitoring risk indicators and risk mitigation actions; and finally, correction in the deviation of the risk mitigation plan. Communication is at the heart of this risk model, which implies that all aspects of the project should improve risk communication, including among multiple groups, such as between project stages and so on.

To deal with the various IDEFO (Integrated Computer-Aided Manufacturing Definition referred to as the DEFO, a standard process definition) data flow diagrams from two perspectives describes the software management process risk management; external view shows the process control, input, output, and mechanism, internal view that the software management process risk management is separate from the software risk identification, risk analysis, risk planning, risk tracking, and risk management processes. The top control to decide when and how the input is a key process of change required, it must meet the entrance standards process, and the output is the result of the process of change is described in the software risk management process model through the control, input, output, and mechanism of the process described in the top control to decide when and how the input is a key process of change required, it must meet the entrance standards process, and the output is the result of the process of change is described in the top control to decide when and how the output This result has already gone through the export standard review mechanism to determine the method that will be utilised.

CMMI (Software Capability Maturity Model Integration) in the risk management process areas

The SEI CMMI is based on the CMM and is used around the world to promote the deployment of software capability maturity assessment standards. It is primarily used to assist software development process improvement and capability assessment. In CMMI Level III, the Risk Management process area has identified a crucial step in the process domain. The CMMI recommends three major measures for risk management. Prepare for risk management, identify and assess risk, and reduce risk are the three steps. It also recommends institutionalising risk management (establishing an organisational policy, planning, training people, managing configurations, relevant stakeholders, monitoring process, improvement information, and higher-level management, among other things).

The risk library is at the heart of the model, and it is updated when each activity is completed to meet the various goals. Which activities to “create and maintain risk management strategies” and the risk of database link are a two-way interaction, that is, work out the risk database by collecting data with the preceding input’s matching activities.

MSF Risk Management Model

Risk management must be active, it is a formal system process, and risk should be continuously assessed, monitored, and managed until it is addressed, or the issue is handled, according to MSF (Microsoft Solutions Framework). The most important characteristic of this model is the integration of learning activities and risk management,

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which emphasises the value of past project learning experience. According to Microsoft's research, investing just 5% of the total budget in risk management could result in a 50-70 percent chance of completing the project on time.

IEEE Risk Management Standards

It defines the software development life cycle risk management process for software firms in software development projects, as well as individual hazards that may arise during the software development process. It defines risk management as a continuous process that systematically describes and manages the software development life cycle, including the following activities: risk management planning and implementation, project risk list management, risk analysis, risk monitoring, risk mitigation, and risk management process assessment.

A broad and valuable risk management standard has been developed by the Institute of Risk Management (IRM), The Association of Insurance and Risk Managers (AIRMIC), and The National Forum for Risk Management in the Public Sector (ALARM). Risk definition, risk management, risk assessment, risk analysis, risk evaluation, risk reporting and communication, risk treatment, risk monitoring, and risk management process review are all included in the standard.

Collaborative Risk Management

Collaborative risk identification: Defining the project goals and description is one of the initial activities in a project. This information is critical for comprehending the scope and complexity of the project. This procedure is usually designed by experts who are close to the clients, such as project managers and consultants (or, in some cases, the entire project team). After the project goals have been determined, team members can begin identifying risks that may affect the project goals, including both positive and negative risks, based on their abilities and expertise. They will categorise the risk impact and probability on a scale of low, medium, and high for each detected risk. Members of the project work alone to identify risks in this procedure. This method may be beneficial for determining each member's risk attitude and risk tolerance, as well as determining the organization's overall risk tolerance. This will also allow the organisation to better comprehend future decisions and track the progress of its risk tolerance. This stage concludes with a preliminary draught of each project member's risk register, which describes the probability and impact.

Collaborative risk selection and combination: The project leader reviews all risks after creating the preliminary risk reports, and some risks may be changed, filtered, or merged. The project team and he can then assess and determine the risk dependencies (identifying the risks that may be influenced by other risks). The risk's likelihood and impact will be assessed using risk dependence theory, which will be utilised to determine the final combined risk probability and impact. The project team will be able to identify and analyse the risks in this manner and determine whether their combination will result in disproportionate project failure. The project team will build the risk probability matrix based on the scale after the selection and combination (low, medium or high). This matrix assists risk prioritising by providing a visual representation of the risk rank. The risk register is the stage's output, containing filtered risks sorted by priority.

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Collaborative risk response strategy: The project sponsors can assess and determine which risks or opportunities they want to pursue or ignore based on the organization's risk tolerance and appetite. They might also introduce new risks, delete or combine existing ones, necessitating a new risk assessment by the project team. Project sponsors may choose to monitor risk/opportunity, decrease the impact of the risk by taking some prior steps, or increase the probability/impact of the opportunities, according to the risk matrix. It would be able to assess some risk-related issues if the project sponsors made judgments concerning the identified hazards. In terms of RM activities, the decisions made at this stage will guide the rest of the organisation.

2.5.3 Tools and Techniques to Identify Project Risks

Identifying and recording particular project hazards as well as sources of overall project risk is the process of identifying risks. The documenting of existing specific project risks as well as the sources of overall project risk is a crucial benefit of this method. It also brings together data so that the project team may respond properly to hazards that have been recognised. Throughout the project, this procedure is followed. The process's inputs, tools and procedures, and outputs are illustrated in the diagram below.

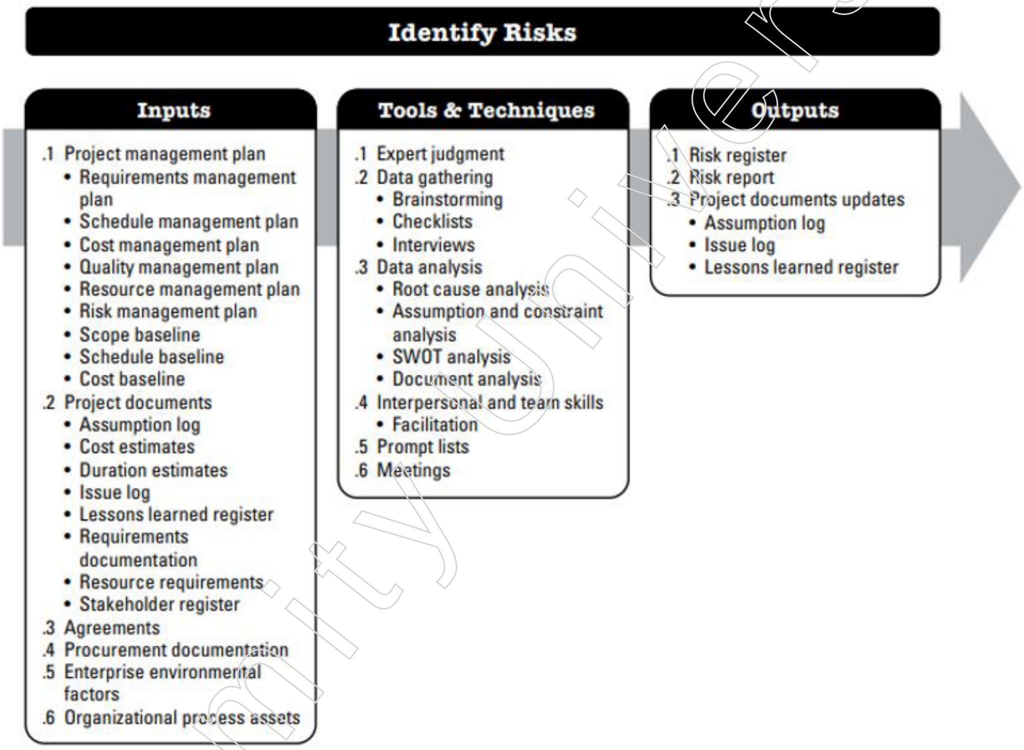

Figure: Identify Risks: Inputs, Tools & Techniques, and Outputs

Identify Hazards takes into account both individual project risks and overall project risk sources. Project managers, project team members, project risk specialist (if assigned), customers, subject matter experts from outside the project team, end users, other project managers, operations managers, stakeholders, and risk management experts within the organisation may all be involved in risk identification activities. While these individuals are frequently significant players in risk identification, all project stakeholders should be encouraged to identify specific project concerns. It's also crucial

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to include the project team so that they may create and maintain a sense of ownership and responsibility for identified individual project risks, overall project risk, and risk response measures.

A consistent structure for risk statements should be utilised for describing and recording individual project hazards to ensure that each risk is understood clearly and unambiguously to assist effective risk analysis and risk response development. Individual project risk owners may be identified during the Identify Risks process and confirmed during the Perform Qualitative Risk Analysis process. Preliminary risk responses may also be identified and recorded, and as part of the Plan Risk Responses process, they will be reviewed and confirmed.

Identifying risks is an iterative process, because as the project proceeds through its life cycle, new individual project hazards may develop, and the total project risk level may vary. The frequency of iteration and involvement in each risk identification cycle will differ depending on the situation, as outlined by the risk management plan.

Identify Risks: Tools and Techniques

Expert judgment

Individuals or groups with specific understanding of similar projects or business areas should be evaluated for expertise. Based on their previous experience and areas of knowledge, such experts should be chosen by the project manager and encouraged to assess all aspects of individual project hazards as well as sources of overall project risk. The prejudice of the experts should be considered during this process.

Data Gathering

This procedure can make use of a variety of data-gathering tools, including but not limited to:

- Brainstorming. The purpose of brainstorming is to come up with a complete list of specific project hazards as well as overall project risk sources. The project team regularly conducts brainstorming sessions, which are frequently attended by a broad group of specialists who are not members of the team. Ideas are developed with the help of a facilitator, either in a freeform brainstorming session or through more controlled methods. Risk categories, such as those found in a risk breakdown structure, can serve as a framework. Because brainstorming can result in concepts that aren't completely formed, it's especially important to make sure that hazards highlighted through the approach are clearly described.
- Checklists. A checklist is a list of things to remember, actions to take, or points to consider. It's frequently utilised to serve as a reminder. Risk checklists are created based on historical data and knowledge gathered from previous projects as well as other sources of information. They are a useful tool for capturing lessons gained from similar completed projects by documenting particular individual project hazards that have occurred in the past and may be applicable to this project. The organisation may keep a risk checklist based on its own completed projects or use industry-standard risk checklists. While a checklist is quick and easy to use, it is impossible to create an extensive one, and caution should be exercised to prevent using the checklist to avoid the effort of accurate risk identification. The

project team should additionally look at items that aren't on the list. In addition, the checklist should be checked on a regular basis to ensure that new information is added and that outdated material is removed or archived.

- Interviews. Interviewing experienced project participants, stakeholders, and subject matter experts can help identify individual project risks as well as causes of overall project risk. To encourage honest and fair contributions, interviews should be conducted in an atmosphere of trust and confidentiality.

Data Analysis

Data analysis techniques are:

- Determining the source of the problem. Root cause analysis is commonly used to identify the fundamental reasons of an issue and to design preventive measures. It can be used to discover threats by starting with a problem statement (for example, the project may be late or over budget) and then investigating whether dangers could cause that problem to materialise. Starting with a benefit statement (for example, early delivery or under budget), and analysing which opportunities can result in that benefit being achieved, the same technique can be used to locate opportunities.
- Assumption and constraint analysis. Every project and its project management plan are founded on a set of assumptions and are built within a set of restrictions. These are frequently included in scope baselines and project estimates. Assumption and constraint analysis looks into the validity of assumptions and constraints to see which ones are potentially dangerous to the project. The inaccuracy, instability, inconsistency, or incompleteness of assumptions can be used to identify threats. By reducing or relaxing a limiting factor that impacts the execution of a project or process, constraints can lead to opportunities.
- SWOT analysis. This method looks at the project from the standpoints of its strengths, weaknesses, opportunities, and threats (SWOT). It is used to broaden the scope of detected hazards by integrating internally created risks in risk identification. The technique begins by identifying the organization's strengths and weaknesses, focusing on either the project, the company, or the business area in general. The SWOT analysis then highlights any project opportunities that may develop from strengths, as well as any dangers that may arise from weaknesses. The analysis also looks at how well organisational strengths can counteract threats and whether weaknesses might stifle opportunities.
- Document analysis. An organised evaluation of project materials, such as plans, assumptions, restrictions, previous project files, contracts, agreements, and technical documentation, can help identify risks. Inconsistencies within a document or across separate papers, as well as uncertainty or ambiguity in project documents, may be indicators of project risk.

Interpersonal and team skills

Facilitation is one of the interpersonal and team abilities that can be used in this process, but it is not the only one. Many of the strategies used to identify specific project hazards and sources of overall project risk benefit from facilitation. A qualified facilitator can assist participants in staying focused on the risk identification work,

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precisely following the procedure connected with the technique, ensuring clear risk descriptions, identifying and overcoming sources of bias, and resolving any potential conflicts.

Prompt lists

A prompt list is a pre-determined list of risk categories that could result in specific project risks as well as sources of overall project risk. When applying risk identification methodologies, the prompt list can be utilised as a framework to help the project team generate ideas. Individual project hazards can be prompted using the risk categories at the lowest level of the risk breakdown structure. PESTLE (political, economic, social, technological, legal, environmental), TECOP (technical, environmental, commercial, operational, political), and VUCA (volatility, uncertainty, complexity, ambiguity) are some common strategic frameworks that are better for identifying sources of overall project risk

Meetings

A specialist meeting of the project team may be held to identify risks (often called a risk workshop). Most risk workshops involve some type of brainstorming, however depending on the level of the risk process outlined in the risk management plan, different risk identification approaches may be incorporated. The meeting will be more effective if a trained facilitator is used. It's also critical to make sure the correct people attend the risk workshop. On larger projects, the project sponsor, subject matter experts, sellers, customer representatives, or other project stakeholders may be invited. For smaller projects, risk workshops may be limited to a subset of the project team.

2.5.4 Process of Performing Quantitative Risk Analysis

To establish the extent and priority of identified hazards, qualitative risk analysis evaluates their likelihood and impact. This section explains how to create a prioritised list of hazards using a probability/impact matrix. It also shows how to use the Top Ten Risk Item Tracking technique to create an overall project risk ranking and follow trends in qualitative risk analysis. Finally, the role of expert judgement in risk assessments is discussed in this section. It's worth noting that other organisations simply categorise dangers as high, medium, or low and colour code them as red, yellow, or green based on their severity. Using the methodologies given in this section, qualitative risk analysis can be considerably improved.

Perform The process of numerically examining the combined influence of recognised individual project risks and other sources of uncertainty on overall project objectives is known as quantitative risk analysis. The main advantage of this method is that it estimates overall project risk exposure and can also provide extra quantitative risk data to aid risk response planning. This method is not required for every project, but it is followed throughout the project when it is used. Figure 11-11 shows the inputs and outputs of this procedure. The data flow diagram for the procedure is shown in Figure 11-12.

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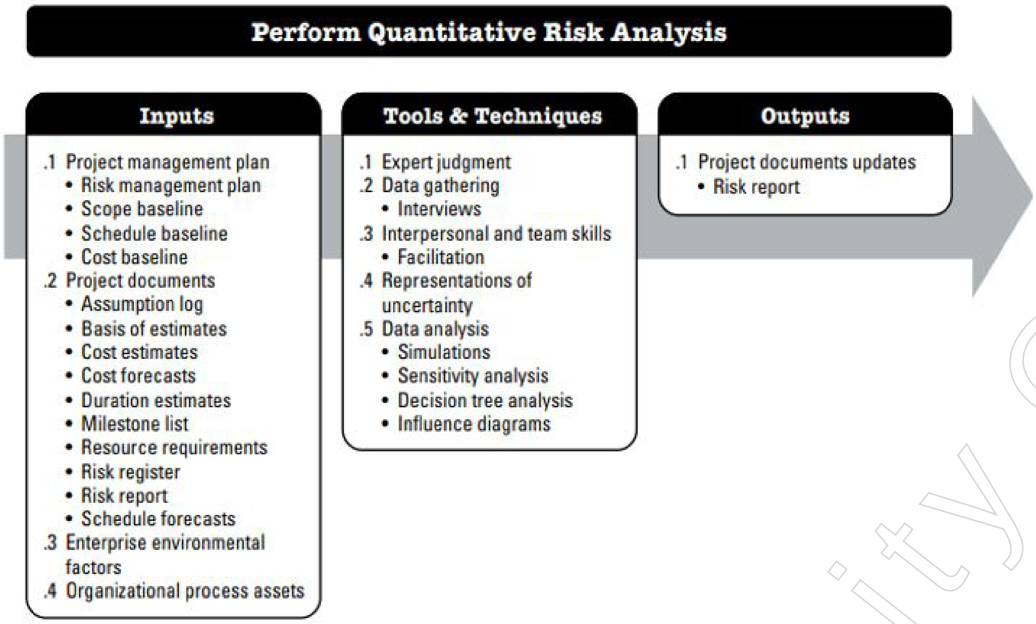

Although quantitative risk analysis is frequently performed after qualitative risk analysis, the two processes can be performed together or independently. The team may only undertake qualitative risk analysis on specific projects. Which risk analysis methodologies are utilised, depends on the nature of the project and the amount of time and money available. Large, complicated projects using cutting-edge technologies frequently necessitate a thorough quantitative risk assessment. This section focuses on employing decision tree analysis, simulation, and sensitivity analysis as quantitative risk analysis and modelling tools.

Quantitative Risk Analysis isn't necessary for every project. The availability of high-quality data about specific project risks and other sources of uncertainty, as well as a sound underlying project baseline for scope, time, and cost, are all prerequisites for conducting a thorough analysis. Quantitative risk analysis typically necessitates the use of specialised risk software as well as knowledge on how to develop and analyse risk models. It also takes up more time and money. The risk management plan for a project will specify whether or not quantitative risk analysis will be used. Large or difficult projects, strategically important projects, projects for which it is a contractual necessity, or projects for which a key stakeholder requires it are the most likely candidates. Quantitative risk analysis is the only valid method for assessing overall project risk by assessing the combined influence of all individual project risks and other sources of uncertainty on project outcomes.

Individual project risks that have been identified as having a considerable potential to harm the project's objectives by the Perform Qualitative Risk Analysis procedure are used in Perform Quantitative Risk Analysis.

The Plan Risk Responses process uses the outputs from Perform Quantitative Risk Analysis as inputs, notably in advising responses to the degree of overall project risk and significant individual hazards. Following the Plan Risk Responses process, a quantitative risk analysis can be performed to estimate the potential success of planned responses in decreasing total project risk exposure.

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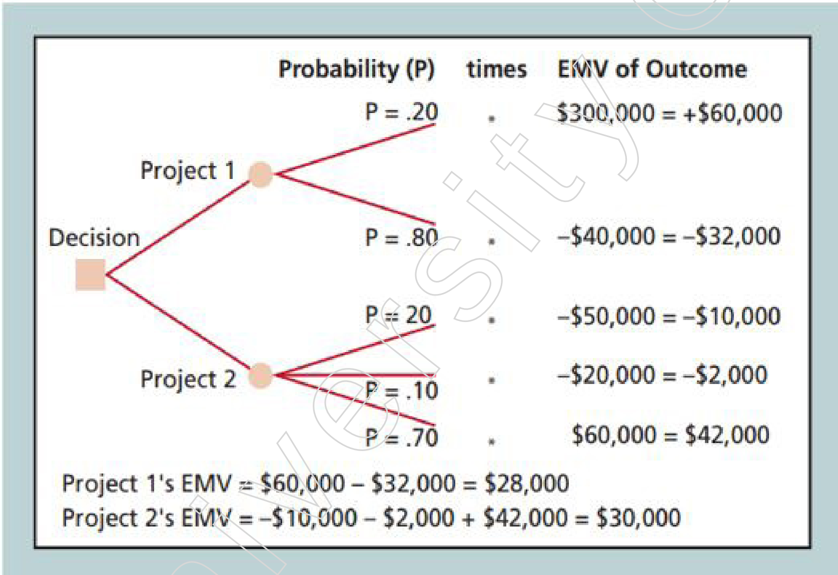
Decision Trees and Expected Monetary Value

When future outcomes are uncertain, a decision tree is a diagramming analysis tool that can help you choose the best course of action. Calculating predicted monetary value is a frequent use of decision tree analysis. The product of a risk event's probability and its monetary worth is the expected monetary value (EMV). The issue of which project(s) an organisation should undertake is used to demonstrate this topic in the diagram below. Assume Cliff Branch's company is debating whether to submit a proposal for Project 1, Project 2, both, or neither project. A decision tree with two branches, one for Project 1 and one for Project 2, might be drawn by the team. To aid in this decision, the company may assess the estimated monetary value.



Expected monetary value (emV) example

You must assess the probabilities or chances of various events occurring in order to design a decision tree and, more particularly, to compute expected monetary value. For example, the outcome of the top branch in the image shows a 20% probability (. P 5 20) that Cliff's firm would receive the contract for Project 1, which is projected to be worth $300,000 in earnings. There is an 80% chance (. P 5 80) that the firm will not receive the contract for Project 1, and the outcome is projected to be $40,000, which means that the firm will have invested $40,000 in Project 1 and will not be reimbursed if it does not win the contract. The sum of the probabilities for each project's outcomes must equal one (for Project 1, .20 plus .80). Expert judgement is usually used to evaluate probabilities. Cliff or others in his firm should have a notion of how likely certain projects are to be successful.

Project 2's probabilities and results are also shown in the graph above. Assume that there is a 20% chance that Cliff's company will lose $50,000 on Project 2, a 10% chance that it will lose $20,000, and a 70% chance that it will make $60,000. Experts would have to assess the financial amounts and probabilities once again.

To figure out the EMV for each project, multiply the probability by the outcome value for each possible outcome and add the results. To calculate the EMV for Project 1, multiply the chance by the outcome for each branch and add the results from left to right. The EMV for Project 1 in this scenario is $28,000.

.2($300,000) +.8($40,000) = $60,000 - $32,000 = $28,000

The EMV for Project 2 is $30,000.

.2(- $50,000) +.1(- $20,000) +.7($60,000) = -$10,000 -$2,000 +$42,000 = $30,000

You desire a positive EMV since it provides an estimate of the entire dollar value of a decision; the greater the EMV, the better. Cliff's firm would expect a favourable conclusion from both Projects 1 and 2 because the EMV is positive for both and might bid on both. Cliff's firm should bid on Project 2 because it has a higher EMV if it has to select between the two projects due to limited resources.

If you merely look at the prospective outcomes of the two projects in the diagram above, you'll see that Project 1 appears to be more tempting. Revenues from Project 1 may be $300,000, but profits from Project 2 could only be $60,000. Cliff would naturally want to bid on Project 1 if he wanted to take a chance. However, on Project 1, there is only a 20% probability of winning $300,000, compared to a 70% possibility of earning $60,000 on Project 2. Using EMV reduces the inclination to pursue unduly aggressive or conservative risk strategies by accounting for all conceivable outcomes and their probabilities of occurrence.

Simulation

Simulation, which uses a representation or model of a system to examine its expected behaviour or performance, is a more complex technique for quantitative risk analysis. The majority of simulations are based on Monte Carlo analysis. Monte Carlo analysis simulates the outcome of a model many times in order to get a statistical distribution of the estimated findings. Monte Carlo analysis for example, can decide that a project will finish just 10% of the time by a given date, and another date for which the project will finish 50% of the time. In other words, Monte Carlo analysis can predict whether a project will be completed on time or whether the cost will be equal to or less than a certain amount. When running a Monte Carlo analysis, you can employ a variety of distribution functions. A simplified approach is shown in the following example. The following are the basic steps in a Monte Carlo analysis:

- Gather the most likely, optimistic, and pessimistic estimates for each of the model's variables. The project network diagram for example, would be your model if you were attempting to determine the chance of fulfilling project schedule goals. For each task, you would collect the most likely, optimistic, and pessimistic time estimates. It's worth noting that this stage is similar to gathering data for PERT estimates. Instead of using the same PERT weighted average calculation, you use a Monte Carlo simulation to accomplish the steps below.
- Determine each variable's probability distribution. How likely is it that a variable would lie between the optimistic and most likely estimates? For example, if an expert assigned to a work gives you a most likely estimate of 10 weeks, an optimistic estimate of 8 weeks, and a pessimistic estimate of 15 weeks, you might ask about the likelihood of finishing the task in 8 to 10 weeks. The expert might say there's a 20% chance of it happening.
- Choose a random value for each variable, such as the time estimate for a task, depending on the probability distribution for the variable's occurrence. For

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example, in the foregoing case, you might choose a value between 8 and 10 weeks at random. 20% of the time and a duration of between 10 and 15 weeks a majority of time.

- Run a deterministic analysis or a single pass through the model with the values you've chosen for each variable. On the first run, one of the tasks in the preceding scenario might have a value of 12. On the first run, all of the other tasks would be assigned a random value based on their estimates and probability distributions.
- To get the probability distribution of the model's results, repeat Steps 3 and 4 several times. The number of iterations necessary varies depending on the number of variables and the level of confidence required in the results, but it usually ranges from 100 to 1,000. The final simulation results, using the project schedule as an example, will show you the likelihood of finishing the project within a certain time frame.

The results of a Monte Carlo simulation of a project schedule are shown in the diagram below. Microsoft Project and Risk+ software were used to run the simulation. A chart with columns and an S-shaped curve can be found on the left side of Figure 11-8. The sample count is indicated by the height of each column, which reflects how many times the project was finished in a specific time interval throughout the simulation run. The simulation was ran 250 times in this example, with a time interval of two working days. The first column reveals that only two times during the simulation was the project completed by January 29. The cumulative chance of finishing the project on or before a certain date is depicted by the S-shaped curve. The information is tabulated on the right side of Figure 11-8. For example, the project has a 10% chance of being completed by 2/8 (February 8), a 50% chance of being completed by 2/17 (February 17), and a 90% chance of being completed by 2/25 (February 25). (February 25).

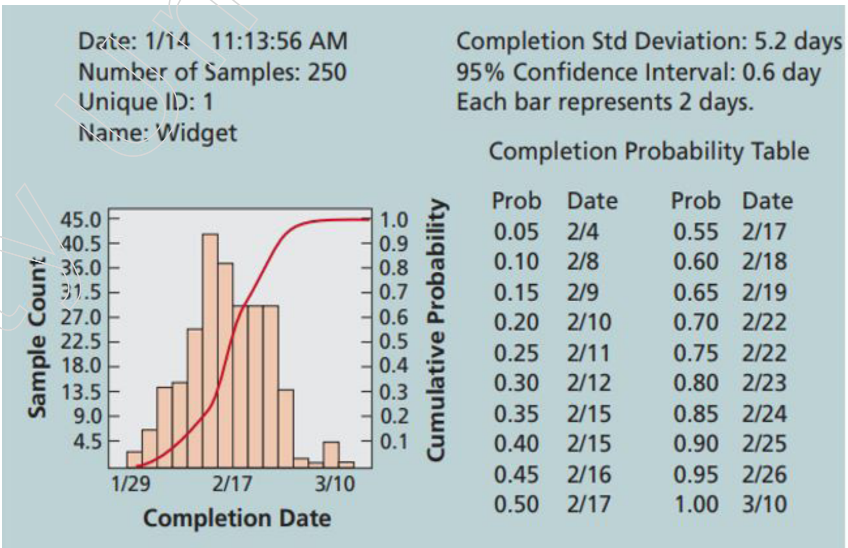

Figure: Sample Monte Carlo–based simulation results for project schedule

There are several PC-based Monte Carlo simulation software packages available. Based on the simulation results, many tools indicate the primary risk drivers for a project. This allows you to pinpoint the primary source of project schedule uncertainty. For example, a large range for a task estimate could be the source of the majority of the project schedule's uncertainty.

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Sensitivity Analysis

Many people are aware with sensitivity analysis, which is used to assess how changing one or more variables affects a result. Many people for example, use a sensitivity analysis to calculate their monthly payments for a loan based on varying interest rates or loan terms. If you borrow $100,000 for 30 years at 6% interest, what will your monthly mortgage payment be? If the interest rate is 7%, how much will the payment be? What will your payment be if you pay off the loan in 15 years at 5% interest?

Sensitivity analysis aids in determining which specific project risks or other sources of uncertainty are likely to have the greatest impact on project results. It links changes in project outcomes to changes in the quantitative risk analysis model's elements.

The tornado diagram, which shows the calculated correlation coefficient for each aspect of the quantitative risk analysis model that can influence the project outcome, is a common example of sensitivity analysis. Individual project risks, project activities with a high degree of variability, or specific sources of ambiguity are examples of this. The items are arranged in descending order of correlation strength, providing the tornado effect. Figure 2 shows an example of a tornado diagram.

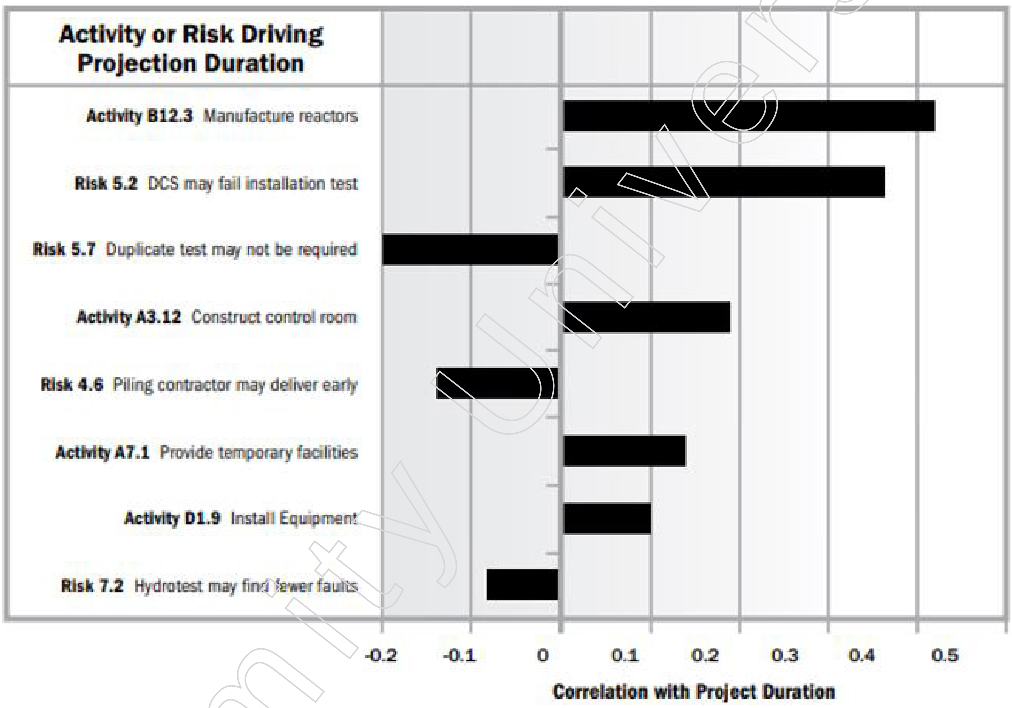

Figure: Example Tornado Diagram

Representations of Uncertainty

Quantitative risk analysis necessitates the input of specific project hazards and other sources of uncertainty into a quantitative risk analysis model.

When the duration, cost, or resource requirements for a planned activity are unknown, the model can describe the range of probable values as a probability distribution. This can take a variety of forms. Triangular, normal, lognormal, beta, uniform, and discrete distributions are the most prevalent. When choosing a probability

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distribution to represent the range of possible values for the proposed activity, care should be given.

Probability distributions may be able to cover individual project risks. Risks can also be added to the model as probabilistic branches, in which optional activities are added to represent the risk's time and/or cost impact if it occurs, and the chance that these activities actually occur in a specific simulation run matches the risk's probability. Branches are especially effective for dangers that develop without regard to any planned action. Correlation is used in the model to highlight a relationship between hazards, such as with a common cause or a logical reliance.

Updates to project documents, such as the risk report and risk register, are the key outputs of quantitative risk analysis. The quantitative analysis also gives high-level information on the likelihood of meeting specific project goals. The project manager may be prompted to make modifications to contingency reserves as a result of this information. In some circumstances, based on the quantitative analysis, projects may be redirected or discontinued, or the quantitative analysis may be utilised to assist launch other initiatives to help the existing one succeed.

2.5.5 Basic Concept of Monitoring and Controlling Risks

Monitoring risks entails ensuring that proper risk responses are implemented, tracking known hazards, detecting and analysing new risks, and assessing the project's risk management performance. The initial risk assessment is only the beginning of project risk management. Risks that have been identified may not materialise, or their chances of occurrence or loss may decrease.

It may be established that previously identified risks have a higher chance of occurrence or a higher projected loss value. Similarly, as the project continues, additional risks will be uncovered. Newly discovered hazards must follow the same steps as those discovered during the original risk assessment. Because of the relative changes in risk exposure, a redistribution of risk management resources may be required.

Individual risk management plans entail monitoring risks based on pre-determined milestones and making decisions about risks and response strategies. It may be essential to change an ineffective strategy, establish a contingency plan, or remove a risk from the list of potential dangers when it no longer exists. When project teams don't have contingency plans in place, they may resort to workarounds—unplanned solutions to risk situations.

Data analysis, audits, and meetings are some of the tools and approaches used to monitor risks. Work performance data, modification requests, and updates to the project management plan, project papers, and organisational process assets are all examples of outputs.

Implementing response plans, tracking and monitoring identified risks, identifying and responding to new risks as they arise, and improving risk management processes are all part of the Monitor and Control Risks process. This procedure additionally takes into account the following:

- Risk response strategies that are put in place as a result of risk events are evaluated.
- Risk triggers will be monitored during the project.
- Examining existing hazards to see if they've altered or if they need to be closed off.
- Remaining dangers are being monitored.
- Validity of project assumptions is being re-evaluated.
- Ensure policies and procedures are adhered to.
- Assuring that risk response and contingency plans are implemented correctly and effectively.
- Providing for contingencies.

The process of maintaining track of recognised risks, monitoring residual risks, detecting new risks, assuring the execution of risk plans, and evaluating their efficacy in decreasing risk is known as risk monitoring control. Risk monitoring and control keeps track of the risk indicators that come with putting contingency plans in place. Risk management and control is a continuous procedure that lasts the duration of the project. As the project progresses, new risks emerge, and previously predicted hazards vanish.

Successful risk monitoring and control systems give information that aids in making effective decisions prior to the occurrence of the risk. To assess the acceptability of the project's risk level on a regular basis, communication with all project stakeholders is required.

Choosing alternate tactics, developing a contingency plan, taking corrective action, or replanning the project are all examples of risk management. The risk response owner should update the project manager and the risk team leader on the plan's efficacy, any unanticipated consequences, and any mid-course corrections required to minimise the risk on a regular basis.

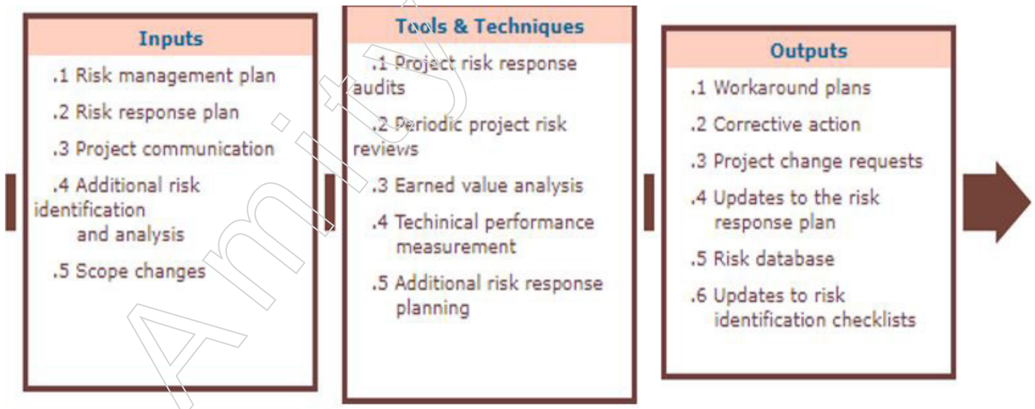

Figure: Risk Monitoring and Control

Purpose of Risk Monitoring

- Risk mitigation has gone off without a hitch.

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- Are risk response actions as effective as planned, or should additional remedies e developed?
- The assumptions made during the project are still valid.
- With the analysis of trends, risk exposure has changed from its previous state.
- There has been a danger trigger.
- Policies and procedures are followed correctly.
- There have been new dangers that were not previously recognised.

Inputs to Risk Monitoring and Control

- A risk management strategy.
- Keep a risk log.
- Other processes' outputs are included here: identified risks and owners, risk responses, triggers, and warning indicators.
- Change Requests that have been approved.
- Modifications to the scope, timeline, manner of work, or contract terms have all been approved. This may necessitate a fresh risk analysis to consider the impact on the present strategy as well as the identification of new risks and remedies.
- Information about job performance.
- Risk monitoring and risk control necessitate project status and performance reports.

Tools and Techniques for Risk Monitoring and Control

- Risk Reassessment
  - Every team meeting includes a risk assessment of the project.
  - At critical junctures, major evaluations are conducted.
  - During the course of the project, risk evaluations and prioritisation may vary. Additional qualitative or quantitative risk analysis may be required as a result of the changes.
- Risk audits

Examine and document the risk response planning's efficacy in reducing risk, as well as the risk owner's effectiveness.

- Variance and Trend Analysis

When compared to a baseline plan, this tool is used to track overall project cost and schedule performance. Risk identification and analysis should be updated if there are significant deviations. Measuring technical performance

- Reserve Analysis

Some risk events may occur as the project advances, having a positive or negative influence on cost or schedule contingency reserves. Reserve analysis compares available reserves to the level of risk that is still present at the time to evaluate whether reserves are enough.

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- Status meetings

Risk management can be addressed on a regular basis by incorporating it into project meetings.

Outputs from Risk Monitoring and Control

- Risk Register Updates
    - Risk reassessments, audits, and risk reviews' outcomes. Risk likelihood, impact, rank, and response may all be affected by the update.
    - Actual risk and risk response outcomes are saved in the project file and can be used on future projects.
- Corrective action.

The contingency plan or workaround is used as a corrective step. Workarounds are last-minute answers to unexpected dangers. Workarounds must be well-documented and incorporated into the project and risk management plans.

- Recommended Preventive Actions

Used to steer the project in the direction of the project management plan.

- Project change requests

When contingency plans or workarounds are implemented, it is common for the project plan to need to be changed in order to adapt to risks. As a result, a change request is issued, which is then controlled by overall change control.

- Organizational Process Assets Updates

The data gathered throughout the risk management processes is saved and used in future projects: Risk management strategy, probability-impact matrix, risk registry, lessons learned, and updated RBS templates are included.

- Project Management Plan Updates

As a result of the approval of requested revisions, the project management plan has been updated.

Summary

- Project Management and Direction Execution is the process of carrying out the tasks outlined in the project management plan in order to meet the project's goals.
- The project manager, along with the project management team, oversees the project's technological and organisational interfaces. Applicable to Direct and Manage Project Execution. In the project management plan, deliverables are the outcomes of activities performed to complete the project job. During project execution, data on deliverable completion and accomplishments is collected and fed into the performance reporting process. The monitoring and controlling process group will also receive the work performance data.
- A Perform Integrated Change Control status update will reveal which changes have been accepted and which have not. The project team schedules approved change requests. Approved change requests are requests to expand or reduce the

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scope of a project. Accepted change requests can affect rules, procedures, prices, budgets, and schedules. Approved change requests may necessitate preventive or remedial actions such as:

- Enterprise environmental Factors.
- Organizational Process assets

- The project management information system provides automated tools like scheduling software, configuration management, information collecting and distribution, or web interfaces to other online automated systems that you can use to Direct and Manage Project Execution.
- After gathering requirements and determining scope, the project manager designs a work breakdown structure. A WBS is a deliverable-oriented grouping of work that specifies the entire project scope. Because most projects contain many people and many deliverables, it's necessary to organise and divide the work into logical pieces. The WBS is an important project management tool because it helps plan and control project schedules, budgets, resources, and modifications. Some project managers believe that work should not be done on a project unless it is specified in the WBS. Hence, a complete WBS is critical.
- Project initiation, project planning, project execution, and project closing are all part of the standard project cycle.
- The methods and approaches for estimating activities that work for all sorts of projects are listed below.
    - Expert Judgment
    - Analogous Estimation
    - PERT Method
    - Three-Point Estimates
    - Parametric Estimating
    - Alternative Analysis
    - Publish Estimating Data
    - Vendor Bid Analysis
- After defining project tasks, the following step in project schedule management is to sequence or determine their dependencies. Enterprise environmental elements and organisational process assets are all inputs to the Activity Sequencing process. The sequencing process assesses the reasons and types of interdependence.
- Assembling and recording connections between project tasks is called sequencing. Thus, the major goal of the sequence activities process is to finish the project scope and job objectives.
- A network diagram is a schematic representation of the logical links and sequencing of project operations. Network diagrams are often known as project schedule network diagrams or PERT charts.
- The critical path method (CPM), also known as critical path analysis, is a network diagramming methodology for estimating project duration. This useful tool aids in the prevention of project schedule overruns.

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- Life cycle costing provides a big-picture view of a project's cost over its entire life cycle. This aids in the development of an accurate financial cost and benefit prediction for a project. The entire cost of ownership, or development plus support costs for a project is considered in life cycle costing.
- The approach of determining the projected annual expenses and benefits for a project, as well as the resulting annual cash flow, is known as cash flow analysis.
- The top-down method of estimating is based on the software project's overall uniqueness. Beginning at the topmost level, the project is divided into lower-level components and life cycle phases. When only global attributes are known, this method is better appropriate for early cost estimations. Macro Model is another name for top-down estimating.
- Bottom-up estimation is identifying and estimating each component separately, then merging the data to obtain a total project estimate. Because the necessary information may not be available early in the life cycle process, performing a bottom-up estimate can be difficult. This method is also more time-consuming, and it may not be feasible when time or staff are limited.
- The COCOMO model, or Constructive Cost Estimation Model, predicts the labour and time required to construct a model based on the size of the source code. It incorporates 15 multiplication factors derived from various project variables, and then uses this information to determine time and effort.
- The process of combining the projected costs of different activities or work packages to generate a permitted cost baseline is known as determine budget. The primary advantage of this method is that it establishes a cost baseline against which project performance can be measured and regulated.
- A baseline budget is a time-phased plan that incorporates all direct and indirect cost estimates. This can be used as a starting point for all future operations, as well as a tool for analysing performance and projects.
- Money is at the heart of any enterprise. You could certainly get more people to work on your project faster and provide more if you had a larger budget. That is why no project plan is complete unless a budget has been established.
- Project risk management is the art and science of identifying, evaluating, and responding to risk in order to achieve project objectives. Risk management, a sometimes overlooked aspect of project management, can significantly boost project success. Risk management can aid with project selection, scope, timeline, and cost estimation. It helps stakeholders understand the project, team members identify strengths and limitations, and integrate other project management knowledge areas.
- Risk categories are the classification of hazards based on the organization's business activities, and they provide a structured picture of the underlying and prospective dangers they confront. Strategic, financial, operational, personnel, regulatory, and financial risk classifications are the most popular.
- Risk is a situation that has the potential to produce loss or jeopardise a project's success, but has yet to occur. These issues could have a negative impact on the

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project's cost, schedule, or technical success, as well as the quality of the software products and project team communication.

- Risk management is separated into five areas that repeat themselves: identification, analysis, planning, tracking, and control.
- Identifying risks is an iterative process, because as the project proceeds through its life cycle, new individual project hazards may develop, and the total project risk level may vary.
- Monitoring risks entails ensuring that proper risk responses are implemented, tracking known hazards, detecting and analysing new risks, and assessing the project's risk management performance. The initial risk assessment is only the beginning of project risk management.
- The process of maintaining track of recognised risks, monitoring residual risks, detecting new risks, assuring the execution of risk plans, and evaluating their efficacy in decreasing risk is known as risk monitoring control.

Glossary

- ERP: Enterprise Resource Planning
- PERT: Program Evaluation and Review Technique
- PND: Project Network Diagram
- AOA: Activity-On-Arrow
- ADM: Arrow Diagramming Method
- PDM: Precedence Diagramming Method
- WBS: Work Breakdown Structure
- CPM: Critical Path Method
- ROM: Rough Order of Magnitude
- AACE: Association for the Advancement of Cost Engineering
- FTE: Full-Time-Equivalent
- EVM: Earned Value Management
- EVA: Earned Value Analysis
- AT: Actual Time
- SPI: Schedule Performance Index
- CEE: Century Effort Estimation
- FS: Finish-To-Start
- SF: Start-To-Finish
- SS: Start-to-Start
- FF: Finish-To-Finish
- SLOC: Source Lines of Code
- COCOMO: Constructive Cost Approach Model

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- LOC: Lines Of Code
- CV: Cost Variance
- SV: Schedule Variance
- AC: Actual Cost
- PV: Planned Value
- OI: Return On Investment
- ACWP: Actual Cost of Work Performed
- BCWP: Budgeted Cost of Work Performed
- BCWS: Budgeted Cost of Work Scheduled
- BAC: Budget At Completion
- EAC: Estimate At Completion
- ETC: Estimate To Complete
- CPI: Cost Performance Index
- FCPI: Future Cost Performance Index
- TCPI: To-complete performance index
- RMP: Risk Management Professional
- SEI: Software Engineering Institution
- CRM: Continuous Risks Management
- IDEFO: Integrated Computer-Aided Manufacturing
- IRM: Institute of Risk Management
- AIRMIC: The Association of Insurance and Risk Managers
- PESTLE: Political, Economic, Social, Technological, Legal, Environmental
- TECOP: Technical, Environmental, Commercial, Operational, Political
- VUCA: Volatility, Uncertainty, Complexity, Ambiguity
- EMV: Expected Monetary Value

Check Your Understanding

1. A_ _ _ _ _ _ is a deliverable-oriented grouping of work that specifies the complete scope of a project.
   a) PLC
   b) Project Management
   c) Scope Management
   d) Work Breakdown Structure (WBS)
2. _ _ _ _ _ _is the process of breaking down project deliverables into smaller, more manageable pieces.
   a) WBS

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b) Risk Management

c) Decomposition

d) Quality management

3. The project start-up is often referred to as_ _ _ _ _ _

a) Project Initiation

b) Project Planning

c) Project Execution

d) Project closing

4. _ _ _ _ _ _is the stage at which specific plans are made..

a) Project Cost

b) Project Planning

c) Project Management

d) None of the above

5. The practice of finding and documenting linkages between project tasks is known as_ _ _ _ _.

a) PERT Method

b) Sequence Activities

c) PLC

d) Scheduling

6. The process of finding and recording linkages between project activities is known as_ _ _ _ __ _.

a) Activities

b) Sequencing

c) Scheduling

d) None of the above

7. The_ _ _ _ _ _ _ _ _ is a network diagramming methodology for estimating project duration.

a) WBS

b) Project Planning

c) Critical Path Method (CPM),

d) Activities

8. _ _ _ _ _is a method for balancing cost and schedule trade-offs in order to get the most schedule compression for the least amount of money.

a) Project Life Cycle

b) Project Cost

c) CPM

d) Crashing

9. _ _ _ _ _also known as top-down estimates, use the actual cost of a previous, similar project to estimate the present project's cost
   a) Three Point Estimates
   b) Scope Planning
   c) Analogous estimates
   d) Bottom-up

10. _ _ _ _ _ _to estimate project expenses, a mathematical model is used to incorporate project characteristics.
    a) Parametric estimating
    b) Bottom-up estimating
    c) Three-point estimate
    d) None of the above

11. _ _ _ _ _ _ _ _provides a big-picture view of a project's cost over its entire life cycle. This aids in the development of an accurate financial cost and benefit prediction for a project.
    a) Life cycle costing
    b) Project Costing
    c) Both a and b
    d) None of these

12. The approach of determining the projected annual expenses and benefits for a project, as well as the resulting annual cash flow, is known as_ _ _ _ _
    a) Indirect Costs
    b) Cash flow analysis
    c) Sunk Cost
    d) All of the above

Exercise

1. What are the tools and techniques for directing and managing project work?
2. Define tools and techniques for creating work break down structure.
3. What are the activities during project management?
4. Define tools and techniques for estimating the activity durations.
5. What are the sequence activities during project management?
6. What are the tools and techniques for sequence activities during project management?
7. Define Gantt Chart, CPM Technique with Example
8. Explain introductory concept of project cost estimation
9. What are the key concepts in project cost management?

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10. Explain trends and emerging practices in project cost management.
11. Compare various techniques of project cost estimation.
12. What all are the tools related to project cost management?
13. Define COCOCMO cost estimation model?
14. Explain problems faced during cost estimation.
15. Define cost budgeting.
16. What all are the preparation of budget baseline?
17. What is the impact of budget on project progress?
18. What is input and output to control project cost?
19. What all are the tools and techniques to control project cost?
20. What are risk management and its categories?
21. What all are the different risk management models?
22. Write down the tools and techniques used to identify project risks.
23. What is process of performing quantitative risk analysis?
24. What are the basic concepts of monitoring and controlling risks?

Learning Activities

- Why cost budgeting is the most important aspect of business?
- Define the Performance Index of Project Cost Management.
- Which Techniques of Project Cost Estimation is more effective and why?

Check Your Understanding - Answers

1. d
2. c
3. a
4. b
5. b
6. a
7. c
8. d
9. c
10. a
11. a
12. b

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Module - III: Project Planning

Learning Objectives:

At the end of this module, you will be able to understand:

- Basic Concept of Project Scheduling and Its Benefits
- Techniques of Scheduling Project
- Basic Concept of Schedule Control
- Linear Responsibility Chart (LRC)
- PERT Chart
- Gantt Chart, CPM Technique with Example
- Introduction to Risk Management
- Risk Response Planning, Developing Risk Management Plan
- Key Concepts of Project Resource Management
- Trends and Emerging Practices in Project Resource Management
- Concept related to HRP, Acquiring Resources
- Concept of Developing and Managing the Team
- Real Time Case Study: Discussing the Tools and Techniques for Directing and Managing Project Work, Creating a Project Charter, Estimating the Activity Resources
- Introductory Concept of Communication Planning
- Need of Communication Requirement Analysis
- Different Communication Models
- Information Distribution, Managing Stakeholders

Introduction

In a production or industrial process, scheduling is the process of organising, managing, and optimising work and workloads. Plant and machinery resources are allocated, human resources are planned, production processes are planned, and supplies are purchased using scheduling. Forward scheduling is the process of arranging tasks from the time resources become available to the time they are shipped or due. Backward scheduling involves determining the start date and/or any capacity changes required by planning work from the due date or required-by date.

As a fundamental time-management tool, a schedule or timetable comprises of a list of times at which possible tasks, events, or activities are intended to occur, or of a sequence of events in the chronological order in which such things are intended to occur. The act of constructing a timetable - selecting how to sequence these tasks and how to allocate resources among the various tasks - is known as scheduling, and the person in charge of generating a specific schedule is known as a scheduler. Making and sticking to schedules is a human activity that dates back thousands of years.

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A project schedule is a timetable that organises tasks, resources, and due dates in the most efficient order possible to ensure that a project is completed on time. During the planning phase, a project schedule is prepared, which comprises the following:

- A project timetable containing start, finish, and milestone dates
- The time and effort required to complete the project's deliverables
- The related costs, resources, and dependencies for each task
- The members of the team that are in charge of each task

Project schedules are developed and tracked using project scheduling software, which includes critical features that enable project managers to track task, resource, and cost progress in real time. They can also assign work, link related tasks, view dashboards, and allocate resources, among other things.

The HRP procedure is divided into four phases. They include analysing current labour supply, projecting labour demand, balancing predicted labour demand with supply, and assisting in the achievement of organisational objectives. HRP is a crucial investment for any company since it allows them to remain productive and profitable.

Many businesses do not have effective procurement management systems in place. This is frequently the outcome of organisations depending on manual, paper-based processes rather than adopting digital solutions that automate activities.

High processing expenses, missing papers, delayed approval cycles, missed discount opportunities, and uncontrolled costs plague manual procurement management methods. Supplier relationships suffer as a result of the instability, with ineffective dispute settlements, poor vendor management, late payments, and other issues.

Communication and management are inextricably interwoven. Because communication is the process of two or more individuals exchanging information, and management is the act of managers disseminating information to their employees. Furthermore, communication and management are inextricably linked. It is a method of extending control and a key component of project management.

The cycles involved with the development of a task from start to completion can be actually compelled without the benefit of a good communications management system. It also provides the core project integrity required to provide information assistance to all members of the team. Inside the association, this data must flow descending, upward, and horizontally. Furthermore, it serves as both the master and the servant of project control. It is the component that takes action, the integrator of the project's assembly process. The project manager leads the multidiscipline of the plan and construct team, as project management is both an art and a science.

3.1 Concept of Project Scheduling

Schedules can be beneficial for both short-term planning, such as a daily or weekly schedule, and long-term planning, such as planning for months or years. They are frequently created using a calendar, on which the individual creating the schedule can write down the dates and hours for specific events. Schedules that do not specify

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particular times for occurrences may instead provide an algorithmically predicted order in which events can or must occur.

Schedules can be unpredictable in some instances, such as when everyday life is influenced by environmental elements beyond human control. People who are on vacation or otherwise attempting to relax and reduce stress may choose to forego having a schedule for a period of time.

3.1.1 Basic Concept of Project Scheduling

One of the most common issues and sources of friction among managers is the requirement to complete projects on time. Part of the reason for the prevalence of scheduling issues is that time is easily measured and recalled. You can argue about scope and cost overruns to make actual numbers look closer to estimates, but once a project schedule is established, people remember the projected completion date, and anyone can quickly estimate schedule performance by subtracting the original time estimate from how long the project actually took to complete. People frequently compare planned and actual project completion times without accounting for approved project adjustments. The variable with the least amount of freedom is time. Whatever occurs in a project, time passes.

This team-building tool has a feature that deals with attitudes toward structure and deadlines. Some people prefer detailed schedules that place a high value on task accomplishment. Others, on the other hand, prefer to keep things open and adaptable. Schedules are viewed differently by different cultures and even countries. In some nations for example, companies close for several hours every afternoon for siestas. Distinct countries may have different holidays, which implies that at certain times of the year, not much work will be done. Labour ethic may differ according to culture; some cultures encourage hard work and rigorous schedules, while others appreciate the capacity to stay relaxed and adaptable.

With so many potential schedule conflicts, it's critical for project managers to adopt effective project schedule management. Simply put, project schedule management refers to the procedures that must be followed to ensure that a project is completed on time. Project schedule management involves six basic processes:

- The policies, methods, and documentation that will be utilised for planning, executing, and managing the project schedule are all part of the planning schedule management process.
- Defining activities entails determining the particular tasks that project team members and stakeholders must do in order to achieve project deliverables. An activity or task is a type of work item that is typically included on a work breakdown structure (WBS) and has a set length, cost, and resource required.
- Identifying and recording the links between project tasks is part of the sequencing process. Updates to project papers, requirements, and a resource breakdown structure.
- Estimating activity durations entails calculating the number of work periods required to execute specific tasks.

- To build the project schedule, analysts must examine activity sequences, resource requirements, and activity duration estimations.
- Controlling the timetable entails keeping track of and managing project schedule changes.

Project schedule is a thorough plan that shows how and when the project will deliver the products, services, and outcomes specified in the project scope. It is used for communication, managing stakeholder expectations, and reporting performance.

A scheduling method, such as critical path or an agile approach is chosen by the project management team. The project-specific data is then entered into a scheduling tool to produce a schedule model for the project, which includes activities, intended dates, durations, resources, dependencies, and limitations. As a result, a project schedule is created.

For smaller projects, defining activities, sequencing activities, estimating activity durations, and building the schedule model are all considered as a unified process that can be completed in a short amount of time by a single person. Because the tools and techniques used in each step differ, these procedures are given as separate pieces. The Practice Standard for Scheduling delves more into several of these processes.

When at all possible, the detailed project schedule should be adaptable throughout the project to accommodate new information, improved risk understanding, and value-added activities.

Trends and Emerging Practices in Project Schedule Management

With high levels of uncertainty and unpredictability in a fast-paced, highly competitive global marketplace where long-term scope is difficult to define, a contextual framework for effective adoption and tailoring of development practices to respond to changing environmental needs is becoming even more important. Adaptive planning establishes a strategy but recognises that once work begins, priorities may shift, and the plan must adjust to reflect this new information.

Some of the newer project scheduling systems include, but are not limited to, the following:

Iterative scheduling with a backlog. This is a type of rolling wave planning that is based on adaptive life cycles, like the agile product development strategy. The requirements are defined in user stories, which are prioritised and revised immediately before construction, and the product features are built in time-boxed work periods. This method is frequently used to provide incremental value to customers or when many teams may work on a big number of features with few interrelated requirements at the same time. As seen by the broad and expanding usage of adaptive life cycles for product development, this scheduling strategy is suitable for a wide range of projects. This technique has the advantage of welcoming modifications throughout the development life cycle.

On-demand scheduling. This method, which is commonly employed in a Kanban system, is based on lean manufacturing's theory-of-constraints and pull-based scheduling ideas to limit a team's work in progress in order to balance demand versus delivery throughput. On-demand scheduling does not rely on a previously created

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timetable for the creation of the product or product increments, but instead pulls work from a backlog or intermediate queue of work to be completed as resources become available. On-demand scheduling is frequently utilised in operational or sustainment contexts for projects that incrementally grow the product, and when jobs may be made reasonably similar in size and scope or grouped by size and scope.

Project scheduling necessitates the identification of all tasks required to finish the project, as well as the earliest time each work can be accomplished. A specific amount of time is normally made aside when drafting a timetable as a contingency against unforeseen days. Scheduling variance, often known as float, is a key notion in the critical path technique.

Because estimations are utilised to determine timings, a schedule developed using critical path methodologies is frequently not realised perfectly. If one mistake is made, the results of the analysis may vary. If the estimates are taken at face value and revisions are not handled swiftly, this could cause problems with the project's implementation. However, critical path analysis is structured in such a way that every change's deviation from the original schedule may be measured, and its impact mitigated or corrected for. The As Built Critical Path (ABCP), which analyses the particular causes and implications of changes, is a significant part of project post-mortem analysis.

Construction, aerospace and defence, software development, research initiatives, product development, engineering, and plant maintenance are just a few of the industries that employ CPM. This mathematical analysis method can be used on any project with interdependent activities. Although the original CPM programme and methods are no longer in use, the phrase is now used to describe any method for analysing a project network logic diagram.

"Crash duration" is a word that refers to the minimum amount of time that an activity can be scheduled. It is accomplished by allocating more resources to the completion of that activity, resulting in less time spent and, in many cases, a lower quality of work because the emphasis is on speed. The conventional model for crash duration is a linear relationship between cost and activity time; however, in many circumstances, a convex function or a step function is more appropriate.

A schedule is a list of actions from a collection of transactions in a database, and scheduling is how multiple processes are assigned in computer multitasking and multiprocessing operating system design. This type of scheduling is built within the computer programme, and the user may have no idea what tasks are being completed or when. The activity of a network scheduler or packet scheduler, an arbiter programme that governs the transfer of particular pieces of information in the computer, are examples of scheduling operations and challenges in computing. Scheduling for open shops, job shops, and flow shops A scheduler's responsibilities include solving scheduling difficulties and solving optimization problems in computer science.

3.1.2 Benefits of Project Scheduling

The project management schedule is the method for carrying out activities while taking into account both time and resource constraints. This verifies that what has occurred has occurred, and that action is being taken to ensure that the project is completed on time. PERT (Program Evaluation and Research Technique), CPM (Critical Path Method), and other software-based project scheduling approaches are common misconceptions about project management. Scheduling software is only a small component of project management, according to a more realistic perspective.

The advantage of a project management schedule is that it allows for much more efficient scheduling and expense management, resulting in considerably less time, more detail, or both. As a result, a project can be better planned and completed. This allows you to focus on other areas of project management.

Every project management organisation or project manager performs project planning. However, they frequently overlook project scheduling. Although project scheduling is a minor part of project management, it is unquestionably the most significant approach for meeting the project deadline. There are numerous advantages to project scheduling, including those listed below.

It entails project coordination. The importance of integration in the project management schedule cannot be overstated. Integration ensures that all aspects of a project management schedule, such as human resources, equipment, and supplies, are in sync.

Scope management- The scope of a project is critical since it dictates not only what is included but also what is excluded. As a result, maintaining scope management is critical. It is taken care of according to the project timetable.

Quality management- “Conformance to requirements/specification” is the simplest definition of quality. The client is more likely to be happy with the project’s output if the requirements for the project’s goods are compatible with the clients’ genuine, or perceived, demands. The completion of a project is made easier and more convenient with the use of a project schedule. As a result, the quality management goal is readily achieved because all criteria and specifications are taken into account prior to drawing a timetable.

Time management- Time management is critical to every project’s success. The goal of a project management schedule is to keep track of time, start dates, and due dates.

Reduces Lead Time: The project schedule lays out the tasks that must be accomplished in order of priority or concurrently with other tasks. This keeps the rest of the team informed and prevents any delays or postponements, decreasing the lead time.

Cost Reductions: It allows you to keep track of your resources by preventing jobs from overlapping. It also leads to more efficient resource consumption and prompt return of unused resources, lowering expenses.

Facilitates Productivity: Resources that are not optimally employed might be assigned to extra tasks after examining logical connectivity between the jobs, resulting in increased productivity.

Foresee problems in Advance: A detailed project schedule allows you to anticipate any issues relating to resource under- or over-utilization and guarantees that you get the most out of your resources.

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Sets a Goal: A project timeline allows us to create short- and long-term goals, as well as provide direction and vision while working on the project. It also informs everyone in the team on the principles and procedures for achieving these objectives. The project would be ill-defined without a schedule. As a result, it is difficult to manage and organise the duties in order to complete them successfully.

Current Progress Updates and Alerts: The project schedule is a rough sketch that lays the groundwork for the project. A project may face problems, but how can it go in the right path if there is no route map? In this scenario, a project schedule can assist in determining how far off track a project has gotten and viable solutions for getting it back on track.

3.1.3 Techniques of Scheduling Project

The process of defining policies, methods, and documentation for planning, developing, managing, executing, and controlling the project schedule is known as plan schedule management. The main advantage of this method is that it provides guidance and direction on how the project schedule will be managed throughout the duration of the project. This procedure is carried out only once or at predetermined intervals during the project.

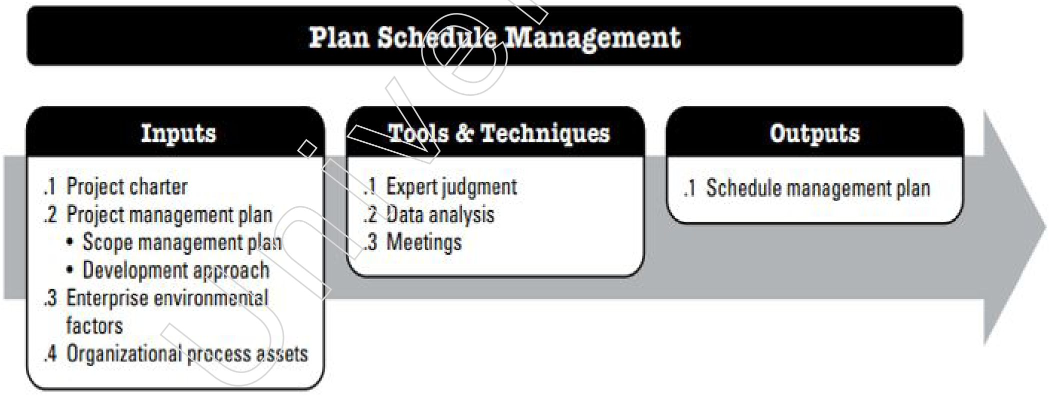

Figure: Plan Schedule Management: Inputs, Tools & Techniques, and Outputs

Planning how the schedule will be managed throughout the project's life cycle is the first stage in project schedule management. Project schedules develop from the foundational documents that kick off a project. Project start and conclusion dates are frequently mentioned in the project charter, and these dates serve as the beginning point for a more thorough timetable. The project team develops the schedule management plan using expert judgement, analytical methodologies, and meetings after examining the project management plan, project charter, enterprise environmental variables, and organisational process assets.

Like the scope management plan, the schedule management plan can be casual and broad or formal and comprehensive, depending on the project's demands. In general, the following information is included in a schedule management plan:

- Project schedule model development: A schedule model, which incorporates project activities with anticipated durations, dependencies, and other planning information that may be utilised to create a project schedule, is included in many

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projects. For more on using Microsoft Project 2016 to develop a scheduling model, see Appendix A (available on the Companion website for this text).

- Level of accuracy and units of measure: This section examines how precise schedule estimations should be and determines whether time is measured in hours, days, or another unit.
- Limits of control: For the purpose of monitoring schedule performance, variance thresholds such as 10% are specified.
- Performance measurement rules: If team members are expected to track the percentage of work accomplished for example, this section explains how to do so.
- Reporting formats: This section explains the format and frequency of the project's schedule reports.
- Process descriptions: The schedule management plan also explains how all of the procedures in the schedule management system will be carried out.

The Program Evaluation and Review Technique (PERT), Critical Path Method (CPM), Resource Constrained Project Scheduling Problem (RCPSP) Model, Search based techniques, and Event Based Scheduler Software Project Management Net (SPMnets) Model are just a few of the well-known project scheduling techniques.

The fundamental goal of examining all of these existing strategies is to deliver the project on time, distribute work, and manage human and technological challenges. To meet end user objectives and manage projects, each technique is built on a certain premise.

Program Evaluation and Review Technique (PERT)

PERT is a method for analysing the tasks involved in completing a project, particularly the time required to accomplish each work, and determining the shortest time required to finish the entire project.

The dependencies (precedence relationships) between the work breakdown structure parts are explicitly defined and made visible in the PERT chart. It allows identifying the critical path and making it visible easier, as well as identifying the early start, late start, and slack for each task. Due to a better understanding of interdependence and increased overlapping of activities and tasks where possible, PERT might potentially minimise project length. For decision-making purposes, the enormous amount of project data can be grouped and displayed in a diagram.

PERT has a number of major drawbacks, including the fact that it is difficult to scale for smaller projects. Most PERT/CPM charts lack a period, making it difficult to show status, however colours can help (e.g., specific colour for completed nodes). The network charts are typically huge and bulky, requiring multiple pages to print and particular paper sizes. PERT charts are no longer used to manage projects as they grow cumbersome, and there can be hundreds or thousands of actions and individual dependent relationships.

Uncertainty in Project Scheduling:

However, due to unpredictability, a real-life project will never execute exactly as planned during execution. It could be ambiguity caused by subjective estimations that

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are prone to human mistake, or variability caused by unanticipated events or dangers. Because of this scheduling unpredictability, PERT may deliver erroneous information about the project completion time. This inaccuracy is significant enough that such estimations are useless.

One way to improve solution resilience is to integrate safety in the baseline schedule, which will allow the system to absorb any expected disturbances. This is referred to as proactive planning. Pure proactive scheduling is a pipe dream; including safety into a baseline schedule that allows for every possible interruption would result in a baseline schedule with a long make-span. A second approach, reactive scheduling, involves creating a procedure for reacting to interruptions that the baseline plan cannot absorb.

Critical Path Method (CPM)

A Critical Path Method is a project management method that determines where potential delays are most likely to occur by formulating a time schedule for a project. The method contains a step-by-step procedure that gives the developer a visual picture of potential bottlenecks as the project progresses.

CPM is frequently used in industry for project scheduling, monitoring, and management, and it determines slack and float times. A project manager can identify the actual dates for each action, compare what should happen to what is happening, and respond accordingly.

The project duration is determined by CPM, which minimises the sum of direct and indirect costs. It determines whether activities can occur concurrently and can establish many, equally important pathways. A network of activities and their outcomes can be depicted.

CPM's key drawbacks/flaws include their complexity, which increases with the size of the project. Personnel scheduling and resource allocation are not handled by this position. The crucial path isn't always obvious and must be carefully assessed. Estimating activity completion times might be challenging.

Program Evaluation and Review Technique (PERT) vs. Critical Path Method (CPM):

CPM and PERT (Program Evaluation and Review Technique) are both project management technologies that allow users to plan, monitor, and update their projects as they advance. There are numerous parallels and distinctions between the two.

Both PERT and CPM employ network diagrams and follow the same methods to plan the scheduling of individual activities that make up a project. They may also be used to identify the earliest and latest start and finish times for each activity.

The differences between PERT and CPM include the fact that PERT is probabilistic whereas CPM is deterministic. Estimates of activity length in CPM are based on past data; however, estimates in PERT are uncertain, and we talk about duration ranges and the possibility that activity duration will fall within that range, whereas CPM focuses on the Time/Cost trade-off.

Resource-Constrained Project Scheduling Problem (RCPSB) Model:

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The scheduling of project activities according to precedence and resource restrictions in order to fulfil the objective(s) in the best possible way is referred to as resource-constrained project scheduling.

The RCPSP entails arranging a project's length while adhering to PERT/CPM zero-lag finish-start precedence restrictions and constant availability constraints on the required set of renewable resources.

Search-based Techniques

Search-based strategies for resource allocation optimization in software projects: Search-based techniques can be used to optimise resource allocation in software engineering projects. The encoding method, the hill climbing strategy, and the simulated annealing approach are three significant search-based strategies.

Experiments that change the number of project teams led to the development of search-based approaches. While double-sized teams do not boost performance when overall staffing levels are low, when overall staffing levels are high enough, double-sized teams have proven to be effective.

Event Based Scheduler (EBS)

The goal of Event Based Scheduler (EBS) is to create a flexible and effective software project planning methodology. A work list and a projected employee allocation matrix are used in this approach to depict a plan. Both job scheduling and employee allocation concerns can be addressed in this manner.

The start of the project, when resources are freed from completed tasks, and when employees join or depart the project are all considered events in the EBS.

The EBS's main concept is to adjust personnel allocation at events while keeping it constant at non-events. The EBS technique allows for the simulation of resource conflict and task pre-emption while maintaining flexibility in human resource allocation with this strategy.

ACO (Ant Colony Optimization) algorithm is used - The basic concept of ACO is to mimic ant foraging behaviour.

3.1.4 Gantt Chart, CPM Technique with Example

A Gantt chart is a common style for displaying project schedule information in calendar form by listing project activities and their associated start and finish dates. To represent project tasks and scheduling information, managers used to draw Gantt charts by hand. This tool established a common method for planning and reviewing all early military projects' work.

By listing project activities and their accompanying start and finish dates in calendar form, Gantt charts provide a consistent method for showing project schedule information. Because the start and finish dates of the activities are depicted as horizontal bars, Gantt charts are sometimes referred to as bar charts.

Notes

A Gantt chart is a sort of bar chart created by Henry Gantt to show the progress of a project. Gantt charts are popular for displaying schedule activities because they are simple to read. The start and conclusion dates of a project's terminal and summary elements are shown in these graphs. The project's work breakdown structure is made up of terminal and summary sections. The dependency relationships (i.e., precedence network) between activities are also shown in some Gantt charts.

As a bar chart with the time scale across the top, Gantt charts represent all of the important stages of a project and their duration. The essential stages are listed in order on the bar chart, beginning in the upper left corner and finishing in the lower right corner. A Gantt chart is a simple tool that project managers use to provide an approximate estimate of how long it will take to accomplish essential tasks. It's sometimes a good idea to start with the target completion date for the entire project, because it'll become clear quickly whether the time frame is too short or too long. After the major objectives have been identified, the comprehensive Gantt chart is usually created.

The notion of a Gantt chart dates back to World War I. However, most new project management students have just been exposed to it since the 1980s. The new and more widely accepted usage of project management software, as well as the use of the Gantt chart as a primary tool in software applications, may account for this late familiarity. Project tasks are charted using software programmes. The Gantt chart was created manually before the introduction of automation, using graph paper.

When a project manager and team have identified what has to be done when, in what order, by whom, over what amount of time, and with what non-human resources, they have finished project planning.

A simple Gantt chart for Project X built with Microsoft Project is shown below.

Figure: Gantt chart for project X

Notes

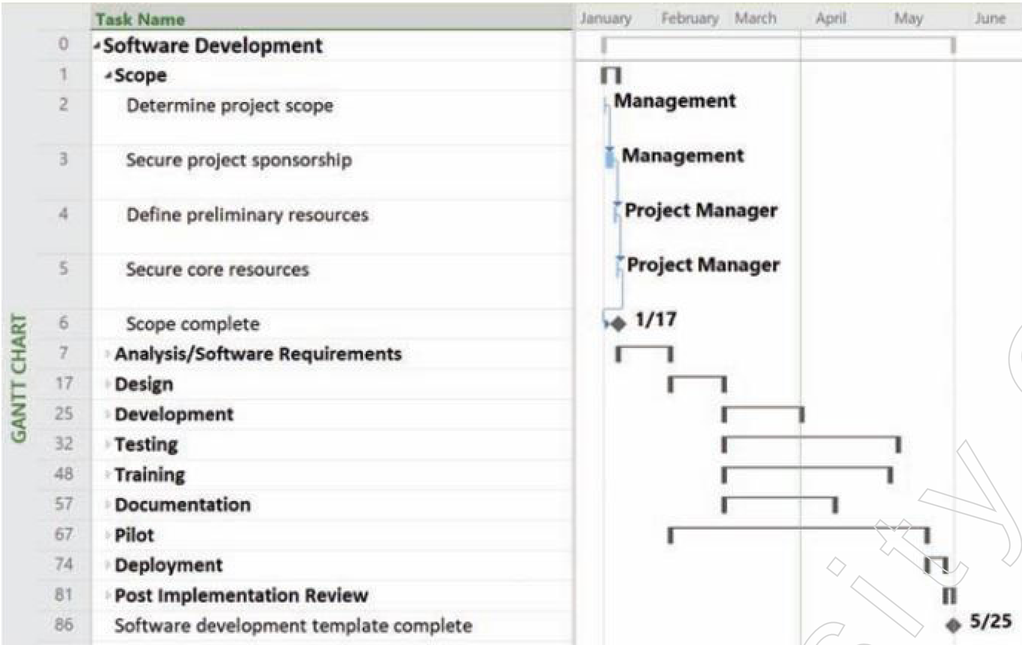


Figure: Gantt chart for software launch project

On the Gantt chart for the software launch project (see Figure above), note the various symbols:

- The black diamond is a symbol of achievement. Task 6, "Scope complete," is a January 17 milestone in the diagram above. Top managers may choose to see only milestones on a Gantt chart for very large projects. Microsoft Project allows you to filter the information presented on a Gantt chart so that specific tasks, such as milestones, may be easily displayed.
- Summary tasks are represented by the thick black bars with rectangles at the beginning and end. The actions indicated in rows 2-5 for example, are all subtasks of Task 1's summary task, "Scope." In most project management software, WBS activities are referred to as tasks and subtasks.
- Tasks 2, 3, 4, and 5 have light blue horizontal bars that reflect the duration of each activity.
- Relationships or dependencies between tasks are shown by arrows linking these symbols. Gantt charts frequently fail to indicate dependencies, which is one of its fundamental flaws. Dependencies are automatically displayed on the Gantt chart if they have been set in Microsoft Project.

Adding Milestones to Gantt Charts

Milestones, especially for major projects, can be critical components of timetables. Many individuals enjoy focusing on achieving goals, so you may use them to highlight major events or project accomplishments. Normally, milestones are created by inserting tasks with no duration. By ticking the relevant option in the Advanced tab of the Task Information dialogue box in Microsoft Project, you may label any task as a milestone. The task's length will not alter to zero, but the Gantt chart will display a milestone symbol based on the task's start date. For more information, see Appendix A (available on the Companion website for this text).

Notes

Some people use the SMART criteria to help establish milestones in order to make them more meaningful. The SMART criteria are a set of rules that say milestones should include:

- Specific
- Measurable
- Assignable
- Realistic
- Time-framed

Distributing a marketing strategy for example, is defined, quantifiable, and assignable if everyone knows what should be in it, how it should be delivered, how many copies should be given and to whom, and who is responsible for the actual delivery. If it is a feasible event that is scheduled at an opportune time, distributing the marketing plan is reasonable and can be time framed.

Advantages of Bar Charts

Because of their simplicity and ease of preparation and interpretation, bar charts have achieved widespread recognition and popularity. There is no "theory" or sophisticated math involved. They are simple to comprehend. With just a pencil and paper, they can be made anywhere. As a result, while bar charts can carry (or be loaded with) additional data, the user must be careful not to overwhelm them, which would negate their fundamental benefit: simplicity.

Bar charts, unlike networks, are time-scaled, which means that the length of a bar representing a certain activity is related to the duration of that action. You can get an idea of the duration of each task and the full project just by looking at the chart.

Another advantage of bar charts is that they appeal to those with little or no technical knowledge. Some clients and upper-level managers for example, may comprehend the strategy for completing a building project better by looking at a bar chart rather than a logic network diagram.

The flexibility to roll up or down a timetable based on a specific activity code (e.g., area, phase, responsibility, or floor) or the project's work breakdown structure is another benefit of bar charts (WBS).

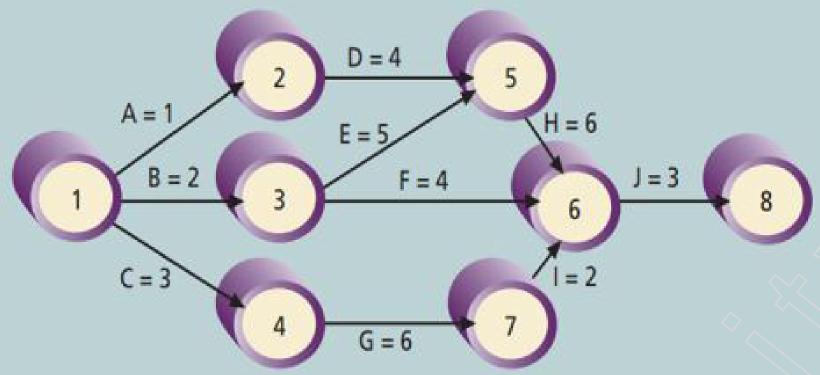
Critical Path Method

Many initiatives fail to reach their deadlines. The critical path method (CPM), also known as critical path analysis, is a network diagramming methodology for estimating project duration. This useful tool aids in the prevention of project schedule overruns. A project's critical path is a set of events that determine when the project will be completed. It is the longest and has the least amount of slack or float in the network diagram. The amount of time an activity can be postponed without affecting the next action or the project's completion deadline is known as slack or float. On most projects, numerous jobs are completed in parallel, and most projects have multiple paths through a network diagram. The project's completion date is determined by the longest path or the path that contains the most crucial activities. You are not finished with the project until all of the tasks have been completed.

Notes

Calculating the Critical Path

To determine a project's critical route, you must first create a decent network diagram, which requires a strong activity list based on the WBS. To establish the critical path, you must first design a network diagram and then estimate the time of each action. The critical path is calculated by combining the durations of all activities along each path in the network diagram. The essential path is the one that is the longest.



Note: Assume all durations are in days.

Path 1:	A-D-H-J	Length = 1+4+6+3 = 14 days
Path 2:	B-E-H-J	Length = 2+5+6+3 = 16 days
Path 3:	B-F-J	Length = 2+4+3 = 9 days
Path 4:	C-G-I-J	Length = 3+6+2+3 = 14 days

Since the critical path is the longest path through the network diagram, Path 2, B-E-H-J, is the critical path for Project X.

Figure: Determining the critical path for project X

The AOA network diagram for Project X is shown in the above Figure once again. To establish the critical route for projects, you can use either the AOA or the precedence diagramming technique. Figure 6-8 depicts the four paths that lead via the network design. On the AOA network diagram, each path begins at the first node (1) and ends at the last node (8). The length or total duration of each path through the network diagram is also shown in this graphic. The lengths of the path are calculated by adding the durations of each activity along the way. The crucial path for the project is B-E-H-J, which has the longest duration of 16 days.

What does it mean to be on the crucial path? Despite being the longest road, the critical path represents the lowest time to finish a project. If one or more key route tasks take longer than expected, the entire project timetable will be pushed back until the project manager intervenes.

When it comes to managing the critical path, project teams can be inventive. For example, Joan Knutson, a well-known project management book and speaker, frequently recounts how a gorilla assisted Apple Inc. in completing a project on time. Team members worked in a cubicle area, with a stuffed gorilla on top of the cubicle of whoever was in charge of the current critical path task. Everyone understood that person was pressed for time and didn't require any distractions. When a critical task was done, the gorilla was given to the person in charge of the next critical task.

Notes

Growing Grass Can Be on the Critical Path

People are frequently perplexed as to what a project's crucial path entails. Some people believe that the critical path includes the most critical activities, however it is only concerned with the project's temporal dimension. The fact that it has the word critical in its name does not imply that it covers all critical operations. In a keynote talk at a PMIISSIG Professional Development Seminar for example, Frank Addeman, Executive Project Director at Walt Disney Imagineering, revealed that cultivating grass was a necessary step for developing Disney's Animal Kingdom theme park! For the animals in the 500-acre park, special grass was necessary, and some of it took years to develop. Another misperception is that the critical path is the network diagram's shortest path. The purpose of some fields, such as transportation modelling, is to find the shortest path in network diagrams. However, in order to complete a project, each task or activity on the critical path, as well as other paths, must be completed. It's not a case of taking the shortest route.

Other elements of critical path analysis could be perplexing. Is it possible for a project to have more than one critical path? Is there ever a change in the critical path? Assume that Activity A in Project X has a three-day estimate rather than a one-day estimate. Path 1 would be 16 days long based on this updated duration estimate. There are now two crucial pathways in the project, each of which is the longest and lasts the same amount of time. As a result, a project can have multiple critical paths. To avoid a late project completion, project managers should closely monitor the performance of activities in the critical path. Project managers must keep an eye on all critical paths if there are more than one.

The critical route of a project can shift as it moves along. Assume that everything goes according to plan at the start of the project. Assume that Activities A, B, C, D, E, F, and G all begin and end on schedule. Assume that Activity I encounters difficulties. If Activity I takes longer than four days, path C-G-I-J will be longer than the other paths, providing everything goes according to plan. Path C-G-I-J would become the new crucial path as a result of this alteration. As a result, the critical path of a project can shift.

Using Critical Path Analysis to Make Schedule Trade-Offs

It's crucial to understand the key path throughout the project's life cycle so that the project manager may make trade-offs. If a critical route item is running late, the project manager must be aware of the issue and decide what to do about it. Is it necessary to revise the schedule with stakeholders? Should greater resources be directed to other important path items to compensate for the lost time? Is it permissible for the project to be completed late? The project manager and team take a proactive role in maintaining the project timeline by keeping track of the key path.

Determining the free slack and total slack for each project activity is a strategy that can assist project managers in making scheduling trade-offs. The amount of time an activity can be postponed without delaying the early start date of any immediately following activities is known as free slack or free float. Based on the project network logic, the early start date is the earliest possible time for an activity to begin. Total slack, also known as total float, refers to the amount of time an activity can be postponed from its scheduled start date without affecting the project's completion date.

Notes

A forward and backward trip across a network diagram is used by project managers to quantify free slack and total slack. Each activity's early start and early conclusion dates are determined by a forward pass. Based on the project network logic, the early finish date is the earliest possible time for an activity to be completed. The project's start date is the same as the first network diagram activity's early start date. The early start date plus the duration of the first activity equals the first activity's early finish date. Unless an activity has numerous antecedents, it is also equal to the early start date of each succeeding activity. When an activity has many predecessors, its early start date is the most recent of those predecessors' early finish dates. Tasks D and E for example, come right after Task H in the diagram above.

As a result, Task H's early start date is the early finish date of Task E, which is later than Task D's early finish date. In a similar approach, a backward trip around the network diagram determines the late start and late finish dates for each activity. The late start date is the earliest that an activity can start without delaying the project's completion deadline. The late finish date is the latest time an activity can be performed without causing the project's completion date to be pushed back.

Each activity's early and late start and conclusion dates can be determined by hand by project managers. A simple network diagram with three tasks, A, B, and C, is shown in Figure below. Tasks A and B are both completed before Task C. Assume that all estimates of length are in days. Task A has a 5-day estimated duration, Task B has a 10-day estimated duration, and Task C has a 7-day projected duration. There are just two options available.

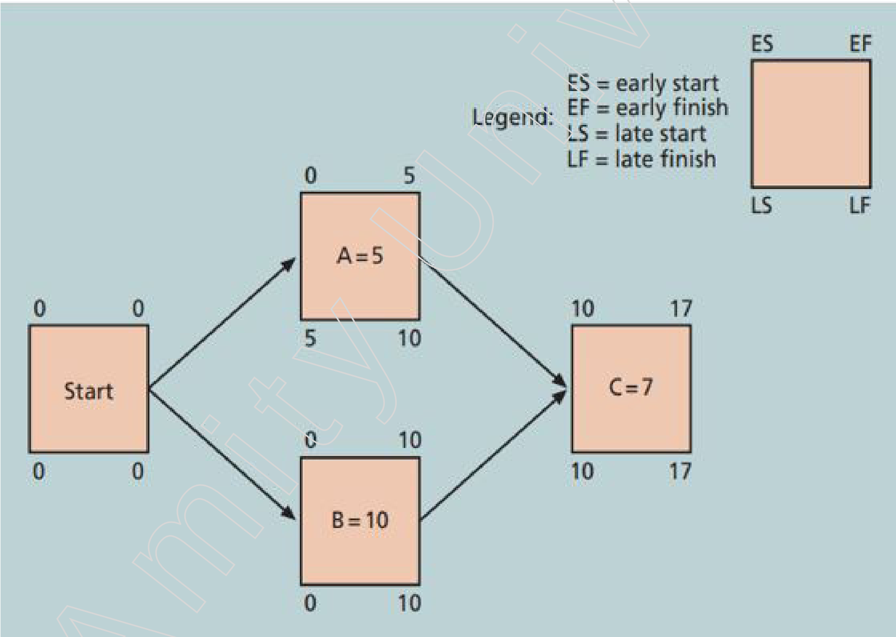


Figure: Calculating early and late start and finish dates

Using the Critical Path to Shorten a Project Schedule

Stakeholders frequently request that a project timetable estimate be shortened. By identifying tasks, determining sequencing, and predicting resources and durations for each activity, a project team may have done its best to develop a project schedule.

Notes

Although the findings of this study may indicate that the project team will need 10 months to finish the project, the sponsor may inquire if the project can be completed in eight or nine months. (It's uncommon for people to request that the project team take longer than originally planned.) The project manager and team can employ many duration compression approaches to shorten the project timetable if they know the crucial path. One method is to shorten the time of critical path activities. By allocating extra resources to critical path tasks or modifying their scope, the project manager can reduce the length of critical path activities. According to some experts, cutting a realistic project timeline by more than 25% is extremely tough.

Remember how Sue Johnson had scheduling issues with the online registration project in the first scenario because multiple users skipped critical project review meetings and one of the senior programmers resigned. Sue and her team could assess their progress toward meeting the May 1 deadline if they built a realistic project schedule, made reliable duration estimates, and defined relationships between tasks. They would have to take corrective actions to finish the project on time if some critical route tasks had already slipped and they had not built in extra time at the end of the project. In order to make up time, Sue might request that her firm or the institution offer more personnel to work on the project. She could also ask for a reduction in the scope of tasks in order to finish the project on time. Sue might potentially shorten the project schedule by employing project schedule management strategies like as crashing or fast tracking.

Crashing is a cost and schedule trade-off strategy that allows you to get the most schedule compression for the least amount of money. Assume that entering course data for the new semester into the new system was one of the critical path items for the online registration project. If this activity has not yet been completed and was originally projected to take two weeks due to the college's provision of a part-time data entry clerk, Sue could recommend that the clerk work full-time so that the task can be completed in one week rather than two. Sue's company would not incur any more costs as a result of this modification, and the project's completion schedule might be shortened by one week. If the college is unable to meet this requirement, Sue may wish to hire a temporary data entry employee for one week to assist her in completing the assignment more quickly. The project timetable can be shortened by focusing on items on the critical route that could be completed faster for no additional cost or at a low cost.

The biggest benefit of crashing is that it reduces the amount of time it takes to complete a project. Crashing has the primary downside of increasing total project expenses.

Fast tracking is another method for reducing the length of a project's timetable. Fast tracking entails performing operations in simultaneously that would ordinarily be completed in order. Sue Johnson's project team for example, may have decided not to begin coding for the online registration system until all of the analysis was completed. Instead, they might consider beginning some coding work before the analysis is finished. The key benefit of fast tracking, like crashing, is that it can reduce the amount of time it takes to complete a project. The biggest negative is that it might raise costs and delay the project schedule because commencing some tasks too early raises project risk and leads to rework.

Notes

Importance of Updating Critical Path Data

It's crucial to update the schedule with actual data after determining the critical path at the start of a project. The project manager should capture the real durations of activities after the project team has completed them. The project manager should also keep track of updated estimates for tasks that are currently underway or that have yet to begin. These adjustments frequently lead a project's critical path to shift, resulting in a revised project completion date. Again, proactive project managers and their teams maintain track of changes so that they may make educated decisions and keep stakeholders informed about significant project decisions.

3.1.5 Basic Concept of Schedule Control

Controlling the timetable is the final step in project schedule management. Schedule control, like scope control, is part of the project integration management's integrated change control process. The purpose of schedule control is to understand the current state of the schedule, to influence the elements that cause schedule changes, to determine when the schedule has changed, and to manage changes as they occur.

The project management plan, project documents (such as the lessons-learned register, project calendars, project schedule, resource calendars, and schedule data), work performance data, and organisational process assets are the major inputs to schedule control. The following are some of the tools and techniques:

- Data analysis tools, including
  - Earned value analysis
  - Iteration burndown charts
  - Performance reviews
  - Trend analysis
  - Variance analysis
  - What-if-scenario analysis
- Critical path method
- Project management information systems
- Resource optimization, such as resource levelling.
- Leads and lags
- Schedule compression, such as crashing and fast tracking

Work performance data, schedule projections, modification requests, project management plan updates, and project document updates are among the key outputs of schedule control.

Controlling changes to project timetables entails a slew of challenges. First and foremost, make certain that the project timetable is feasible. Many projects, particularly those in the IT field, have unreasonable schedule expectations. It's also crucial to underline the necessity of sticking to and meeting project deadlines with discipline and leadership. Although different tools and approaches aid in the development and management of project schedules, project managers must also deal with a number

Notes

of personnel-related difficulties in order to keep projects on track. "Most projects fail due to personnel difficulties rather than a lack of a strong PERT chart." Project managers can conduct a number of reality checks to aid in the management of project schedule changes. Several soft skills can assist project managers in keeping schedule adjustments under control.

The practice of monitoring the project's status in order to update the project schedule and manage changes to the schedule baseline is known as control scheduling. The fundamental advantage of this method is that the schedule baseline is kept consistent throughout the project. Throughout the project, this procedure is followed.

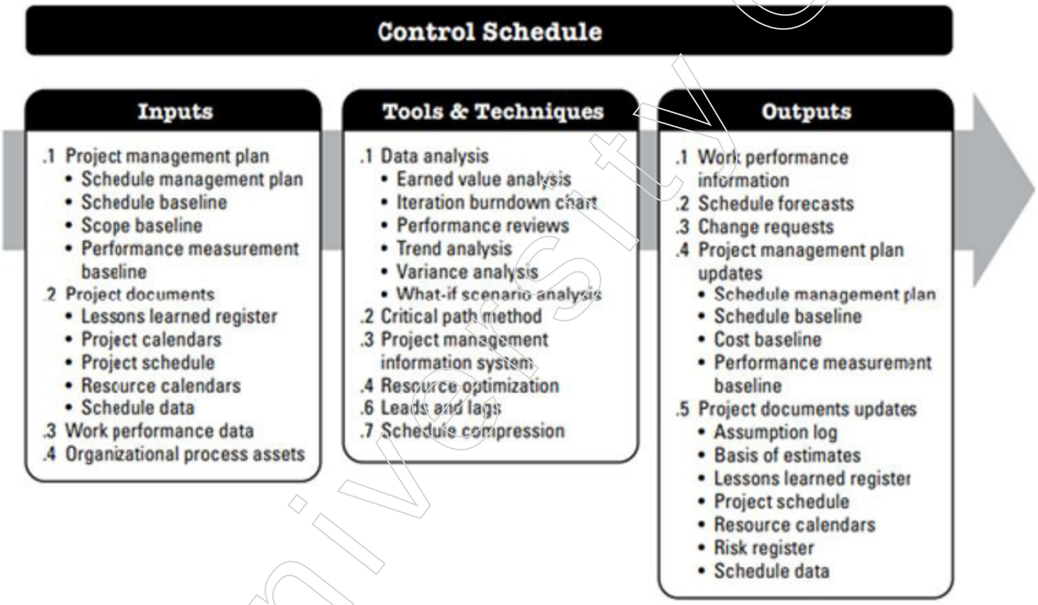


Figure: Control Schedule: Inputs, Tools & Techniques, and Outputs

As part of the Perform Integrated Change Control process, the Control Schedule is concerned with:

- Identifying the project's current status.
- Changing the causes that cause schedule shifts.
- Rethinking the need for schedule reserves.
- Identifying whether or not the project timeline has changed, as well as managing the actual adjustments when they happen.

3.2 Project Scheduling and Planning Tools

We live in a fast-paced, competitive environment where everyone wants their work done as quickly as possible. This concept has spread throughout the world's industries as well. Customers who buy products and services, companies that offer them, and personnel who work on those projects are all under pressure to complete the job on time or early. As a result, it is imperative that project schedules be prepared more precisely and attentively.

Notes

3.2.1 Linear Responsibility Chart (LRC)

Linear Responsibility Chart (LC), Matrix Responsibility Chart (MRC), Responsibility Interface Matrix (RIM), and Responsibility and Accountability Matrix are all terms for the same thing (RAM). Due to their overlapping involvements in project management, it is the chart of responsibility that identifies project participants and demonstrates authority and responsibility relationships among them. General managers, project managers, project managers, and functional managers are all possible participants.

To avoid misunderstandings and conflicts, it explicitly defines the authority and responsibility relationships among project members. It is particularly useful in matrix organisation structures to reduce confusion and conflicts between project managers and functional managers. It defines what project work entails and who is responsible for it. It connects project activities or tasks to the responsible individual, ensuring that the project is implemented effectively to meet set objectives within restrictions.

A matrix responsibility chart depicts all of the primary tasks and obligations of participants in a business initiative. It's just a diagram that organises the entire project by clearly indicating the authority and responsibility of each project participant. The matrix responsibility chart focuses on avoiding any confusion or dispute in departmental or cross-functional initiatives by correctly identifying roles and responsibilities.

RACI stands for four critical duties played by all project stakeholders: responsible, accountable, consulted, and informed. Responsible indicates who is responsible for project work, accountable indicates who is the decision maker and accountable for all project tasks, consulted indicates who should be consulted for additional details or information, and informed indicates who should be informed about all project updates. The matrix responsibility chart is a useful tool for connecting tasks to responsible persons, resulting in efficient project execution and timely fulfilment of set goals.

Every project aims to achieve certain goals while staying within budget, schedule, and quality constraints. Each project has a large number of [participants who effectively fulfil their tasks in order to achieve the set objectives.

The following are the participants: –

- General Manager: He is the organization's executive chief.
- Manager of Project: This is the project department's chief.
- Functional Managers: Chiefs of functional departments are the people in charge of these positions.
- Project Manager: A project manager is the person in charge of a specific project.

The various project participants' authority and duty in the project's operations and decisions can be:

- Actual responsibility for getting the job done.
- General supervision responsibility.
- Must be consulted.
- May be consulted.
- Must be notified.

Notes

- Must approve.

To avoid confusion and conflicts in the project, there should be clear authority-responsibility connections among the project participants. Matrix Responsibility Chart is the primary instrument for accomplishing this goal (MRC).

LRC is produced to identify the responsibility centre for all key project activities, and it is separated into rows, columns, and numbers for this purpose. LRC's rows represent activities, responsibilities, and authorities. The columns identify the project participants' positions, while the numbers represent the level of power and responsibility that existed between the LRC's rows and columns; the numbers can be symbols.

The Matrix Responsibility chart is broken into the following sections:

- Rows: They denote tasks, responsibilities, and authority.
- Columns: They determine the participants' positions in the project.
- Numbers: They show how much power and responsibility there is between the rows and columns. They could be interpreted as symbols.

Activity/Responsibility	General Manager	Manager of Project	Projject Manager	Functional Manager
Establish department's objective and policies	1	3	3	3
Integration of projects	2	1	3	3
Project Direction	4	2	1	3
Project Planning	4	2	1	3
Functional Planning	2	4	3	1
Funtional Direction	2	4	5	1
Project functional conflict resolution	1	3	3	3
Project Budget	4	6	1	3
Project work breakdown structuire	4	6	1	3
Project control	4	2	1	3
Functional control	2	4	3	1

Figure: Linear Responsibility Chart

Symbols/Codes:

- 1 = Actual responsibility
- 2 = General responsibility/ General Supervision
- 3 = Most be consulted
- 4 = May be consulted
- 5 = Must be notifies
- 6 = Must approve

Steps for Charting a RACI Chart

- Identify the project tasks.

  The first step is to list all of the tasks that must be completed in order to complete a project. On the left-hand side of the chart, all of the specified tasks are listed in sequence of completion. The many milestones that participants must meet in order to complete the project are listed here.

- Identify stakeholders of project.

  All of the project's stakeholders have now been identified and are listed at the top of the chart. Project managers, product managers, technical architects, software developers, executive sponsors, project executives, and project initiation are among the various stakeholders.

- Fill up each box with R, A, C and I.

  In this step, all of the model's boxes are filled in by determining who has duty, accountability, and who will be consulted and informed about each activity.

- Assign stakeholder to each role and task.

  It is ensured that each task of a project has a stakeholder who is responsible for it. It is examined here who all the persons are that are assigned to various project jobs.

- Ensuring only one accountable for each task.

  Only one stakeholder should be held accountable for each project task. Any dispute that arises as a result of having more than one person responsible for a task is resolved by assigning it to only one person.

- Discuss, analyse and get approval from stakeholders.

  Before beginning a project, the developed RACI model is discussed with all stakeholders to gain consent. All of the misunderstandings and disagreements have been resolved.

  The advantages of Matrix Responsibility Chart or Linear Responsibility Chart are as follows:

- It explains the project members' roles in project issues. The project participants' authority, duty, and accountability for project activities are defined. It becomes easy to solve problems.
- Communication is made easier. It eliminates red tape.
- It's a good way to keep track of who has what authority and obligations.
- Authority has been delegated.
- It promotes collaboration by defining project rules and responsibilities, as well as authority and responsibility relationships among participants. It eliminates miscommunication and conflict between project and functional managers. It aids in the tracking of project members' responsibilities. It blends organisational structure with work breakdown structure, making assigning responsibilities to project members simple.

Notes

The disadvantages of Matrix Responsibility Chart or Linear Responsibility Chart are as follows:

- It makes no mention of the project's human interactions. It's a mechanical assistive device.
- It's possible that all relationships will be difficult to define.
- Its utility may be limited by customer-imposed constraints.
- It just serves as a mechanical instrument for determining responsibility and does not define the project participants' relationship. It attempts to articulate the authority-responsibility connection in concrete terms. However, expressing the state and degree of all relationships can be challenging. The project is customer-focused, and requirements are always imposed. LRC's utility may be limited as a result of the need.

3.2.2 PERT Chart

PERT (Project Evaluation and Review Technique) was developed by the Program Evaluation Branch of the US Navy's Special Projects office in 1958 for the POLARIS missile programme, with assistance from Lockheed Missile Systems and Booz-Allen & Hamilton Consultants. The computations were set up so that they could be run on the Dahlgren, Virginia-based IBM Naval Ordinance Research Computer (NORC).

The PERT (programme (or project) evaluation and review technique) is a statistical tool used in project management that was created to examine and portray the tasks required in completing a project. It's frequently used in tandem with the critical path method (CPM).

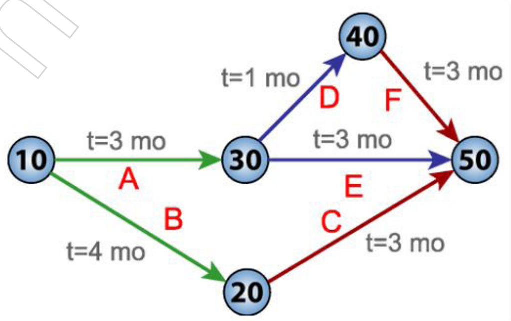


Figure: PERT network chart for a seven-month project with five milestones and six activities

History

The Navy's Special Projects Office, which is responsible for creating the Polaris-Submarine weapon system and the Fleet Ballistic Missile capabilities, has devised a statistical technique for monitoring and forecasting progress in R&D initiatives. This programme evaluation and review method (code-named PERT) is used as a decision-making tool to save time in reaching end-objectives, and it's especially useful for people working on research and development projects when time is an issue.

Time, resources, and technical performance criteria are three aspects that determine the effective completion of research and development programme objectives, according to the new technique. The variable time is used in PERT to represent scheduled resource applications and performance standards. PERT quantifies information about the uncertainties inherent in developmental projects demanding effort at the edge of, or beyond, present knowledge of the subject - effort for which little or no prior experience exists – using time units as a common denominator.

The PERT technique uses an electronic computer to process data that represents the important, finite accomplishments (events) required to attain end-objectives, their interdependence, and estimations of the time and range of time required to complete each activity between two consecutive events. Estimates of "most likely time," "optimistic time," and "pessimistic time" for each action are among the time expectations. The technique is a management control tool that assesses the likelihood of meeting objectives on time; identifies and defines both methodicalness and slack in the flow plan, or the network of sequential activities that must be completed to meet objectives; compares current expectations with scheduled completion dates and computes the probability of meeting scheduled dates; and simulates the effects of options for making decisions.

An operations research team comprised of personnel from Booz, Allen and Hamilton's Operations Research Department, Lockheed Missile Systems Division's Evaluation Office, and the Department of the Navy's Program Evaluation Branch, Special Projects Office developed the PERT idea.

Overview

PERT is a method for analysing the tasks involved in completing a project, particularly the time required to accomplish each work, and determining the shortest time required to finish the entire project.

PERT was created to make the planning and scheduling of large and complicated projects easier. It was created in 1957 for the US Navy Special Projects Office to help with the Polaris nuclear submarine project. It was able to accommodate uncertainty by allowing a project to be scheduled without knowing the exact specifics and durations of all operations. It is more of an event-oriented strategy than a start-and-finish technique, and it is employed in projects when time is more important than money. It is used for one-time, large-scale, sophisticated, non-routine infrastructure and R&D projects. The 1968 Winter Olympics in Grenoble for example, used PERT from 1965 until the beginning of the Games in 1968.

This project paradigm was the first of its kind, a scientific management revival developed by Frederick Taylor (Taylorism) and refined by Henry Ford (Fordism). PERT and DuPont's critical route technique were developed about the same time.

Terminology

- PERT event: a point that indicates the beginning or end of one or more actions It doesn't take up any time or resources. It is not "reached" (does not happen) until all of the activities leading up to the event are done.
- Predecessor event: an occurrence that occurs right before another without any between events An event can have several antecedent events and can also be a precursor to further events.

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- successor event: an event that occurs immediately after another without any between events A single event can have several successor events and can also be the successor of other events.
- PERT activity: the actual execution of a time-consuming and resource-intensive activity (such as labor, materials, space, machinery). It can be interpreted as the amount of time, effort, and resources required to transition from one event to the next. The precursor event must occur before the PERT action may be carried out.
- PERT sub-activity: A PERT activity can be broken down further into sub-activities. For instance, action A1 can be broken down into A1.1, A1.2, and A1.3. Sub-activities have all of the characteristics of activities, including the presence of predecessor and successor events. A sub-activity can be further broken into smaller sub-activities.
- optimistic time (O): the shortest amount of time required to complete a task, if everything goes as planned.
- pessimistic time (P): the greatest amount of time it will take to complete a task if everything goes wrong (but excluding major catastrophes).
- most likely time (M): the best estimate of how long it will take to complete an activity, providing everything goes according to plan.
- expected time (T_E): the best estimate of the time needed to complete a task, taking into account that things don't always go as planned (the implication being that the expected time is the average time the task would require if the task were repeated on a number of occasions over an extended period of time).

  $TE = (O + 4M + P) \div 6$

- Slack, also known as float, refers to the extra time and resources available to execute a task. It's the period of time a project task can be postponed without affecting other tasks (free float) or the entire project (total float). Positive slack means you're ahead of schedule, negative slack means you're behind schedule, and zero slack means you're on track.
- critical path: the longest possible continuous path from the beginning to the end of the event It determines the overall project calendar time; as a result, any time delays along the crucial path will cause the terminal event to be delayed by at least the same amount.
- critical activity: An action in which the total float is zero. Because its path may not be the longest, an activity with zero float is not necessarily on the crucial path.
- Lead time: the deadline by which a preceding event must be completed in order to leave enough time for the actions that must occur before a PERT event may be completed.
- lag time: the earliest possible time for a successor event to occur after a PERT event.
- fast tracking: Performing more vital tasks at the same time.
- crashing critical path: Critical activities are being shortened in duration.

Notes

Implementation

The first stage in project scheduling is to identify the tasks that must be accomplished and in what sequence they must be completed. For some jobs (e.g., when building a house, the land must be graded before the foundation can be built), the sequence may be simple to document, while for others it may be complicated (There are two areas that need to be graded, but there are only enough bulldozers to do one). Furthermore, the time estimations are usually based on normal, non-rushed times. Many times, the time necessary to complete a work might be lowered in exchange for a higher cost or a lower quality.

There are seven tasks designated A through G in the following example. Some jobs (A and B) can be completed simultaneously, whereas others must wait until their predecessor duty is completed (C cannot begin until A is complete). Each activity also provides three time estimates: the optimistic (O), the most likely or normal (M), and the pessimistic (P) . The formula is used to calculate the expected time (T_E).

(O + 4M + P) ÷ 6.

Activity	Predecessor	Time estimates			Expected time
		Opt. (*O*)	Normal (*M*)	Pess. (*P*)	
A	—	2	4	6	4.00
B	—	3	5	9	5.33
C	*A*	4	5	7	5.17
D	*A*	4	6	10	6.33
E	*B*, *C*	4	5	7	5.17
F	*D*	3	4	8	4.50
G	*E*	3	5	8	5.17

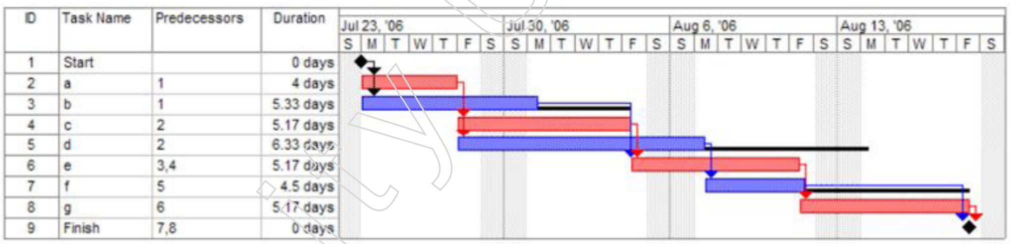

Figure: A Gantt chart created using Microsoft Project

You can draw a network diagram by hand or with diagram software. Activity on arrow (AOA) and activity on node (AON) are two forms of network diagrams (AON). Node diagrams make it easier to develop and interpret activity. Starting with a node named start is suggested (but not needed) when creating an AON diagram. The duration of this "activity" is nil (0). Then for each activity that does not have a predecessor activity (in this case, a and b), draw an arrow from the start to each node. Next, because both c and d identify an as a precursor activity, arrows from an are drawn through their nodes. Because activity e is specified as a predecessor activity to b and c, node e is shown with arrows pointing to both b and c, indicating that e cannot begin until both b and c are done. Because activity f comes before activity d, an arrow

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is created to connect the two. An arrow is drawn from e to g in the same way. Because there are no actions following f or g, connecting them to a node labelled finish is suggested (but not essential).

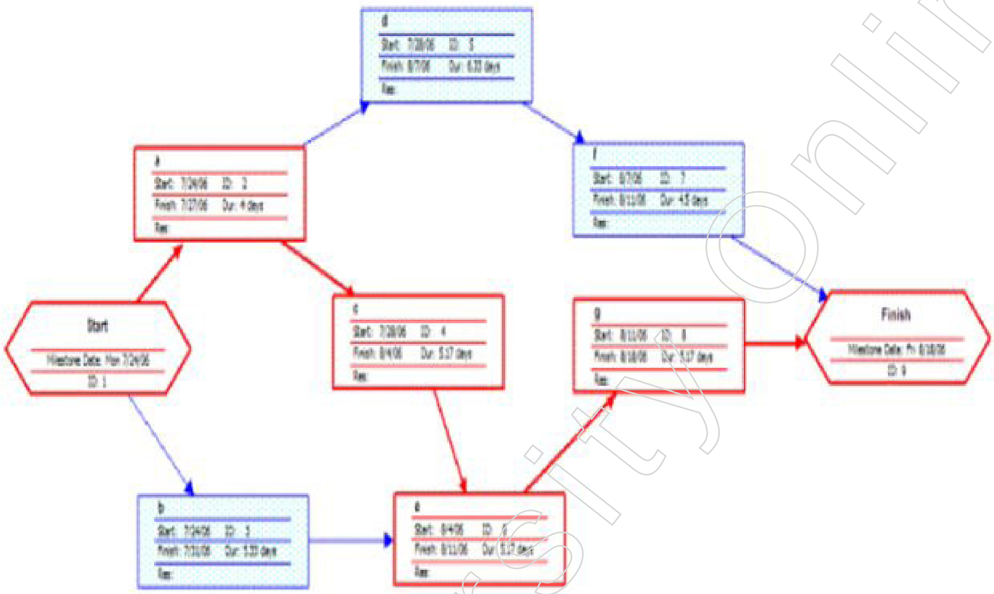

Figure: A network diagram created using Microsoft

Advantages

- The dependencies (precedence relationships) between the elements of the work breakdown structure (often referred to as WBS) are explicitly defined and made apparent using the PERT chart.
- PERT aids in identifying and highlighting the key path.
- Early start, late start, and slack for each activity are easily identified with PERT.
- Because of a greater awareness of dependencies, PERT allows for better overlapping of activities and tasks where possible, resulting in a potentially shorter project length.
- For decision-making purposes, a huge amount of project data can be arranged and displayed in a diagram.

Disadvantages

- Hundreds or thousands of activities and individual dependent relationships are possible.
- PERT is difficult to scale down for smaller projects.
- The network charts are typically huge and bulky, requiring multiple pages to print and particular paper sizes.
- Most PERT/CPM charts lack a period, making it difficult to show status, however colours can help (e.g., specific colour for completed nodes).

3.2.3 Gantt Chart, CPM Technique with Example

Notes

A Gantt chart is a common style for displaying project schedule information in calendar form by listing project activities and their associated start and finish dates. To represent project tasks and scheduling information, managers used to draw Gantt charts by hand. This tool established a common method for planning and reviewing all early military projects' work.

By listing project activities and their accompanying start and finish dates in calendar form, Gantt charts provide a consistent method for showing project schedule information. Because the start and finish dates of the activities are depicted as horizontal bars, Gantt charts are sometimes referred to as bar charts.

A Gantt chart is a sort of bar chart created by Henry Gantt to show the progress of a project. Gantt charts are popular for displaying schedule activities because they are simple to read. The start and conclusion dates of a project's terminal and summary elements are shown in these graphs. The project's work breakdown structure is made up of terminal and summary sections. The dependency relationships (i.e., precedence network) between activities are also shown in some Gantt charts.

As a bar chart with the time scale across the top, Gantt charts represent all of the important stages of a project and their duration. The essential stages are listed in order on the bar chart, beginning in the upper left corner and finishing in the lower right corner. A Gantt chart is a simple tool that project managers use to provide an approximate estimate of how long it will take to accomplish essential tasks. It's sometimes a good idea to start with the target completion date for the entire project, because it'll become clear quickly whether the time frame is too short or too long. After the major objectives have been identified, the comprehensive Gantt chart is usually created.

The notion of a Gantt chart dates back to World War I. However, most new project management students have just been exposed to it since the 1980s. The new and more widely accepted usage of project management software, as well as the use of the Gantt chart as a primary tool in software applications, may account for this late familiarity. Project tasks are charted using software programmes. The Gantt chart was created manually before the introduction of automation, using graph paper.

When a project manager and team have identified what has to be done when, in what order, by whom, over what amount of time, and with what non-human resources, they have finished project planning.

A simple Gantt chart for Project X built with Microsoft Project is shown below.

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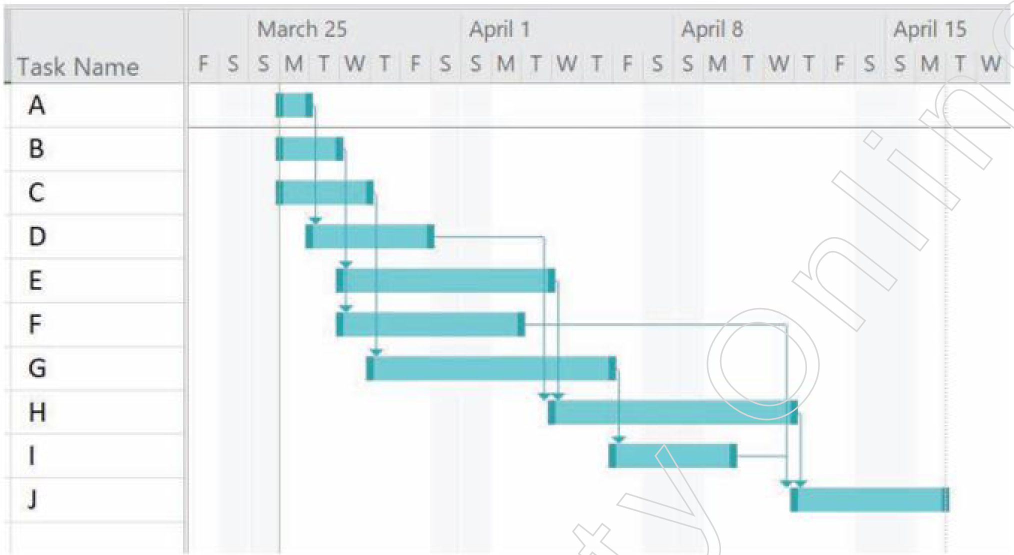

Figure: Gantt chart for project X

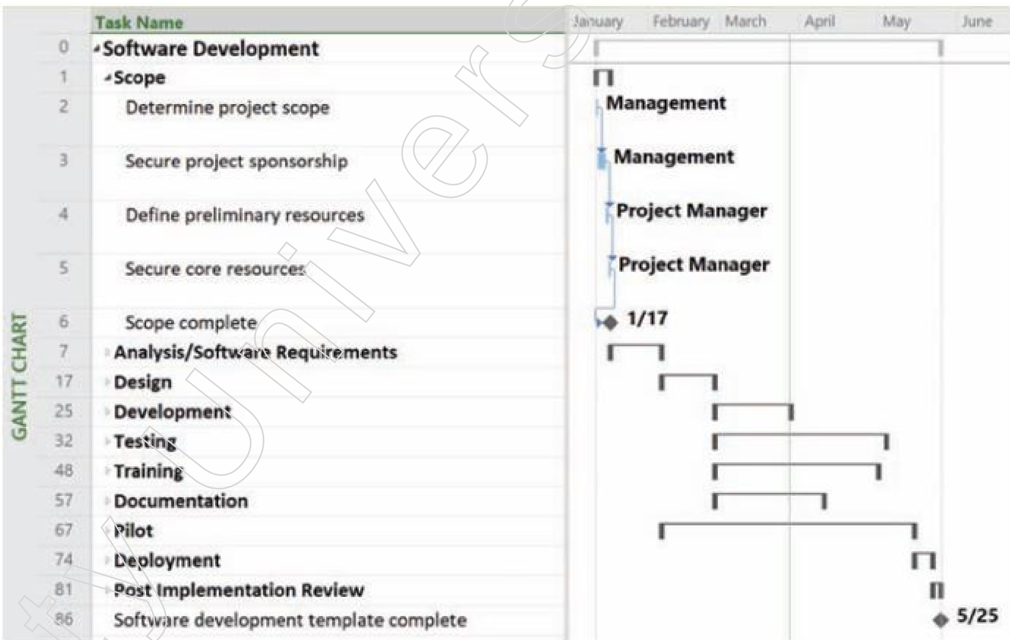

Figure: Gantt chart for software launch project

On the Gantt chart for the software launch project (see Figure above), note the various symbols:

- The black diamond is a symbol of achievement. Task 6, "Scope complete," is a January 17 milestone in the diagram above. Top managers may choose to see only milestones on a Gantt chart for very large projects. Microsoft Project allows you to filter the information presented on a Gantt chart so that specific tasks, such as milestones, may be easily displayed.
- Summary tasks are represented by the thick black bars with rectangles at the beginning and end. The actions indicated in rows 2-5 for example, are all subtasks

of Task 1's summary task, "Scope." In most project management software, WBS activities are referred to as tasks and subtasks.

- Tasks 2, 3, 4, and 5 have light blue horizontal bars that reflect the duration of each activity.
- Relationships or dependencies between tasks are shown by arrows linking these symbols. Gantt charts frequently fail to indicate dependencies, which is one of its fundamental flaws. Dependencies are automatically displayed on the Gantt chart if they have been set in Microsoft Project.

Adding Milestones to Gantt Charts

Milestones, especially for major projects, can be critical components of timetables. Many individuals enjoy focusing on achieving goals, so you may use them to highlight major events or project accomplishments. Normally, milestones are created by inserting tasks with no duration. By ticking the relevant option in the Advanced tab of the Task Information dialogue box in Microsoft Project, you may label any task as a milestone. The task's length will not alter to zero, but the Gantt chart will display a milestone symbol based on the task's start date. For more information, see Appendix A (available on the Companion website for this text).

Some people use the SMART criteria to help establish milestones in order to make them more meaningful. The SMART criteria are a set of rules that say milestones should include:

- Specific
- Measurable
- Assignable
- Realistic
- Time-framed

Distributing a marketing strategy for example, is defined, quantifiable, and assignable if everyone knows what should be in it, how it should be delivered, how many copies should be given and to whom, and who is responsible for the actual delivery. If it is a feasible event that is scheduled at an opportune time, distributing the marketing plan is reasonable and can be time framed.

Advantages of Bar Charts

Because of their simplicity and ease of preparation and interpretation, bar charts have achieved widespread recognition and popularity. There is no "theory" or sophisticated math involved. They are simple to comprehend. With just a pencil and paper, they can be made anywhere. As a result, while bar charts can carry (or be loaded with) additional data, the user must be careful not to overwhelm them, which would negate their fundamental benefit: simplicity.

Bar charts, unlike networks, are time-scaled, which means that the length of a bar representing a certain activity is related to the duration of that action. You can get an idea of the duration of each task and the full project just by looking at the chart.

Another advantage of bar charts is that they appeal to those with little or no technical knowledge. Some clients and upper-level managers for example, may

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comprehend the strategy for completing a building project better by looking at a bar chart rather than a logic network diagram.

The flexibility to roll up or down a timetable based on a specific activity code (e.g., area, phase, responsibility, or floor) or the project's work breakdown structure is another benefit of bar charts (WBS).

Critical Path Method

Many initiatives fail to reach their deadlines. The critical path method (CPM), also known as critical path analysis, is a network diagramming methodology for estimating project duration. This useful tool aids in the prevention of project schedule overruns. A project's critical path is a set of events that determine when the project will be completed. It is the longest and has the least amount of slack or float in the network diagram. The amount of time an activity can be postponed without affecting the next action or the project's completion deadline is known as slack or float. On most projects, numerous jobs are completed in parallel, and most projects have multiple paths through a network diagram. The project's completion date is determined by the longest path or the path that contains the most crucial activities. You are not finished with the project until all of the tasks have been completed.

Calculating the Critical Path

To determine a project's critical route, you must first create a decent network diagram, which requires a strong activity list based on the WBS. To establish the critical path, you must first design a network diagram and then estimate the time of each action. The critical path is calculated by combining the durations of all activities along each path in the network diagram. The essential path is the one that is the longest.

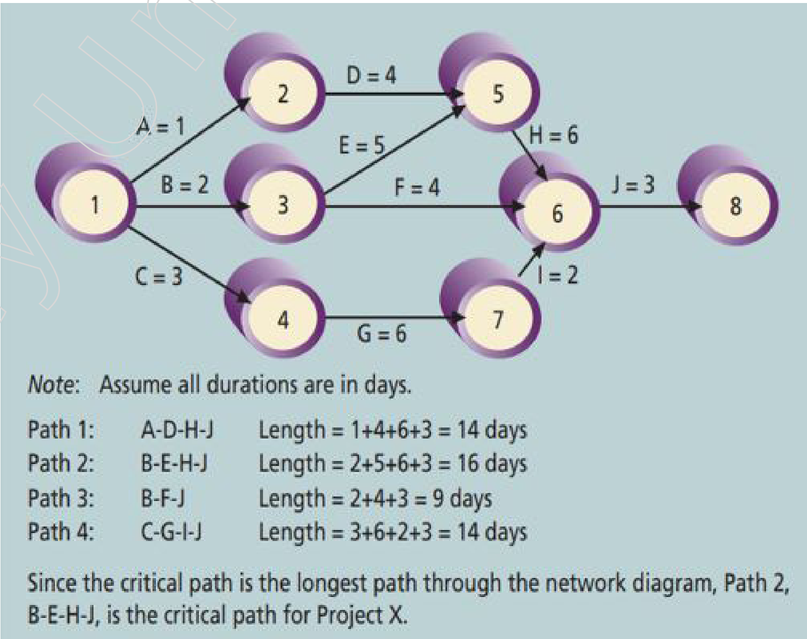

Figure: Determining the critical path for project X

The AOA network diagram for Project X is shown in the above Figure once again. To establish the critical route for projects, you can use either the AOA or the precedence diagramming technique. Figure 6-8 depicts the four paths that lead via the network design. On the AOA network diagram, each path begins at the first node (1) and ends at the last node (8). The length or total duration of each path through the network diagram is also shown in this graphic. The lengths of the path are calculated by adding the durations of each activity along the way. The crucial path for the project is B-E-H-J, which has the longest duration of 16 days.

What does it mean to be on the crucial path? Despite being the longest road, the critical path represents the lowest time to finish a project. If one or more key route tasks take longer than expected, the entire project timetable will be pushed back until the project manager intervenes.

When it comes to managing the critical path, project teams can be inventive. For example, Joan Knutson, a well-known project management book and speaker, frequently recounts how a gorilla assisted Apple Inc. in completing a project on time. Team members worked in a cubicle area, with a stuffed gorilla on top of the cubicle of whoever was in charge of the current critical path task. Everyone understood that person was pressed for time and didn't require any distractions. When a critical task was done, the gorilla was given to the person in charge of the next critical task.

Growing Grass Can Be on the Critical Path

People are frequently perplexed as to what a project's crucial path entails. Some people believe that the critical path includes the most critical activities, however it is only concerned with the project's temporal dimension. The fact that it has the word critical in its name does not imply that it covers all critical operations. In a keynote talk at a PMIISSIG Professional Development Seminar for example, Frank Addeman, Executive Project Director at Walt Disney Imagineering, revealed that cultivating grass was a necessary step for developing Disney's Animal Kingdom theme park! For the animals in the 500-acre park, special grass was necessary, and some of it took years to develop. Another misperception is that the critical path is the network diagram's shortest path. The purpose of some fields, such as transportation modelling, is to find the shortest path in network diagrams. However, in order to complete a project, each task or activity on the critical path, as well as other paths, must be completed. It's not a case of taking the shortest route.

Other elements of critical path analysis could be perplexing. Is it possible for a project to have more than one critical path? Is there ever a change in the critical path? Assume that Activity A in Project X has a three-day estimate rather than a one-day estimate. Path 1 would be 16 days long based on this updated duration estimate. There are now two crucial pathways in the project, each of which is the longest and lasts the same amount of time. As a result, a project can have multiple critical paths. To avoid a late project completion, project managers should closely monitor the performance of activities in the critical path. Project managers must keep an eye on all critical paths if there are more than one.

The critical route of a project can shift as it moves along. Assume that everything goes according to plan at the start of the project. Assume that Activities A, B, C, D, E, F, and G all begin and end on schedule. Assume that Activity I encounters difficulties. If Activity I takes longer than four days, path C-G-I-J will be longer than the other paths,

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providing everything goes according to plan. Path C-G-I-J would become the new crucial path as a result of this alteration. As a result, the critical path of a project can shift.

Using Critical Path Analysis to Make Schedule Trade-Offs

It's crucial to understand the key path throughout the project's life cycle so that the project manager may make trade-offs. If a critical route item is running late, the project manager must be aware of the issue and decide what to do about it. Is it necessary to revise the schedule with stakeholders? Should greater resources be directed to other important path items to compensate for the lost time? Is it permissible for the project to be completed late? The project manager and team take a proactive role in maintaining the project timeline by keeping track of the key path.

Determining the free slack and total slack for each project activity is a strategy that can assist project managers in making scheduling trade-offs. The amount of time an activity can be postponed without delaying the early start date of any immediately following activities is known as free slack or free float. Based on the project network logic, the early start date is the earliest possible time for an activity to begin. Total slack, also known as total float, refers to the amount of time an activity can be postponed from its scheduled start date without affecting the project's completion date.

A forward and backward trip across a network diagram is used by project managers to quantify free slack and total slack. Each activity's early start and early conclusion dates are determined by a forward pass. Based on the project network logic, the early finish date is the earliest possible time for an activity to be completed. The project's start date is the same as the first network diagram activity's early start date. The early start date plus the duration of the first activity equals the first activity's early finish date. Unless an activity has numerous antecedents, it is also equal to the early start date of each succeeding activity. When an activity has many predecessors, its early start date is the most recent of those predecessors' early finish dates. Tasks D and E for example, come right after Task H in the diagram above.

As a result, Task H's early start date is the early finish date of Task E, which is later than Task D's early finish date. In a similar approach, a backward trip around the network diagram determines the late start and late finish dates for each activity. The late start date is the earliest that an activity can start without delaying the project's completion deadline. The late finish date is the latest time an activity can be performed without causing the project's completion date to be pushed back.

Each activity's early and late start and conclusion dates can be determined by hand by project managers. A simple network diagram with three tasks, A, B, and C, is shown in Figure below. Tasks A and B are both completed before Task C. Assume that all estimates of length are in days. Task A has a 5-day estimated duration, Task B has a 10-day estimated duration, and Task C has a 7-day projected duration. There are just two options available.

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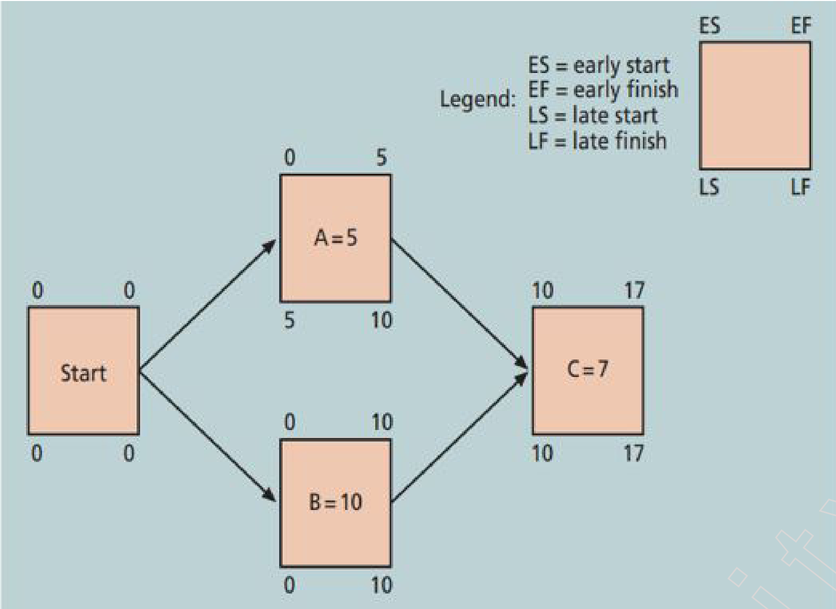

Figure: Calculating early and late start and finish dates

Using the Critical Path to Shorten a Project Schedule

Stakeholders frequently request that a project timetable estimate be shortened. By identifying tasks, determining sequencing, and predicting resources and durations for each activity, a project team may have done its best to develop a project schedule. Although the findings of this study may indicate that the project team will need 10 months to finish the project, the sponsor may inquire if the project can be completed in eight or nine months. (It's uncommon for people to request that the project team take longer than originally planned.) The project manager and team can employ many duration compression approaches to shorten the project timetable if they know the crucial path. One method is to shorten the time of critical path activities. By allocating extra resources to critical path tasks or modifying their scope, the project manager can reduce the length of critical path activities. According to some experts, cutting a realistic project timeline by more than 25% is extremely tough.

Remember how Sue Johnson had scheduling issues with the online registration project in the first scenario because multiple users skipped critical project review meetings and one of the senior programmers resigned. Sue and her team could assess their progress toward meeting the May 1 deadline if they built a realistic project schedule, made reliable duration estimates, and defined relationships between tasks. They would have to take corrective actions to finish the project on time if some critical route tasks had already slipped and they had not built-in extra time at the end of the project. In order to make up time, Sue might request that her firm or the institution offer more personnel to work on the project. She could also ask for a reduction in the scope of tasks in order to finish the project on time. Sue might potentially shorten the project schedule by employing project schedule management strategies like as crashing or fast tracking.

Crashing is a cost and schedule trade-off strategy that allows you to get the most schedule compression for the least amount of money. Assume that entering course data for the new semester into the new system was one of the critical path items for

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the online registration project. If this activity has not yet been completed and was originally projected to take two weeks due to the college's provision of a part-time data entry clerk, Sue could recommend that the clerk work full-time so that the task can be completed in one week rather than two. Sue's company would not incur any more costs as a result of this modification, and the project's completion schedule might be shortened by one week. If the college is unable to meet this requirement, Sue may wish to hire a temporary data entry employee for one week to assist her in completing the assignment more quickly. The project timetable can be shortened by focusing on items on the critical route that could be completed faster for no additional cost or at a low cost.

The biggest benefit of crashing is that it reduces the amount of time it takes to complete a project. Crashing has the primary downside of increasing total project expenses.

Fast tracking is another method for reducing the length of a project's timetable. Fast tracking entails performing operations in simultaneously that would ordinarily be completed in order. Sue Johnson's project team for example, may have decided not to begin coding for the online registration system until all of the analysis was completed. Instead, they might consider beginning some coding work before the analysis is finished. The key benefit of fast tracking, like crashing, is that it can reduce the amount of time it takes to complete a project. The biggest negative is that it might raise costs and delay the project schedule because commencing some tasks too early raises project risk and leads to rework.

Importance of Updating Critical Path Data

It's crucial to update the schedule with actual data after determining the critical path at the start of a project. The project manager should capture the real durations of activities after the project team has completed them. The project manager should also keep track of updated estimates for tasks that are currently underway or that have yet to begin. These adjustments frequently lead a project's critical path to shift, resulting in a revised project completion date. Again, proactive project managers and their teams maintain track of changes so that they may make educated decisions and keep stakeholders informed about significant project decisions.

3.3 Risk Management Plan

A risk management plan is a document created by a project manager to anticipate hazards, quantify their impact, and identify risk responses. A risk assessment matrix is also included.

"An unpredictable event or situation that, if it occurs, has a positive or negative effect on a project's objectives," says one definition of risk. Any project carries risk, and project managers should assess hazards on a regular basis and establish methods to overcome them. The risk management strategy includes a review of potential high- and low-impact risks, as well as mitigation techniques to keep the project on track if typical issues develop. To avoid the analysis becoming stale and not reflecting actual possible project hazards, the project team should review risk management plans on a regular basis.

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3.3.1 Introduction to Risk Management

The art and science of recognising, analysing, and responding to risk throughout the life of a project in the best interests of accomplishing project objectives is known as project risk management. Risk management, a usually overlooked area of project management, can often result in considerable increases in project success. Risk management can help with project selection, scope determination, and the development of realistic schedules and cost estimates. It assists project stakeholders in comprehending the project's nature, including team members in defining strengths and weaknesses, and aids in the integration of other project management knowledge areas.

Unlike crisis management, which indicates an evident threat to a project's success, good project risk management generally goes unreported. In turn, the dilemma piques the interest of the entire project team. Successful risk management does not have the same level of visibility as resolving a crisis, which is generally rewarded by management. When risk management is effective, however, fewer problems arise, and those that do arise are resolved more quickly. Outside observers may find it difficult to determine if risk management or luck played a role in the smooth creation of a new system, but project teams always know that strong risk management contributed to the success of their projects. Managing project risks necessitates a team of motivated and competent individuals. In 2008, PMI established the PMI Risk Management Professional (PMI-RMP)SM certificate to meet this demand. (For further information, go to PMI's website.)

All initiatives are dangerous because they are one-of-a-kind endeavours of varied degrees of complexity with the goal of delivering rewards. They do so while dealing with limits and assumptions, as well as conflicting and changing stakeholder expectations. In order to produce value while balancing risk and reward, organisations should choose to assume project risk in a controlled and planned manner.

The goal of project risk management is to identify and manage risks that aren't covered by other project management techniques. These risks, if left unmanaged, have the potential to cause the project to diverge from the plan and fail to meet the project's established goals. As a result, the success of a project is directly proportional to the effectiveness of Project Risk Management.

Every endeavour contains two levels of risk. Each project has its own set of dangers that can jeopardise the project's success. It's also crucial to examine the entire project's riskiness, which is determined by the combination of particular project hazards and other sources of uncertainty. Both levels of risk in projects are addressed by project risk management processes, which are defined as follows:

- Individual project risk is an unforeseeable event or circumstance that, if it occurs, has a positive or negative impact on one or more project goals.
- Overall project risk is the impact of uncertainty on the project as a whole, resulting from all sources of uncertainty, including individual risks, and represents the exposure of stakeholders to the consequences of both positive and bad project outcomes.

If project risks exist, they might have a positive or negative impact on project objectives. Positive risks (opportunities) should be exploited or enhanced, whereas

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negative risks should be avoided or mitigated (threats). Unmanaged threats can cause challenges or problems such delays, cost overruns, performance shortfalls, and reputational damage. Capturing opportunities can result in time and cost savings, increased performance, or a better reputation.

Project risk can be both positive and bad. Overall project risk management strives to keep project risk exposure within an acceptable range by lowering negative variation drivers, encouraging positive variation drivers, and optimising the likelihood of meeting overall project objectives.

The need of project risk management is often overlooked in all industries, particularly in the software development business. Young H. Kwak and William Ibbs investigated project management maturity in 38 businesses across a variety of industries. Engineering and construction, telecommunications, information systems/ software development, and high-tech manufacturing were grouped into four industry groups. Participants in the survey answered 148 multiple-choice questions about their company's project management maturity in the areas of scope, time, cost, quality, human resources, communications, risk, and procurement. The maturity rating scale varied from 1 to 5, with 5 being the highest. The survey results are shown in the table below. It's worth noting that risk management was the only expertise category with a total score of less than 3. This survey revealed that all enterprises, particularly those in the information systems and software development industry, which had the lowest grade of 2.75, should put more effort into project risk management.

Maturity of project management by industrial group and knowledge area

KEY: 1 = Lowest Maturity Rating, 5 = Highest Maturity Rating				
Knowledge Area	Engineering/ Construction	Telecommunications	Information Systems	High-Tech Manufacturi
Scope	3.52	3.45	3.25	3.37
Time	3.55	3.41	3.03	3.50
Cost	3.74	3.22	3.20	3.97
Quality	2.91	3.22	2.88	3.26
Human resources	3.18	3.20	2.93	3.18
Communications	3.53	3.53	3.21	3.48
Risk	**2.93**	**2.87**	**2.75**	**2.76**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In Mauritius, South Africa, a similar survey was conducted with software development companies. On a scale of 1 to 5, with 5 being the highest maturity rating, the average maturity rating for all knowledge categories was only 2.29. Like the study by Ibbs and Kwak, the lowest average maturity rating, 1.84, was in the field of project risk management. The survey authors highlighted that firms in the study were frequently concerned with cost overruns and had measures in place to help control costs, giving cost management the highest maturity rating of 2.5. The authors also discovered that project maturity was directly associated to project success, and that a low risk management rating was a common cause of project issues and failures.

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To investigate software risk management strategies, the KLCI Research Group polled 260 software companies throughout the world. Some of their conclusions are summarised in the following points:

- Ninety-seven percent of the participants said they had procedures in place to identify and assess risk.
- Eighty percent identified anticipating and avoiding problems as the primary benefit of risk management.
- Seventy percent of the organizations had defined software development processes.
- Sixty-four percent had a Project Management Office

The key benefits of software risk management strategies stated by survey respondents are shown in the graph below. Risk management approaches enabled software project managers avoid surprises, improve negotiations, satisfy customer commitments, and reduce schedule slippages and cost overruns in addition to anticipating and preventing difficulties.

Although many businesses recognise that they do a poor job managing project risk, little progress appears to have been achieved in improving risk management on a project or enterprise level during the last decade. On the subject, several books and articles have been written. Dr. David Hillson, PMP® for example, talked about the necessity of project risk management shortly after the October 2008 stock market meltdown.

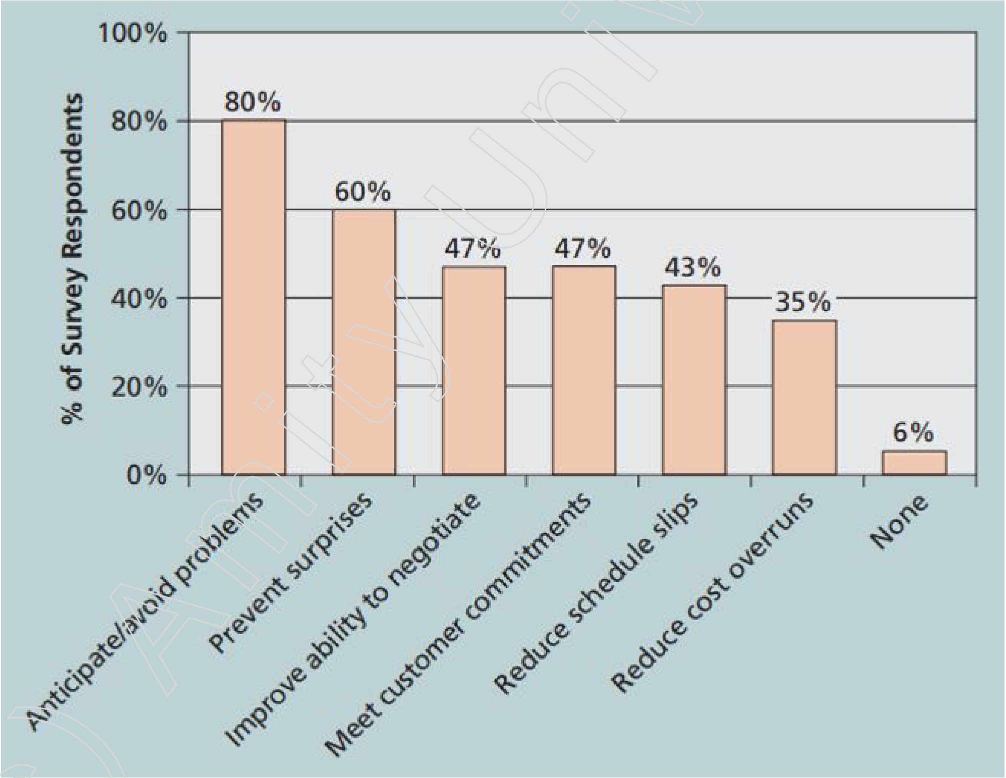

Figure: Benefits from software risk management practices

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Hillson Said:

There is little doubt that dealing with the current aftermath from the credit crunch is posing significant problems to all areas of industry and society. Risk management, on the other hand, should not be viewed as a non-essential cost that may be minimised in these difficult circumstances. Instead, businesses should use the risk process' insights to ensure that they can deal with the inevitable uncertainties and emerge in the best possible position in the future. Risk management is more important than ever, with high levels of volatility enveloping us on all sides, and reducing it would be a false economy. Rather of seeing risk management as a problem, we should consider it as a critical component of the solution.

Negative risk management entails a variety of options for project managers to prevent, mitigate, change, or accept the potential effects of hazards on their projects. Positive risk management is similar to making an investment in a business opportunity. It's crucial to remember that risk management is an investment that comes with price. The amount of money a business is willing to invest in risk management activities is determined by the project's nature, the project team's experience, and the limits imposed on both. In any event, risk management costs should not outweigh the possible advantages.

Why do firms undertake IT initiatives when they are so risky? Many businesses exist today as a result of risky decisions that resulted in lucrative opportunities. When companies seek chances, they have a better chance of surviving in the long run. IT is frequently a critical component of a company's strategy; without it, many enterprises would perish. Given that all projects have risks that might result in either positive or negative results, the question is how to choose which projects to pursue and how to detect and manage project risk throughout the project's life cycle.

Several risk experts believe that in all parts of projects and personal lives, businesses and individuals should aim to strike a balance between risks and possibilities. The concept of achieving balance implies that various companies and people have varied risk attitudes. Some businesses or individuals have a risk tolerance that is neutral, some have a risk aversion, while yet others are risk takers. The utility theory of risk includes these three preferences.

Risk Categories

Risk categories are the classification of hazards based on the organization's business activities, and they provide a structured picture of the underlying and prospective dangers they confront. Strategic, financial, operational, personnel, regulatory, and financial risk classifications are the most popular.

- Risk categories aid in the identification of dangers while also allowing them to become more robust and practical.
- It ensures that consumers may trace the source of an organization's underlying and possible threats.
- These categories aid in determining the effectiveness of a company's control systems across all departments.

- It guarantees that risk identification is thorough, taking into account all possible components of the underlying and future risk situations.
- Users can utilise these categories to identify regions that are particularly vulnerable to dangers, as well as to identify standard and probable causes.
- Users can even create appropriate risk-handling procedures using risk categories.

Operational Risk

The risks of loss stemming from incorrect process execution, external challenges (weather concerns, government rules, political and environmental pressures, and so on), and other factors are referred to as operational risks. Operational hazards are defined as a sort of risk that arises from inefficiencies in an organization's business operations. Inadequate resources, failure to resolve disagreements, and other operational hazards are examples.

Budget Risk

Budget risk is a risk that emerges from an incorrect estimate of a budget allotted to a specific project or activity. Budget risk is also known as cost risk, and the consequences of this risk include delays in project completion, premature project handover, failure to provide a quality project or a compromise in project quality in comparison to what was promised to the customer, and so on.

Schedule Risk

The schedule risk occurs when the project's release or completion is not properly reviewed and addressed. Such a risk can have an impact on a project and may even be the cause of its failure, resulting in financial losses for the organisation.

Technical Environment Risk

The risk associated with the technical environment in which both customers and clients operate can be defined as the risk associated with the environment in which both customers and clients work. This risk can arise as a result of the testing environment, regular manufacturing fluctuations, and so on.

Business Risk

Business risks might arise as a result of the non-availability of a purchase order, contracts in the early stages of a project, delays in obtaining inputs from clients and customers, and so on.

Programmatic Risk

These are risks that aren't under the control of a programme or aren't covered by the operational parameters. Programmatic risks include changes in product strategy or government laws.

Information Security Risk

The violation of the confidentiality of a company's or clients' sensitive data is what information security threats are all about. A breach of such data poses a significant

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danger to an organisation, and it may result in not just financial losses but also a loss of goodwill.

Technology Risk

Technology hazards can arise as a result of a rapid or full shift in technology, or even as a result of the installation of new technology.

Supplier Risk

Supplier risks arise when a third-party supplier interferes with the progress of a project because of his involvement in it.

Resource Risk

The incorrect management of a company's resources, such as its employees, budget, and so on, causes resource risk.

Infrastructure Risk

Infrastructure risk arises as a result of inadequate infrastructure or resource planning, which is why it is critical to have proper infrastructure planning in place so that the project is not harmed.

Technical and Architectural Risk

Technical and architectural risks are the kind of risks that cause an organization's entire operation and performance to fail. These dangers develop as a result of the failure of software and hardware tools and equipment used in a specific project.

Quality and Process Risk

Quality and process risk arises from the wrong application of tailoring a process and the appointment of inexperienced employees to the process, both of which undermine the process's conclusion.

Project Planning

Project planning risks are those that develop as a result of a project's lack of effective planning. This lack of project planning might lead to the project sinking and failing to meet the clients' expectations.

Project Organization

Another danger connected with the wrong organisation of a project is project organisation. This lack of project organisation may cause the project to sink and fail to achieve the clients' expectations.

3.3.2 Risk Response Planning, Developing Risk Management Plan

After identifying and quantifying risks, a business must devise a strategy for dealing with them. Developing a risk response entails considering options and formulating methods for lowering negative risks while increasing positive ones.

The following are the five basic negative risk response strategies:

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Risk avoidance or getting rid of a specific threat, usually by getting rid of its causes. Although not all risks may be mitigated, certain risk occurrences can. A project team for example, may opt to keep using a specific piece of hardware or software on a project because it has proven to be effective. Other items that could be used on the project may be accessible, but they could pose a substantial risk if the project team is inexperienced with them. This risk is eliminated by using known hardware or software.

Risk acceptance or if a risk arises, you must accept the consequences. A project team preparing a large project review meeting for example, could take an active risk management strategy by having a contingency or backup plan in place, as well as contingency reserves, in case the team is unable to obtain consent for a specific meeting location. The squad could, on the other hand, take a passive attitude and accept whatever facilities the organisation offers.

Risk transference or transferring the risk's consequences and management responsibilities to a third-party Risk transference for example, is frequently employed to manage financial risk exposure. For unique hardware required for a project, a project team may obtain special insurance or warranty protection. If the hardware fails, the insurer is required to replace it within a certain time frame.

Risk mitigation or minimising the severity of a risk event by lowering the likelihood of it occurring At the start of this chapter, we offered suggestions for reducing common sources of risk in IT projects. Applying proven technology, having qualified project staff, using various analytical and validation methodologies, and purchasing maintenance or service agreements from subcontractors are all instances of risk mitigation.

Risk escalation or informing a higher-ranking authority. It makes sense to escalate the risk to a higher-level manager within the business if the risk is outside the scope of the project or the proposed solution is outside the project manager's authority.

General risk mitigation strategies for technical, cost, and schedule risks

Technical Risks	Cost Risks	Schedule Risks
Emphasize team support and avoid stand-alone project structure	Increase the frequency of project monitoring	Increase the frequency of project monitoring
Increase project manager authority	Use WBS and CPM	Use WBS and CPM
Improve problem handling and communication	Improve communication, understanding of project goals, and team support	Select the most experienced project manager
Increase the frequency of project monitoring	Increase project manager authority	
Use WBS and CPM		

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The table above shows general project risk mitigation solutions for technical, cost, and schedule risks. 19 Increased project monitoring frequency, as well as the use of a WBS and the Critical Path Method (CPM), are all techniques for all three domains. Increasing the project manager's authority is a technique for decreasing technical and cost risks, and hiring the most experienced project manager for reducing schedule risks is recommended. Improving communication is another important risk-mitigation method.

The following are the five basic positive risk response strategies:

- Risk exploitation or doing all effort to ensure that the favourable risk occurs Assume Cliff's company supported a project to build new computer classrooms for a nearby school that was in desperate need. They might assign one of their best project managers to coordinate media coverage of the project, publish a press release, or arrange another public event to guarantee that the project generates positive public relations for the company, which could lead to more business.
- Risk sharing or transferring risk ownership to a third party Using the same scenario as above, the project manager may develop a partnership with the school's principal, school board, or parent–teacher group to share responsibility for the project's public relations. On the other hand, the company can form a partnership with a local training firm that offers to provide free computer classroom instruction to all teachers.
- Risk enhancement or by identifying and leveraging important positive risk factors, you may change the size of the opportunity. For example, raising knowledge and excitement about the computer classrooms initiative among kids, parents, and instructors could be a key driver of strong public relations. These groups may then perform their own formal or informal advertising of the initiative and Cliff's company, potentially attracting more interest and business.
- Risk acceptance this also applies to positive risks where the project team takes no action to mitigate the risk. For example, the project manager for computer classrooms may think that the project will result in positive public relations for the organisation and hence will not feel obligated to do anything more.
- Risk escalation or positive hazards are likewise subject to notification to a higher-level authority. The project manager for computer classrooms may escalate the risk of working with another firm to a higher-level management with more clout within the company.

Updates to the project management plan and other project documentation, as well as change requests, are among the key outcomes of risk response planning. For example, if Cliff's company wanted to collaborate on the computer classrooms project with a local training firm to share the benefit of positive public relations, it may submit a change request to write a contract with that firm. If the risk response techniques necessitate additional activities, resources, or time, the project management plan and

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its linked plans may need to be changed. Changes to the WBS and project schedule are frequently a result of risk response techniques, thus plans that contain this information must be revised as well. By specifying risk responses, risk owners, and status information, the risk response plans also provide updated information for the risk register.

As previously mentioned, risk response methods frequently incorporate the assessment of residual and secondary risks, as well as contingency plans and reserves. Risks that persist after all of the response options have been applied are known as residual risks. Even if a reliable hardware product has been employed on a project, there is still a chance that it will fail to perform properly. Secondary hazards arise as a direct result of a risk solution being implemented. Using more stable hardware for example, may have increased the likelihood of peripheral devices failing to function properly.

Developing Risk Management Plan

The process of selecting how to approach risk management activities and planning for them in a project is known as risk management planning; the main outcome of this process is a risk management plan. The techniques for controlling risk throughout the project are documented in a risk management strategy. To help construct the risk management plan, project teams should hold numerous planning meetings early in the project's life cycle. Project documentation, as well as corporate risk management policies, risk categories, lessons-learned reports from previous projects, and templates for building a risk management plan, should all be reviewed by the project team. It's also crucial to assess the risk tolerances of different stakeholders. If the project sponsor for example, is risk averse, the project may require a different strategy to risk management than if the project sponsor is risk seeking.

A risk management strategy outlines how risk management will be carried out on a specific project. It becomes a subset of the project management plan, just like plans for other knowledge domains. The topics that a risk management plan should include are shown in the table below. Roles and duties must be clarified, budget and schedule estimates for risk-related activities must be prepared, and risk categories must be identified for consideration. It's also crucial to explain how risk management will be carried out, including the evaluation of risk probabilities and consequences, as well as the compilation of risk-related paperwork. The level of information in the risk management strategy can vary depending on the project's requirements.

Topics addressed in a risk management plan

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Topic	Questions to Answer
Methodology	How will risk management be performed on this project? What tools and data sources are available and applicable?
Roles and responsibilities	Which people are responsible for implementing specific tasks and providing deliverables related to risk management?
Budget and schedule	What are the estimated costs and schedules for performing risk-related activities?
Risk categories	What are the main categories of risks that should be addressed on this project? Is there a risk breakdown structure for the project? (See the information on risk breakdown structures later in this chapter.)
Risk probability and impact	How will the probabilities and impacts of risk items be assessed? What scoring and interpretation methods will be used for the qualitative and quantitative analysis of risks? How will the probability and impact matrix be developed?
Revised stakeholders' tolerances	Have stakeholders' tolerances for risk changed? How will those changes affect the project?
Tracking	How will the team track risk management activities? How will lessons learned be documented and shared? How will risk management processes be audited?
Risk documentation	What reporting formats and processes will be used for risk management activities?

Many projects contain contingency plans, fallback plans, contingency reserves, and management reserves in addition to a risk management strategy.

- Contingency plans are activities that the project team will take if a risk event occurs that has been identified. For example, if the project team anticipates that a new release of software will not be ready in time for the project, the team may devise a contingency plan to use an older version of the programme.
- If attempts to mitigate the risk do not work, fallback strategies are prepared for risks that have a high impact on accomplishing project objectives. A new college graduate for example, might have a major plan and numerous contingency plans for where to live after graduation, but if those plans don't work out, a fallback plan might be to live at home for a while. The phrases "fallback plan" and "contingency plan" are sometimes interchanged.
- Contingency reserves, also known as contingency allowances, are funds built into the cost baseline that can be utilised to prevent cost or schedule overruns if identified risks arise. For example, if a project appears to be off track because the project team lacks familiarity with a new technology, the contingency reserves could be used to hire an outside consultant to teach and advise the project team on how to use the new technology.
- Management reserves are cash set aside for unforeseeable risks and utilised for management oversight. They are part of the project budget and funding requirements, not the cost baseline. If the management reserves are utilised for

unplanned work, the cost baseline is adjusted after the change is approved.

The need of taking a proactive approach to managing project risks is demonstrated by contingency plans, fallback plans, and reserves.

3.4 HRM Plan

Human resource planning (HRP) is a continual process of systematic planning ahead to ensure that an organization's most important asset—quality employees—is used to its full potential. Human resource planning guarantees that employees and jobs are a good match while preventing labour shortages or surpluses.

3.4.1 Key Concepts of Project Resource Management

The most efficient technique of planning, organising, scheduling, and managing a project's resources — people, tools, equipment, technology, and facilities. Maximizing and guaranteeing that the project's elements are used to their full potential.

A resource is defined as everything or anybody who can be scheduled or booked to fulfil a task or project. Resources differ depending on the industry.

The majority of reusable resources are used in resource planning and scheduling. Human resources, such as your workforce and their specialised abilities, are an example. Non-human resources, such as computers, equipment, rooms, vehicles, and so on, can also be used.

The techniques required to make the most effective use of the people and physical resources (facilities, equipment, materials, supplies, and so on) involved with a project are referred to as project resource management. All project stakeholders are included in human resource management: sponsors, customers, project team members, support employees, project suppliers, and so on. Facilities, equipment, materials, and supplies are examples of physical resources. The four procedures that make up project resource management are as follows:

- Planning resource management determines how to estimate, acquire, manage, and employ project resources. A resource management plan, a team charter, and project document updates are the major outputs.
- Estimating activity resources estimating the human and physical resources required to perform project work is part of this process. Resource requirements, basis of estimates, a resource breakdown structure, and project document revisions are among the outputs.
- Acquiring resources obtaining team members, facilities, equipment, materials, supplies, and other resources as needed is part of this process. Physical and project team assignments, resource calendars, modification requests, and updates to many documents are all examples of outputs.
- Developing the project team involves enhancing project performance by developing individual and group capabilities. Many project managers struggle with team-building abilities. Team performance assessments, change requests, and updates to many documents are the key outcomes of this procedure.

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- Managing the project team Tracking team member performance, motivating team members, offering timely feedback, resolving difficulties and conflicts, and organising adjustments to improve project success are all part of the job. Change requests, project management plan updates, project document updates, and organisational process assets changes are all examples of outputs from this procedure.
- Controlling resources ensures that a project's physical resources are available as planned, keeping track of planned versus actual resource consumption, and taking remedial action as appropriate. Work performance data, modification requests, and updates to the project management plan and project papers are all examples of outputs.

Project Resource Management Techniques

Resource allocation – assists you in determining the types and quantities of resources required to complete your projects. Specific resources are assigned to specific project tasks throughout the allocation phase.

Resource aggregation – depicts the quantity of resources consumed on a daily, weekly, or monthly basis. It's simply the total amount of resources needed for a single work or project over a set period of time.

Resource scheduling – It is much easier to schedule resources to actual resource and project plans if you know their allocation and have a good understanding of their consumption. Resource plans show when a resource is required. Resource planning ensures that:

- the effective and efficient use of resources;
- a realistic timetable with task start and finish dates;
- Due to a lack of project resources, determine whether there are any potential issues or conflicts;
- Better planning for the future.

Resource Capacity in Project Management

Once you have a number of projects in your portfolio, you must make certain that all of them are completed. It is at this point that resource capacity planning comes into play. Here are a few strategies for ensuring that there are enough hands to handle the workload.

Resource levelling – is a solution to the problem of requiring a single resource to perform multiple activities at the same time. Or when a project assignment requires more resources than are now available. You can balance the workload of different resources across one or more projects by using resource levelling. Using resource management software that provides a visual picture is your best choice for precise levelling. A resource-based Gantt chart for example. This can tell you when a project will be completed, and which resources will be used. Along the road, you'll be able to assist in the resolution of problems.

For example, if Eric the Engineer is assigned two duties at the same time, resource levelling is required because he may only work 8 hours each day. So, Eric can finish

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his task, you'll need to change the plan and timeline. Alternatively, you may need to reallocate your resources so that Eric can finish on time. It's crucial to keep in mind how your project's timeline may shift during the resource levelling process.

Resource smoothing – When working with an inflexible schedule, this is the best method to maximise your resources. This may imply that you are restricted to a set time range or that you are unable to adjust your schedule. In this instance, you must make the best use of your resources within the time constraints you have.

Consider the following scenario:

Eric, the Engineer, is eager to fulfil both of his tasks. This, however, will result in resource levelling and a two-day delay in the project. To overcome this problem with resource smoothing, you'll need to make better use of your other resources to compensate for the extra two days. When there is an uneven distribution of work, resource smoothing can help.

Resource overallocation – If a resource has too much work to handle, it is over-allocated. To remedy this, you'll need to balance the team's workloads. Alternatively, you can look for alternative options. It's possible that you'll need to reassign someone from another team or employ someone entirely new. Failure to do so could lead to overtime or project delays. Both are expensive for your project, team, and budget.

Consider the following scenario:

Eric the Engineer is part of a project team that includes two other employees and a bulldozer. The work is expected to be completed by the end of the week, allowing the next phase to begin. The project will run behind time unless another bulldozer is assigned to the team, which could lead to employee and team burnout.

3.4.2 Trends and Emerging Practices in Project Resource Management

The Resource Management Plan: Best Practices

A good resource management plan isn't always straightforward to put in place, but it can make the project management process go more smoothly. We may offer some of the tips and methods we've acquired based on our expertise and user feedback. These will assist you in becoming a resource master.

"Patience you must have my young Padawan"

Yoda's insightful words come to mind. Take some time to learn about resource management if it's new to you. On a daily basis, changes, adaptations, and reallocations can occur. It's not a one-time event; it's a continuous process. Taking the effort to learn about it, on the other hand, can avoid your project from falling into the "dark side."

Know the team's skills

You'll need to plan the required talents and resources before allocating resources. The easier your task will be if you know your team and what skills they have. That way, you can be certain that you're allocating the appropriate resources to each task.

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Never plan 100% of utilization

Despite the fact that every organisation needs to maximise resource utilisation, planning resources for 90-95 percent utilisation helps in the event of unanticipated situations. It's impossible to plan for everything. You can, however, anticipate them!

Be flexible

There are always going to be changes. You'll be able to observe which jobs are taking longer or moving faster than intended, as well as which tasks are lagging behind, as the project progresses. Tracking and making adjustments is unavoidable and required for you as the project manager. You'll be able to get the best utilisation and efficiency this way.

Teamwork makes the team work

One of the most common reasons for a project's failure is a lack of communication. Make sure your team is always up to date on any changes. Whether you have a small team sharing a single office or an internationally distributed company, this is critical. Also, remember to congratulate yourself on your accomplishments and milestones. The most successful and engaging approach to manage your team is through good team communication.

Focus on your critical and valuable resources

Some resources are more important than others. Different resources can have a greater impact on the outcome than others. Keep an eye on the most important assets. Also, make certain that their chores are completed first.

Time

Your most important asset. And it's one you shouldn't overlook. In order to make a realistic strategy, you must consider all possible uses of time. Even administrative time, such as responding emails, is valuable. As a result, there will be less time lost overall.

"People are our most precious asset," is a cliché that no senior management team member would dispute. However, for many organisations, the fact is that their personnel remain.

- under valued
- under trained
- under utilized
- poorly motivated, and consequently
- perform well below their true capability

Organizations must absorb and manage change at a much faster rate than in the past because the rate of change has never been greater. Organizations, large and small, must ensure that they have the right personnel capable of delivering the strategy in order to create a successful business strategy to meet this issue.

Human resource management contributions differ according to the size, goals, functions, complexity, construction, physical character of the product, and employer

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appeal of organisations. However, in most cases, the function's ultimate goal is to "ensure that the business is correctly staffed at all times by the right number of individuals with the abilities relevant to the business needs," i.e., neither overstaffed nor understaffed overall or in respect of any one discipline or work grade.

Human resource outsourcing

Human Resource Outsourcing is a business practice in which a corporation hires a third party to handle its HR activities. A corporation may outsource some or all of its HR-related activities to a single or a group of service providers in countries such as India, China, and the Philippines.

Organizations are spending more time focusing on their core business due to rapidly changing market dynamics and worldwide competitive pressures. Organizations are quickly recognising that they can't be everything to everyone. So, whether it's a software firm, a service provider, or a manufacturing firm, organisations today determine what they're strong at and outsource the rest, i.e., focus on their core competency and let someone else handle the rest more efficiently and cost-effectively.

As a result, outsourcing human resources is becoming more common. The number of organisations outsourcing HR functions continues to grow, as does the extent of outsourced HR functions. Payroll administration (printing checks, handling taxes, dealing with sick time and vacations), employee benefits (health, medical, life insurance, cafeteria, etc.), human resource management (hiring and firing, background interviews, exit interviews, and wage reviews), risk management, and other HR functions may be outsourced. Outsourcing has been a frequent approach to better manage people and technological resources, improve services, and reduce costs.

- Services offered by HR Outsourcing

  Maintenance of personnel records

  Annual review and revision of employee handbook

  Audit of HR strategies, policies and procedures

  Implementation of employment/termination procedures

  Job description process

  Exit interviews

  Employee development program

  Performance management process

  On-site support

  Employee retention programs

  Long term incentive/equity stock option programs

  Employee Morale Building

  Compensation plan review

- Recruiting services

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  - Retained Search
  - Job Description Development Strategy
  - Ad Placement
  - Applicant Screening
  - Reference and Background Check
  - Candidate Interviews and Recommendations
  - Development and Coordination of Offer
  - Integration of New Hire
- HR management services
  - Compensation plan review and analysis
  - Culture development
  - Due diligence/Acquisition planning
  - Incentive and retention programs
  - Executive Coaching
  - Succession Planning
- Benefits administration
  - Brokerage Services
  - Custom Benefit Plan Strategies and Design
  - Benefit analysis, cost control and reduction recommendations
  - Development of Employee Communications
  - Eligibility and Enrolment Services
  - Employee claims resolution
  - Monthly invoice audit and reconciliation
  - On-line employee access to benefits information
- Payroll services
  - Employee self-service features
  - Payroll processing and reporting
  - Payroll tax reporting
  - Time off tracking
  - Online benefits enrolment

Greater Reliance on Digital and Remote Teams

Project management, like other professions, is no longer confined to the four walls of a traditional office. Digital and remote teams are more common than ever before, thanks to a variety of causes such as increased connection, shifting corporate ideals, and the rise of the gig economy.

The start of the Coronavirus (COVID-19) pandemic triggered an unusual shift in the predominance of remote work, which was already on the rise. Organizations all around the world have implemented new work-from-home policies that prioritise digital communication over face-to-face connection in an effort to protect workers and restrict the spread of the virus. Up to half of American workers are now telecommuting, and this trend is expected to continue even after the pandemic has passed, posing significant issues for project managers.

Some business functions for example, are easier to carry out when all members of a project team are in the same location. When all members of the team are in close proximity to one another, spontaneous cooperation, team building, project alignment, and other project management responsibilities are simply easier to manage.

This difficulty does not, however, imply that digital or remote teams are inevitably ineffective. Remote work has a number of advantages, including improved flexibility, which can help a company attract and retain top people from around the world.

Project managers must develop strategies to eliminate friction and inefficiencies that may arise as a result of the boom in remote labour, which is expected to remain even after the global health crisis fades. Clear and open communication has always been a vital approach for efficient project management, but as this trend continues to expand, it will become even more important.

A Closer Connection between Projects and Strategy

Project management is traditionally an organisational technique for working toward and achieving defined goals, such as the introduction of a single product or service or the pursuit of a specific outcome. In this view, a project is a temporary undertaking with a defined beginning and finish, and the project manager's job is to see it through to completion.

However, in recent years, project management has begun to play a larger role in many firms. The paradigm is increasingly being extended to broader strategy and objectives, making project management more than just a tool for achieving specific goals.

"As associate teaching professor in Northeastern's Master of Science in Project Management programme, we understand the importance of strategy and vision inside the firm," says Joseph Griffin, a certified PMP. "However, the question that emerges again and time again is: How do we execute?" "How can we put that strategy into action?"

"We're able to execute and make that plan actionable through the vehicles of projects and programmes," he continues. "One of the key trends we're seeing right now is a focus on programme and portfolio management, and how it may help us execute and manage strategy in an organisation."

Understanding the link between project, programme, and portfolio management is critical for project managers who want to put their abilities to greater strategic use within their organisation. This will enable you to identify how specific initiatives link to one another and to larger strategic goals, allowing you to make more informed decisions for your company in the future.

Project Management and Change Management

An organisation can go through dozens, if not hundreds, of organisational changes per year. Small changes to internal procedures to complete overhauls of a company's

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products, services, supply chain, strategy, or structure are all possible. While this has always been the case, the discovery of the new coronavirus has compelled many businesses to accept significant reform initiatives while still finishing old projects.

Project managers are increasingly being tasked with overseeing not only their own projects but also the organization's change initiatives.

According to the International Project Management Association's (IPMA) most recent Project Management Survey, 63 percent of firms perform projects that include at least some type of change management. Only 30% of these firms believe their change management capabilities are "very" or "very" effective, according to the same research.

You might be thinking, "What exactly does a project manager do?" Fortunately, even during times of significant organisational change, there are steps you can do to better manage your projects. For example, as part of your overarching project plan, you can create a change management strategy that describes the actions and regulations that your team will follow.

The Emergence of Hybrid Project Management Approaches

In the not-too-distant past, project managers—and even entire organizations—tended to follow a single project management technique for all projects. While project managers and organisations may have used different methodologies, a dependence on a single framework was often the rule.

However, in recent years, project managers and the businesses for which they work have become more adaptive in their approaches. Some have even combined several methodologies to create hybrid ways that are unique to their project or industry's demands. This trend has been aided by the rising acceptance of alternative project management approaches such as Kanban, Agile, and Scrum, as well as shifting corporate principles that allow for greater flexibility.

Hybrid approaches are being adopted by an increasing number of businesses. According to a recent survey, more than half of the manufacturers questioned utilise a combination of methods. According to the same survey, individuals who employ a combination are the most satisfied with their project management techniques.

While there are advantages to concentrating in a single framework, people who want to keep up with the project management business should endeavour to become familiar with all of the major techniques.

An Emphasis on Soft Skills

To be effective in their responsibilities, project managers must have a particular level of analytical and organisational skills. However, a project manager's job does not finish with the completion of project scope and budget documents. Understanding people and how to manage them in a way that produces the best results is at the heart of their business. As a result, having a strong set of "soft skills" might be just as crucial as having the hard talents that are commonly associated with the subject.

Effective project managers must be able to anticipate their team's needs, comprehend their hopes and motives, and detect and eliminate impediments before they impede project development.

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According to the Project Management Institute's (PMI) "Pulse of the Profession" study, most firms are increasingly emphasising leadership capabilities nearly as much as technical skills. The necessity for these qualities is supported by data from the World Economic Forum's "Future of Jobs" study, which shows that social skills are one of the top skillset businesses look for in new recruits, and that this trend is likely to continue.

The Impact of Artificial Intelligence and Data Analytics

The advent of artificial intelligence (AI), machine learning, and the explosion of data collecting and analysis that has characterised much of the twenty-first century will have an impact on project management, as it has on virtually every other business.

It's difficult to say with certainty what this influence will look like. Most experts, however, agree that some disruption is unavoidable, as the Association for Project Management points out in its "Projecting the Future" report.

Many administration-focused duties that currently fall to project managers, such as resource allocation, project balance, and schedule and budget updates, will likely be automated as a result of artificial intelligence. Another example would be resource allocation automation, which has traditionally featured variable degrees of automation.

While some may be concerned about the effects of automation on the profession, these changes also carry a lot of promise. By automating low-value-add processes, project managers may focus their resources and energy on tasks that will have the most impact on their organisation, allowing them to make more change and increase the likelihood of meeting the project's strategic goals.

To prepare for these changes, project management professionals do not need to become specialists in AI or data analytics, but they should seek to understand their organization's AI plans in order to anticipate changes in their responsibilities and everyday work.

3.4.3 Concept related to HRP, Acquiring Resources

The progression of the organisation from its current human resource position to the projected one is determined by human resource planning. It's a method for determining and securing the required amount and type of people at the right time and in the right location to meet an organization's goals.

Human resource planning, according to Dale. S. Beach, is "a process of determining and assuring that the organisation will have an adequate number of qualified persons, available at appropriate times, performing jobs that meet the enterprise's needs and provide satisfaction for the individuals involved."

Human resource planning is a continual process of locating the correct type and number of people at the right time and in the right place to perform in the organisation, thereby benefiting both the company and the individual. Human resource planning should be in sync with the organization's overall strategy.

Human resource planning that is correctly performed improves productivity and aids in the achievement of business objectives. It also aids in the reduction of employee turnover. Human resource planning allows managers to put the appropriate people in the right jobs at the right time. This is achievable if the human resource department

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is effectively integrated into the operations of the company and allowed complete autonomy in its responsibilities.

Human resource requirements should be carefully forecasted and acquired as far in advance as feasible. Effective planning provides the right quantity and type of people with the relevant skills and talents at the right time for the organisation. Human resource planning can be focused on the short, medium, or long term. Short-term human resource planning may focus solely on staff recruitment and selection, but medium-term human resource planning strives to include provisions for human resource training and development in addition to acquisition.

Long-term human resource planning focuses on acquisitions, training and development, health, welfare, and safety, determining wages, salaries, bonuses, and other fringe benefits, maintaining a human resources information system, performance evaluation, career planning, and stress counselling, among other things. Long-term planning is required for human resource development. This will assure the development and progress of the organisation. Every business must go through numerous stages of development. The organization's approach to human resource planning varies depending on the stage.

Human resource planning during the early stages of an organisation is based on the needs of the organisation. During this time, the government offers numerous benefits like as tax exemptions, low-cost electricity, and so on. The goal is to allow the company to expand. Human resource planning in a growing organisation takes on a new dimension of predicting human resources and caring for their development. Long-term human resource planning is used by the fully formed and established organisation.

The current state of human resources and their potentialities are assessed, and performance is appraised. The organisation can create and maintain human resource information in a computer software system that is accessible to all line and human resource managers, allowing them to assess human resource inventory on the go, which aids in human resource planning.

Human resource planning involves assessing present human resource inventory and anticipating future requirements. In this aspect, the human resource information system can assist in decision-making. Managers will find it easier to make decisions about recruitment, promotion, transfer, training, and salary fixing as a result of this.

Human resource planning is the process of making decisions about human resource procurement, development, compensation, information, welfare, assessment, and safety. It is a method of bringing organisational plans and objectives to life by supplying quantitative and qualitative human resource requirements and ensuring that they are properly utilised.

The kind and type of organisation determines the formulation and choice of human resource planning. It may prefer short-term or long-term human resource planning, as well as flexible or rigorous human resource planning. It is mostly determined by the strategy followed by the organisation.

Human resources come in a variety of shapes and sizes. They differ not only in their abilities, skills, potentialities, capabilities, excitement, and techniques, but also in the qualities they possess. While forecasting for future needs, human resource planning takes into account the stock of these standard skills inventories maintained by the human resource department.

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The human resource plan is interwoven with the broader organisational plan. To help achieve business objectives, human resource determines and sets goals for completing human resource responsibilities such as acquisition, development, compensation, promotion, transfer, retention, termination, retirement, welfare, and safety.

Acquiring Resources

The IT job market became increasingly competitive in the late 1990s. It was a seller's market, with businesses vying for a small pool of competent, experienced IT experts. Because the job market was in such bad shape in the early 2000s, employers were able to be quite picky when it came to hiring. Many firms are now experiencing a scarcity of IT personnel. However, regardless of the present job market, finding talented IT experts is vital. The project manager who is the smartest member on the team is said to have done a terrible job of recruitment. In addition to hiring team members, it's critical to secure the necessary physical resources (facilities, equipment, supplies, and so on) and deliver the appropriate resources at the appropriate time and location. This section covers critical aspects of project resource acquisition, such as resource assignment, resource loading, and resource levelling.

The process of securing team members, equipment, materials, and other resources needed to complete the project is known as resource acquisition.

The project plan is the most important factor in obtaining resources. This section will outline what resources are projected to be required to complete product delivery or project management. This should include a credible estimate of the resources needed for the project, as well as a timeline for when and for how long those resources would be needed.

As needed, the Acquire Resources process is repeated at various phases during the project. A high-level resource demand will be supplied in the early stages of the project, but as the plan is refined, more detail will be added, resulting in more precise resource specifications.

Resources may be chosen based on the following criteria:

- Relevant skills and experience for the job.
- When compared to the project budget, the cost.
- Availability when the project plan calls for it.
- The resource's attitude toward the project's objectives.

Using a score matrix to evaluate potential resources will provide a tool to ensure that the best resources for the project are chosen.

To ensure that the budget remains accurate, the budget for the project must be updated each time the Acquire Resources procedure is completed to reflect the projected expenses for the resources.

A Resource Management Plan is an important aspect of this process because it ensures that resources are scheduled, procured, and assigned at the most appropriate

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point in the project timeline. This is especially important when a single resource is assigned to multiple tasks in a project.

After the resources have been acquired, they must be assigned to the proper project tasks and given the information they require to perform their duties effectively. When it comes to human resources, integrating the function into the project team and managing that resource are critical to getting the most out of them.

3.4.4 Concept of Developing and Managing the Team

The difference in productivity between an average team and a high-performing, turned-on team is not 10%, 20%, or 30%, but 100%, 200 percent, or even 500 percent!

The term "synergy," which comes from the Greek word sunergos, which means "working together," captures the wonder and power of teamwork. Synergy can be both beneficial and bad. The expression "the total is greater than the sum of the parts" captures the core of positive synergy. Negative synergy, on the other hand, happens when the total is less than the sum of its parts.

Synergy is best seen on a basketball court, soccer field, or football field, as teammates work together to defeat a superior opponent (see Snapshot from Practice: The 2008 Olympic Redeem Team). Positive and negative synergy can be noticed and felt in the daily operations of project teams, albeit it is less evident than in team sports. Here's a description from one of the team members we spoke with:

"We fractionalized into a succession of subgroups instead of operating as a single large team." The marketing team, as well as the systems team, stayed together. A significant amount of time was spent talking and grumbling about one another. When the project began to fall behind schedule, everyone began to conceal their tracks and attempt to shift blame to others. After a while, we stopped having face-to-face conversations and instead used e-mail. Management finally pulled the plug on the project and brought in a new team to save it. It was one of the most dreadful project management situations I've ever had."

The following are some of the characteristics that are frequently connected with high-performing teams that have positive synergy:

- The team has a sense of common purpose, and each member is eager to contribute to the project's success.
- Individual abilities and experience are identified and utilised by the team, based on the project's demands at any given time. The team voluntarily accepts the influence and leadership of the individuals whose abilities are pertinent to the immediate work at hand at these times.
- To enhance work completion as well as sentiments of group cohesion and morale, roles are balanced and shared.
- Rather of being depleted by interpersonal concerns or competitive struggles, the team devotes its energy to problem solution.
- Different points of view are welcomed and freely expressed.
- Mistakes are considered as learning opportunities rather than punishments to encourage risk-taking and inventiveness.

- Members establish high personal performance goals for themselves and encourage one another to achieve the project's goals.
- Members identify with the group and see it as a valuable source of professional and personal development.

High-performing teams become champions, creating game-changing products, exceeding customer expectations, and completing projects on time and on budget. Mutual interdependence and a common aim or vision bind them together. They have a high level of trust and teamwork between them.

The Five-Stage Team Development Model

- Forming. During this stage, the members become familiar with one another and gain a better understanding of the project's scope. They start by determining what behaviours are appropriate in terms of both the project (what function they will play, what performance goals are in place) and interpersonal relationships (who is truly in charge). When members begin to see themselves as part of a group, this stage is complete.
- Storming. This stage is characterised by a high level of internal conflict, as the name implies. Members acknowledge that they are part of a project group, but they object to the project's and group's restrictions on their uniqueness. There is a disagreement about who will be in charge of the group and how decisions will be made. The project manager's leadership becomes accepted when these disagreements are overcome, and the group progresses to the next stage.
- Norming. The third stage involves the development of close ties and the demonstration of group cohesion. Camaraderie and shared responsibility for the project are at an all-time high. When the group structure is solidified and the group adopts a common set of expectations for how members should collaborate, the norming phase is accomplished.
- Performing. At this stage, the team's functioning structure is completely functional and acceptable. The focus of the group's energy has shifted from getting to know one another and figuring out how to operate together to achieving the project's objectives.
- Adjourning. Performing is the final stage of growth for traditional labour groups. There is, however, a finishing phase for project teams. The team is preparing for its own disbandment at this point. High performance isn't as important as it once was. Instead, the focus is on completing the project. Members' reactions differ at this level. Some members are optimistic, praising the project team's achievements. Others may feel depressed as a result of the loss of camaraderie and friendships formed throughout the project's execution.

This paradigm has various consequences for project team members. The first is that the model provides a framework within which the group can comprehend its own growth. Project managers have found that sharing the model with their teams has been beneficial. It assists members in accepting the tensions of the storming phase and refocusing their attention on the more productive stages. Another result is that it emphasises the importance of the norming phase, which has a substantial impact on the degree of productivity in the performance phase. As we will see, project managers

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must play an active part in developing group norms that will contribute to the project's eventual success. See the Punctuated Equilibrium Research Highlight for an alternative model of group growth.

Situational Factors Affecting Team Development

High-performance project teams are significantly more likely to develop under the following conditions, according to experience and research:

- Each squad has ten or less people.
- Members offer to participate on the project team as volunteers.
- Members work on the project from start to finish.
- Full-time members are assigned to the project.
- Members are part of a company culture that encourages collaboration and trust.
- The project manager is the only one who reports to the members.
- The team includes members from all important functional areas.
- There is a compelling goal to the project.
- Members are at easy talking distance of one another.

In practice, a project manager is unlikely to be allocated a project that fits all of these criteria. Many projects for example, necessitate the active participation of more than ten people and may involve a complicated network of interlocking teams totalling more than 100 people. In many organisations, project members are assigned by functional managers or central manpower departments with little participation from the project manager. Team members' involvement may be part-time or participants may shift in and out of the project team on an as-needed basis to maximise resource usage. In the case of ad hoc task forces, no one on the team is dedicated to the project full-time. In many companies, there is an NIH (not invented here) culture that discourages cross-functional collaboration.

Team members are frequently assigned to multiple managers, and in some situations, the project manager has no direct influence over team member performance evaluations or development chances. It is possible that key functional areas will not be represented throughout the project, but will only be involved in a sequential fashion. Not every initiative has a compelling goal. It can be difficult to elicit enthusiasm for ordinary projects such as a simple product extension or a standard housing complex. Finally, team members are frequently dispersed throughout multiple corporate locations and buildings, or across the globe in the case of a virtual project. It's critical for project managers and team members to understand the limits they're working with and do their best to work within them. It would be naïve to suppose that every project team has the same ability to develop into a high-performing unit. It may be difficult just to meet project goals in less-than-ideal circumstances. To maximise the effectiveness of a project team, ingenuity, discipline, and attention to team dynamics are required.

Building High-Performance Project Teams

Project managers are crucial in the development of high-performing project teams. They recruit members, hold meetings, construct a team identity, create a shared vision

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or a common sense of purpose, manage a reward system that encourages teamwork, coordinate decision-making, handle internal issues, and renew the team when energy wanes. Project managers take use of situational aspects that naturally aid team development while improvising around those that hinder it. They demonstrate a very engaged management style that exemplifies teamwork by doing so.

Reward and Recognition Systems

The implementation of team-based reward and recognition systems is another significant technique for encouraging team development. Management will encourage or reinforce the concept that people perform more efficiently in groups if they reward teamwork. Employees that accomplish or exceed corporate or project goals may be rewarded with bonuses, trips, or other incentives. People who willingly labour overtime to accomplish an aggressive schedule objective or go out of their way to help a teammate can be recognised and rewarded in a project context. People who work overtime for the sake of greater income or because of their own bad work or planning should not be rewarded by project managers.

Project managers must evaluate their team's performance on a regular basis. It's their job to figure out the best approach to grow their people and increase performance when they uncover areas where individuals or the entire team may improve.

The project manager must not only establish the project team, but also lead them through numerous project activities. (Note that PMI prefers the term "managing the project team" over "leading the project team," thus that terminology is used here as well.) After evaluating team performance and related data, the project manager must determine whether changes to the project should be sought, or whether improvements to enterprise environmental factors, organisational process assets, or the project management plan are required. Project managers must employ soft skills to determine the most effective methods for motivating and managing each team member.

General Advice on Managing Teams

"Teamwork remains the one lasting competitive advantage that has been completely untapped," says Patrick Lencioni, a well-known author and consultant on teams. "Teamwork is nearly always lacking within firms that fail, and often present within those that win." However, cooperation is difficult to establish, and maintaining teamwork is much more difficult because teams are prone to dysfunction. The following are the five types of team dysfunction:

- Absence of trust
- Fear of conflict
- Lack of commitment
- Avoidance of accountability
- Inattention to results

Each of these dysfunctions is addressed in detail in Lencioni's books. He advises for example, that team members use the Myers-Briggs Type Indicator, which was discussed earlier in this chapter, to help people open up to one another and create trust. He recommends that teams practice having unfiltered, passionate arguments about significant matters to master conflict. He emphasises the need of expressing

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all conceivable ideas and getting individuals to agree to disagree in order to establish commitment, but then having them commit to decisions. Lencioni highlights the significance of defining and focusing on everyone's top priorities in order to embrace accountability. He also claims that peer pressure and the reluctance to disappoint a co-worker are often more effective motivators than authoritative involvement. Finally, employing a scoreboard to focus on team results reduces ambiguity and ensures that everyone understands what it takes to produce positive results.

The following are some additional recommendations for ensuring that teams are productive:

- With your team, be patient and kind. Assume the best in people; don't assume your co-workers are slackers or irresponsible.
- Instead of blaming people, fix the problem. By concentrating on habits, you can assist people in resolving issues.
- Set up productive meetings on a regular basis. Concentrate on accomplishing project goals and achieving favourable outcomes.
- Allow teams time to complete Tuckman's basic team-building processes of forming, storming, norming, performing, and adjourning. Expect teams to work at their peak performance level over time.
- Workgroups should be limited to three to seven people.
- Plan some social activities to allow members of the project team and other stakeholders get to know one another better. Make the social events enjoyable rather than obligatory.
- Make a big deal of your team's identity. Make traditions that everyone on the team enjoys.
- Team members should be nurtured and encouraged to assist one another. Determine and deliver training to assist individuals and the team as a whole in becoming more effective.
- Recognise individual and group achievements.
- Take extra steps to collaborate with virtual team members. When starting a virtual project or introducing a virtual team member, if possible, have a face-to-face or phone meeting. People should be thoroughly screened to ensure that they can function well in a virtual setting. Determine how members of the virtual team will communicate.

Controlling Resources

Controlling resources entails ensuring that the project's physical resources are available when they are needed. It also entails keeping track of planned vs. actual resource usage and taking corrective action as needed. The Manage Team method deals with making optimal utilisation of team members. Data analysis, problem solving, interpersonal and team skills, and project management information systems are examples of tools and techniques. Work performance data, modification requests, project management plan updates, and project document changes are all examples of key outputs.

Considerations for Agile/Adaptive Environments

Team arrangements that optimise concentration and collaboration, such as self-organizing teams with generalising specialists, benefit projects with high variability.

Collaboration is supposed to increase productivity and improve problem-solving creativity. Collaborative teams can help with rapid integration of different job tasks, improved communication, knowledge exchange, and work assignment flexibility, among other things.

Because there is less time for centralised tasking and decision making, collaborative teams are typically important to the success of projects with a high degree of variable and rapid changes, despite the benefits of collaboration being applicable to other project environments.

Physical and human resource planning is substantially less predictable in high-variability projects. Agreements for quick supply and lean processes are crucial in these situations for cost reduction and meeting deadlines.

Collaboration, problem solving, and knowledge sharing are all crucial on all types of projects. Team members on agile projects, on the other hand, are usually totally dedicated to a single team. Trust is the foundation of relationships, and collaboration is constantly improved through regular feedback loops. Each sprint's end-of-sprint delivery of usable product for example, decreases uncertainty and increases team confidence. Another distinction is that some agile teams do not employ project managers. They might be self-directing teams or they could have a Scrum master.

Daily stand-up meetings are intended to improve the frequency of communication among project team members while keeping these brief meetings focused on the topic at hand. Co-location of users and development teams is a significant way to meet social needs. Communication between the development team and the user group is likely to be inadequate, and co-location should be promoted.

Physical resources, in addition to human resources, should be handled in an adaptive manner. Prototypes, simulations, feasibility studies, and other risk-reduction techniques can help you figure out which resources are ideal for the job and how to employ them. This method entails breaking down the task into manageable chunks, each with its own set of resources and costs, and implementing them in a logical order as the deliverables take shape within the larger project.

Much more than using tools to assess and track resource loading and level resources is involved in project resource management. On most projects, people are the most valuable asset, and human resources are distinct from other resources. You can't simply replace people like you can replace a piece of machinery. It is critical to treat individuals with compassion and respect, to comprehend their motivations, and to communicate with them thoughtfully. What makes successful project managers outstanding is their ability to empower project team members to deliver their best work on a project, not their use of tools.

3.5 Procurement Management System

Procurement management is a strategic method to reducing the amount of money spent by a company. Sourcing, requisitioning, ordering, inspection, and reconciliation

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are all invoiced. It implies getting your goods and services from selected vendors on or before the deadline, while staying within your budget.

3.5.1 Real Time Case Study: Discussing the Tools and Techniques for Directing and Managing Project Work, Creating a Project Charter, Estimating the Activity Resources

Payton Corporation

Payton Corporation had made the decision to reply to a government RFP for a new project's R&D phase. The statement of work stipulated that the project must be finished within ninety days after receiving approval, and that the contract would be for a set price and fee. The development lab would be in charge of the majority of the work. Government requirements require that the anticipated cost be based on the department's average cost, which was $19.00 per hour (unburdened).

Payton was awarded the contract for a total package of $305,000 (cost + fee). After looking over the first weekly labour report, it was clear that the development lab was spending $28.50 per hour. The project manager decided to speak with the development lab's manager about the issue.

Project manager: "Obviously you know why I'm here. At the rate that you're spending money, we'll overrun our budget by 50 percent."

Lab manager: "That's your problem, not mine. When I estimate the cost to do a job, I submit only the hours necessary based on historical standards. The pricing department converts the hours to dollars based on department averages."

Project manager: "Well, why are we using the most expensive people? Obviously there must be lower-salaried people capable of performing the work."

Lab manager: "Yes, I do have lower-salaried people, but none who can complete the job within the two months required by the contract. I have to use people high on the learning curve, and they're not cheap. You should have told the pricing department to increase the average cost for the department."

Project manager: "I wish I could, but government regulations forbid this. If we were ever audited, or if this proposal were compared to other salary structures in other proposals, we would be in deep trouble. The only legal way to accomplish this would be to set up a new department for those higher-paid employees working on this project. Then the average department salary would be correct.

"Unfortunately the administrative costs of setting up a temporary unit for only two months is prohibitive. For long-duration projects, this technique is often employed.

"Why couldn't you have increased the hours to compensate for the increased dollars required?"

Lab manager: "I have to submit labor justifications for all hours I estimate. If I were to get audited, my job would be on the line. Remember, we had to submit labor justification for all work as part of the proposal.

"Perhaps next time management might think twice before bidding on a short duration project. You might try talking to the customer to get his opinion."

Project manager: "His response would probably be the same regardless of whether I explained the situation to him before we submitted the proposal or now, after we have negotiated it. There's a good chance that I've just lost my Christmas bonus."

Questions:

1. What is the basis for the problem?
2. Who is at fault?
3. How can the present situation be corrected?
4. Is there any way this situation can be prevented from recurring?
5. How would you handle this situation on a longer-duration project, say one year, assuming that multiple departments are involved and that no new departments were established other than possibly the project office?
6. Should a customer be willing to accept monetary responsibility for this type of situation, possibly by permitting established standards to be deviated from? If so, then how many months should be considered as a short-duration project?

3.5.2 Introductory Concept of Communication Planning

Improper communication planning can result in issues such as message delivery delays, sensitive material being communicated to the wrong audience, or a lack of communication with some of the required stakeholders.

A communication plan allows the project manager to document the best way to communicate with stakeholders in the most efficient and effective way possible. Information is delivered in the correct format, at the right time, and with the right impact when it is communicated effectively. Only presenting the information that is required is what efficient communication entails. On most projects, communications planning takes place early on, such as with the development of the project management strategy. This enables for the proper allocation of resources, such as time and money, to communication initiatives. To ensure continuous applicability, the outputs of this planning process should be reviewed and amended as needed during the project.

Failure to communicate, according to many experts, is the greatest threat to the success of any project, particularly IT initiatives. Many issues in other areas of knowledge, such as a hazy scope or unreasonable deadlines, suggest communication issues. Project managers and their teams must prioritise good communication, particularly with senior management and other key stakeholders.

The IT field is always changing, and with that shift comes a lot of technical jargon. Technical jargon can often complicate problems and cause confusion when computer specialists engage with those who aren't as adept with or informed about computers—a category that includes many business professionals and senior managers. Despite the fact that the majority of people now use computers, the divide between users and developers is widening as technology progresses. Some of the communication issues between technical personnel and their business colleagues are caused by this knowledge and experience divide. Of course, not every computer expert is a terrible communicator, but communication skills can be improved by almost anyone in any area.

Furthermore, many school institutions favour strong technical skills above excellent communication and social skills for IT graduates. Most IT-related degree programmes include a lot of technical prerequisites, but just a few of them need courses in communication (speaking, writing, listening), psychology, sociology, or the humanities.

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People frequently believe that mastering these soft skills is simple, yet they are critical skills that must be learned and developed.

Soft skills are needed by IT professionals as much, if not more, than other skills, according to numerous studies. When working on IT projects, you can't completely separate technical and soft abilities. Every project team member requires both types of talents and must continue to develop them through formal education and on-the-job training in order for projects to thrive.

According to studies, there is a great demand for IT workers, and solid communication and business abilities are essential. In an article published in the International Journal of Business and Social Science, it is stated:

- Employers are searching for employees that have the right blend of technical, soft, and business abilities.
- Problem solving, teamwork, listening, ability to adapt to new technologies and languages, time management, ability to transfer knowledge to application, multitasking, verbal communication, ability to visualise and conceptualise, "be the customer" mentality, interpersonal skills, understanding business culture, inter-team communication, and the ability to give and receive constructive criticism are the most important non-technical skills.
- "The need for these non-technical abilities is so high that several IT firms have stated that they will hire someone with only rudimentary technical skills if they can demonstrate strong soft and business skills."

The purpose of project communications management is to guarantee that project information is generated, collected, disseminated, stored, and disposed of in a timely and suitable manner. In project communications management, there are three basic processes:

- Stakeholders' information and communication demands must be determined while planning communications management. What information is required by whom? When are they going to need it? What method will be used to provide the information to them? This procedure produces a communications management plan, project management plan updates, and project document updates, among other things.
- According to the communications management plan, managing communications entails developing, distributing, storing, retrieving, and discarding project communications. Project communications, project management plan updates, project document updates, and organisational process assets changes are the major outputs of this procedure. Remember from Chapter 4 that formal and informal plans, policies, procedures, guidelines, information systems, financial systems, management systems, lessons learned, and historical information are all examples of organisational process assets. These assets assist people in an organisation in understanding, following, and improving business processes.
- Monitoring communications entails ensuring that the communication demands of stakeholders are satisfied.

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3.6 Communication Management System

Communications management entails the systematic planning, implementation, monitoring, and revision of all communication channels within and between organisations, as well as the organisation and dissemination of new communication directives related to an organisation, network, or communications technology. Developing corporate communication strategies, devising internal and external communications directives, and controlling the flow of information, including internet communication, are all aspects of communications management. It is merely a procedure that assists an organisation in becoming more systematic within the confines of communication.

3.6.1 Need of Communication Requirement Analysis

Because the organization's structure will have a significant impact on the project's communications requirements, the Plan Communications process is closely tied to enterprise environmental elements.

Following up with an internal communication plan is critical once the project deliverables and work have been clearly specified. Poor communication is frequently cited as a key cause of project failure. A solid communications plan may go a long way toward preventing project issues and ensuring that clients, team members, and other stakeholders get the information they need to do their tasks.

During the early stages of project planning, the project manager and/or the project team normally construct a communication plan.

When it comes to planning and managing project schedules, challenges, and action items, communication is crucial. The plan lays out how information will be distributed to various stakeholders and becomes an important aspect of the overall project plan. A project communication strategy specifies what, who, how, and when information will be communicated to project stakeholders in order to manage schedules, issues, and action items.

The following fundamental questions are addressed in project communication plans:

- What information should be collected and when should it be collected?
- Who will be the recipients of the information?
- What mechanisms will be employed to collect and store data?
- What, if any, restrictions exist on who has access to certain types of information?
- When will the details be made public?
- What method will be used to communicate it?

The following basic phases are frequently included in developing a communication plan that answers these questions:

- Conducting a stakeholder analysis. Determine the target demographics. Customers, sponsors, project teams, project offices, and anybody else that needs project information to make choices and/or contribute to project progress are examples of typical groupings.

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- Information requirements. What information is important to stakeholders who are involved in the project's development? Top management for example, requires information on how the project is progressing, whether it is experiencing critical issues, and the extent to which project objectives are being met. This data is essential in order for them to make strategic decisions and manage a project portfolio. Schedules, task lists, requirements, and the like are needed by project team members so they know what needs to be done next. Any changes in the timeline and performance requirements of the components they provide must be communicated to external entities. The following are some of the most common information requirements found in communication plans:
  - Project status reports
  - Deliverable issues
  - Changes in scope
  - Gating decisions
  - Action items
  - Team status meetings
  - Accepted request changes
  - Milestone reports
- Informational resources. The next stage is to determine the information sources once the information needs have been determined. Where does the data dwell, in other words? What method of collection will be used? The minutes and reports of various groups for example, might contain information on the milestone report, team meetings, and project status meetings.
- Modes of distribution E-mail, teleconferencing, Lotus Notes, SharePoint, and a variety of database sharing programmes are now used to supplement traditional status report meetings in today's world. Many businesses, in particular, are using the Internet to create a "virtual project office" where they can store project data. Project management software sends data directly to the website, allowing different people to see relevant project data right away. In some circumstances, key stakeholders are automatically notified of relevant information. For many project changes and action items, a backup paper hardcopy to specified stakeholders is still required.
- Timing and accountability: Decide who will be responsible for disseminating the information. A common practice for example, is for meeting secretaries to provide minutes or specialised information to the necessary stakeholders. The project manager or project office may bear some responsibility in some cases. It's important to figure out the best time and frequency for distributing the information.

Establishing a communication plan has the advantage of allowing you to manage the flow of information rather than responding to information requests. This avoids ambiguity and unwanted disruptions, as well as giving project managers more control.

Senior management will feel more comfortable letting the team complete the project without intervention if you report on how things are going and what is happening on a regular basis.

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Table: Project Communication Plan

What Information	Target Audience	When?	Method of Communication	Provider
Milestone report	Senior management and project manager	Bimonthly	E-mail and hardcopy	Project office
Project status reports & agendas	Staff and customer	Weekly	E-mail and hardcopy	Project manager
Team status reports	Project manager and project office	Weekly	E-mail	Team recorder
Issues report	Staff and customer	Weekly	E-mail	Team recorder
Escalation reports	Staff and customer	When needed	Meeting and hardcopy	Project manager
Outsourcing performance	Staff and customer	Bimonthly	Meeting	Project manager
Accepted change requests	Project office, senior mgmt., customer, staff, and project mgr.	Anytime	E-mail and hardcopy	Design department
Oversight gate decisions	Senior management and project manager	As required	E-mail meeting report	Oversight group or project office

It is impossible to stress the necessity of creating an early plan for delivering critical project information. Many project issues can be traced back to a lack of effort spent on a solid internal communication strategy.

The information requirements of project stakeholders are determined by analysing communication requirements. These specifications are created by combining the type and structure of information required with an assessment of its value. Only project resources are used to communicate information that is critical to success or where a lack of communication could lead to failure.

The number of potential communication channels or paths should also be considered by the project manager as an indicator of the communication complexity of the project. n(n-1)/2 is the total number of potential communication routes, where n is the number of stakeholders. As a result, a project with ten stakeholders has 10(10-1)/2 = 45 communication routes to consider. Determining and limiting who will contact with whom and who will receive what information is, thus, an important part of designing the project's actual communications.

The following is a list of common sources of information used to determine project communication needs:

- Graphs of organisation.
- Relationships between stakeholders and project organisation.
- The project's disciplines, departments, and specialties are all involved.
- The logistics of how many people will be participating in the project and where they will be located.

Notes

- Internal data requirements (e.g., communicating across organizations).
- External information requirements (e.g., interacting with the media, the general public, or contractors), and internal information requirements
- Information about stakeholders from the stakeholder register and the stakeholder management plan.

3.6.2 Different Communication Models

A basic communication model, as depicted in the diagram below, depicts how information is delivered and received between two parties, the sender and the receiver. The following are some of the model's most important features:

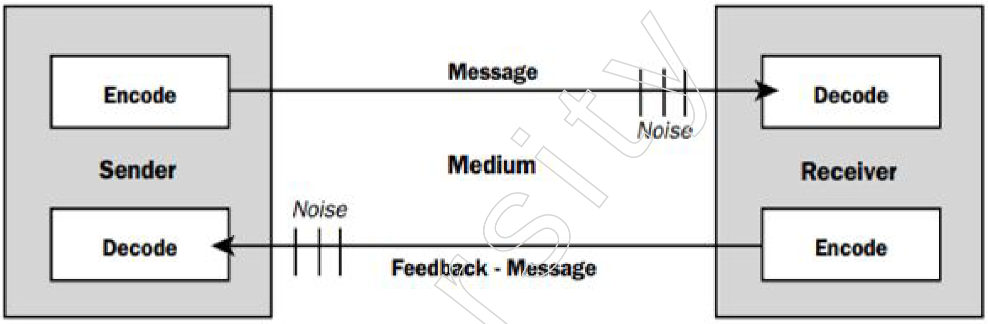

Figure: Basic Communication Model

- Encode. To put one's thoughts or ideas into a language that others can understand.
- Message and feedback-message. The result of the encoding process.
- Medium. The method used to convey the message.
- noise. Anything that obstructs the message's transmission and comprehension (e.g., distance, unfamiliar technology, lack of background information).
- Decode. Reconcile the message with relevant thoughts or concepts

A basic communication model is shown in the diagram above. An action to acknowledge a message is built into the model. The receiver acknowledges that he or she has received the message but does not necessarily agree with it. Another activity is a message response, which indicates that the receiver has decoded, comprehended, and is responding to the message.

When considering project communications, the components of the communications model must be considered. The sender is responsible for making the information clear and comprehensive so that the receiver can receive it appropriately, as well as checking that it has been received correctly. The receiver must ensure that the information is received in its completeness, appropriately interpreted, and recognised. A lack of communication might have a detrimental influence on the project.

There are numerous obstacles in properly communicating with project stakeholders utilising these components. Consider a multi-national project team with a high level of technical expertise. Encoding the message in the appropriate language, sending the message using a variety of technologies, and having the receiver decode the message and reply or provide feedback are all examples of how one team member can successfully communicate a technical concept to another team member in another country. Any noise produced along the road detracts from the message's original meaning.

Communication Methods

Information is shared among project stakeholders through a variety of communication strategies. These techniques can be divided into three categories:

Interactive communication. A multidirectional exchange of information between two or more parties. Meetings, phone conferences, video conferencing, and other methods are used to ensure that all participants have a shared knowledge of specific topics.

Push communication. Messages are sent to selected individuals who require the information. This ensures that the information is transmitted, but it does not guarantee that the intended audience received it or comprehended it. Letters, memoranda, reports, emails, faxes, voice mails, and press releases are examples of push communication.

Pull communication. Used when there is a lot of information or a lot of people, and the recipients have to view the communication content at their own choice. Intranet sites, e-learning, and knowledge repositories are examples of these methods.

The project manager determines what, how, and when communication methods will be employed in the project based on communication requirements.

Plan Communications: Outputs

- Communications Management Plan

  The project management plan contains or is a component of the communications management strategy. The communications management strategy might be formal or informal, specific or wide, and tailored to the project's requirements.

  Typically, a communications management plan includes:

  - Requirements for stakeholder communication.
  - Language format, substance, and level of detail are all factors to consider while communicating information.
  - The purpose of disseminating that knowledge.
  - Distribution of essential information within a specific time range and on a regular basis.
  - The person in charge of disseminating the information.
  - Person in charge of approving the release of secret information.
  - The individual(s) or group(s) who will be receiving the information.
  - Memos, e-mail, and/or press releases are examples of methods or technology used to transmit information.
  - Time and budget have been set aside for communication efforts.

Notes

- Time frames and the management chain (names) for escalation of issues that cannot be resolved at a lower staff level are identified in the escalation procedure.
- As the project progresses and develops, this method for updating and enhancing the communications management strategy is used.
- A glossary of commonly used terms.
- Flow charts depicting the project's information flow, workflows with various permission sequences, a list of reports, and meeting agendas, among other things; and
- Constraints on communication are typically come from specialised legislation or regulation, technology, and organisational policies, among other things.

Guidelines and templates for project status meetings, project team meetings, e-meetings, and e-mail can all be included in the communications management plan. If they are used in the project, a project website and project management software can also be included.

- Project Document updates

Documents related to the project that may be modified include, but are not limited to:

- Project schedule,
- Stakeholder register, and
- Stakeholder management strategy.

3.6.3 Information Distribution, Managing Stakeholders

Information Distribution

The process of making relevant information available to project stakeholders as planned is known as distribute information. It's done at every stage of the project's life cycle, as well as in all management activities. The execution process, which involves implementing the communications management plan as well as responding to unanticipated demands for information, is the main focus here. A variety of approaches are used to effectively distribute information, including:

- Models with a sender and a recipient. Communication obstacles and feedback loops
- Media selection. When to communicate in writing vs. orally, when to write an informal note vs. a formal report, and when to communicate face-to-face vs. through e-mail, depending on the situation.
- Style of writing Active versus passive voice, sentence construction, and word choice are all important considerations.
- Techniques for meeting management. Creating a schedule and resolving problems
- Techniques of presentation Body language and visual aids design
- Techniques for facilitation Constructing consensus and overcoming roadblocks

Distribute Information: Inputs

- Project Management Plan

  The communications management plan is included in the project management plan.

- Performance Reports

  Performance reports are intended to disseminate project performance and status information, and they should be accessible prior to project meetings and as accurate and current as feasible.

  Forecasts are modified and published as the project progresses, based on work performance metrics. This data pertains to the project's previous performance that may have an impact on the project's future performance, such as estimates at completion and estimates to complete. Earned value methods are commonly used to create forecast information, but alternative methods such as analogy with previous projects, re-estimating remaining work, including the impact of external events in the timetable, and others may also be used. This information, together with performance data and other critical data that must be disseminated for decision-making, should be available.

- Organizational Process Assets

  The following are examples of organisational process assets that can influence the Distribute Information process:

  - Policies, procedures, and guidelines regarding information distribution,
  - Templates, and
  - Historical information and lessons learned

Distribute Information: Tools and Techniques

- Communication Methods: Information is distributed through individual and group meetings, video and audio conferences, computer chats, and other remote communication methods.
- Information Distribution Tools: A variety of tools can be used to transmit project information, including:
  - Electronic communication and conferencing tools, such as e-mail, fax, voice mail, telephone, video and web conferencing, websites and web publishing;
  - Electronic project management tools, such as web interfaces to scheduling and project management software, meeting and virtual office support software, portals, and collaborative work management tools; and
  - Electronic communication and conferencing tools, such as e-mail, fax, voice mail, telephone, video and web conferencing, websites and web publishing.

Distribute Information: Outputs

Updates to Organisational Process Assets

The following are examples of organisational process assets that could be updated:

- Notifications to stakeholders. Stakeholders may be informed about addressed issues, approved changes, and the overall progress of the project.

Notes

- Reports on projects. Lessons learned, issue logs, project closing reports, and outputs from other Knowledge Areas are all included in formal and informal project reports that reflect project status.
- Presentations on a project: The project team communicates with any or all project stakeholders formally or informally. The information and presentation technique should be appropriate for the audience's demands.
- Records of the project. Correspondence, memos, meeting minutes, and other documents outlining the project are examples of project records. To the degree practicable and acceptable, this information should be kept in an organised fashion. Members of the project team can also keep track of things in a project notebook or register, which can be physical or electronic.
- Stakeholders' responses Information about project operations collected from stakeholders can be disseminated and used to adjust or improve the project's future performance.
- Documentation of the lessons learned. The causes of issues, the logic behind the corrective action selected, and other sorts of information distribution lessons learned are all documented. Lessons learnt are documented and disseminated so that they become part of the project's and performing organization's history databases.

Managing Stakeholders

Stakeholders are a crucial component of the project management process. Projects are requested, approved, rejected, supported, and opposed by stakeholders. The Project Management Institute decided to create an entire knowledge area devoted to stakeholder management in 2013 because it is so important to project success. Many of the same concepts that apply to communications and resource management also apply to stakeholder management, but specific activities are necessary to do it effectively. The goal of project stakeholder management is to identify all people or organisations who are impacted by a project, understand stakeholder expectations, and effectively involve stakeholders in project decisions throughout the project's life cycle. To achieve stakeholder satisfaction, project managers and their teams must maintain open lines of communication with stakeholders and resolve concerns as they arise.

Projects frequently result in organisational changes, and when a project is over, some people may lose their positions. For example, a project can result in the outsourcing of work to an external group to make the organisation more efficient, or a project might result in the creation of a new system that renders some jobs redundant. These and other negatively affected stakeholders may perceive project managers as adversaries. Some people, on the other hand, may see project managers as allies if they lead a project that boosts profitability, creates new jobs, or raises remuneration for specific stakeholders. Project managers must learn to recognise, comprehend, and work with a variety of stakeholders in any instance.

The following are the four processes involved in project stakeholder management:

- Stakeholder identification entails identifying everyone involved in or affected by the project and finding the best strategies to manage interactions with them. A stakeholder registration is the key product of this approach.

- Stakeholder engagement planning is formulating methods for effectively including stakeholders in project decisions and activities, taking into account their needs, interests, and potential impact. A stakeholder engagement plan is the result of this approach.
- Communicating and working with project stakeholders to meet their needs and expectations, resolving difficulties, and encouraging participation in project decisions and activities are all part of managing stakeholder engagement. Change requests, project management plan updates, and project document changes are the outcomes of this procedure.
- Monitoring stakeholder engagement entails keeping track of stakeholder interactions and updating stakeholder engagement plans and strategies as needed. Work performance data, change requests, project management plan changes, and project document updates are all outputs of this procedure.

Stakeholders are those who are affected by or can affect a project in a positive or bad way. Some stakeholders may have limited influence over the project's work or outcomes, while others may have a significant impact on the project and its projected outcomes. Academic studies and evaluations of high-profile project failures emphasise the significance of taking a systematic strategy to identifying, prioritising, and engaging all stakeholders. The project manager's and team's ability to properly identify and engage all stakeholders can spell the difference between project success and failure. The process of stakeholder identification and engagement should begin as soon as feasible after the project charter has been accepted, the project manager has been assigned, and the team has begun to assemble to increase the odds of success.

As a project goal, stakeholder satisfaction should be recognised and monitored. Focus on continuous communication with all stakeholders, including team members, to understand their needs and expectations, address issues as they arise, manage conflicting interests, and foster appropriate stakeholder engagement in project decisions and activities is the key to effective stakeholder engagement.

It is an iterative process to identify and engage stakeholders for the project's benefit. Despite the fact that the processes in Project Stakeholder Management are only stated once, the activities of identification, prioritising, and engagement should be evaluated and modified on a regular basis, and at least when:

- The project goes through several stages as it progresses through its life cycle.
- Current stakeholders are no longer active in the project's work, or new stakeholders join the project's stakeholder community, or
- The organisation or the larger stakeholder community undergoes substantial changes.

Summary

- The act of constructing a timetable - selecting how to sequence these tasks and how to allocate resources among the various tasks - is known as scheduling, and the person in charge of generating a specific schedule is known as a scheduler.
- Some of the project scheduling systems include, but are not limited to, the following: a) Iterative scheduling with a backlog, b) On-demand Scheduling

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- Iterative scheduling with a backlog, this is a type of rolling wave planning that is based on adaptive life cycles, like the agile product development strategy.
- On-demand scheduling does not rely on a previously created timetable for the creation of the product or product increments, but instead pulls work from a backlog or intermediate queue of work to be completed as resources become available.
- A project management schedule enables for more efficient scheduling and expense management, saving time, money, or both. So a project can be planned and performed better. This frees up your time for other tasks.
- The process of defining policies, methods, and documentation for planning, developing, managing, executing, and controlling the project schedule is known as plan schedule management.
- PERT is a method for analysing the tasks involved in completing a project, particularly the time required to accomplish each work, and determining the shortest time required to finish the entire project.
- A Critical Path Method is a project management technique that identifies potential delays in a project's timeline. The approach provides a visual representation of potential bottlenecks as the project advances.
- A Gantt chart is a common style for displaying project schedule information in calendar form by listing project activities and their associated start and finish dates.
- Crashing is a cost and schedule trade-off strategy that allows you to get the most schedule compression for the least amount of money.
- Fast tracking is another method for reducing the length of a project's timetable. Fast tracking entails performing operations in simultaneously that would ordinarily be completed in order.
- A matrix responsibility chart illustrates all of the members' key tasks and commitments. It's a simple diagram that organises the project by defining each participant's authority and responsibilities. The matrix responsibility chart identifies roles and duties to avoid any confusion or disputes in departmental or cross-functional projects.
- The PERT (programme (or project) evaluation and review technique) is a statistical tool used in project management that was created to examine and portray the tasks required in completing a project.
- Bar charts, unlike networks, are time-scaled, which means that the length of a bar representing a certain activity is related to the duration of that action. You can get an idea of the duration of each task and the full project just by looking at the chart.
- Project risk management is the art and science of identifying, evaluating, and responding to risk in order to achieve project objectives. Risk management, a sometimes-overlooked aspect of project management, can significantly improve project success. Risk management can aid with project selection, scope, timeline, and cost estimation. It helps stakeholders understand the project's nature, team members identify strengths and limitations, and integrate other project management knowledge areas.

Notes

- Risk categories are the classification of hazards based on the organization's business activities, and they provide a structured picture of the underlying and prospective dangers they confront.
- The process of selecting how to approach risk management activities and planning for them in a project is known as risk management planning; the main outcome of this process is a risk management plan.
- A risk management strategy outlines how risk management will be carried out on a specific project. It becomes a subset of the project management plan, just like plans for other knowledge domains.
- A resource is defined as everything or anybody who can be scheduled or booked to fulfil a task or project.
- The key concepts of Project resource management are as follows: a) Planning resource management, b) Estimating activity resources, c) Acquiring resources, d) Developing the project team, e) Managing the project team, f) Controlling resources.
- A strong resource management strategy isn't always easy to implement, but it can help the project management process. We may share part of our knowledge and experience gained from user comments. These will help you master resources.
- Human Resource Outsourcing is the practice of hiring a third party to undertake HR functions. A company can outsource any or all of its HR functions to a single or multiple service providers.
- Human resource planning determines the organization's transition from its current to planned human resource position. It's a way of determining and securing the right personnel at the correct time and place to achieve an organization's goals.
- A communication plan allows the project manager to document the best way to communicate with stakeholders in the most efficient and effective way possible.
- Information is shared among project stakeholders through a variety of communication strategies. These techniques can be divided into three categories: a) Interactive communication. b) Push communication. c) Pull communication.

Glossary

- ABCP: As Built Critical Path
- CPM: Critical Path Method
- PERT: Program Evaluation and Research Technique
- RCPSP: Resource-Constrained Project Scheduling Problem
- SPMnets: Software Project Management Net
- EBS: Event Based Scheduler
- ACO: Ant Colony Optimization
- LRC: Linear Responsibility Chart
- MRC: Matrix Responsibility Chart
- RIM: Responsibility Interface Matrix

Notes

- RAM: Responsibility and Accountability Matrix
- RACI: Responsible, Accountable, Consulted, and Informed
- NORC: Naval Ordinance Research Computer
- AOA: Activity on Arrow
- AON: Activity on Node
- RPM: Risk Management Professional
- IPMA: International Project Management Association
- PMI: Project Management Institute
- AI: Artificial Intelligence

Check Your Understanding

1. A_ _ _ _ _ _ is a list of actions from a collection of transactions in a database.
   a) Programme
   b) Model
   c) Project
   d) Schedule
2. _ _ _ _ _ _ __ is a method for analysing the tasks involved in completing a project, particularly the time required to accomplish each work, and determining the shortest time required to finish the entire project.
   a) CPM
   b) PERT
   c) PLC
   d) None of these
3. A_ _ _ _ _ _ _ _ is a project management method that determines where potential delays are most likely to occur by formulating a time schedule for a Project Life Cycle
   a) Critical Path Method
   b) PERT
   c) EBS
   d) Gantt chart
4. A _ _ _ _ _ _is a common style for displaying project schedule information in calendar form by listing project activities and their associated start and finish dates.
   a) PERT
   b) CPM
   c) SDLC
   d) Gantt chart

Notes

5. _ _ _ _ _ _ _ _is a cost and schedule trade-off strategy that allows you to get the most schedule compression for the least amount of money.

    a) Product Cost

    b) Crashing

    c) PLC

    d) Project

6. _ _ _ _ _ _ _ _ _entails performing operations in simultaneously that would ordinarily be completed in order.

    a) Fast tracking

    b) Scheduling

    c) Crashing

    d) None of the above

7. A_ _ _ _ _ _ _ _ chart depicts all of the primary tasks and obligations of participants in a business initiative.

    a) PERT

    b) GANTT

    c) Project Management

    d) Matrix Responsibility

8. _ _ _ _ _ _ _ _ _the shortest amount of time required to complete a task, if everything goes as planned..

    a) Pessimistic Time

    b) Optimistic Time

    c) Expected Time

    d) All of the above

9. _ _ _ _ _ _ _ _the greatest amount of time it will take to complete a task if everything goes wrong (but excluding major catastrophes).

    a) Pessimistic Time

    b) Optimistic Time

    c) Most Likely Time

    d) None of the above

10. _ _ _ _ _ _ _ _are popular for displaying schedule activities because they are simple to read.

    a) PERT

    b) Gantt charts

    c) SDLC

    d) None of the above

Notes

11. The art and science of recognising, analysing, and responding to risk throughout the life of a project in the best interests of accomplishing project objectives is known as_ _ _ _ _ _ _ _ _

a) Project Risk Management

b) Project Cost Management

c) Project Management

d) All of the above

12. _ _ _ _ _is a risk that emerges from an incorrect estimate of a budget allotted to a specific project or activity.

   a) Operational Risk

   b) Budget Risk

   c) Schedule Risk

   d) Business Risk

13. _ _ _ _ _ _ are the kind of risks that cause an organization's entire operation and performance to fail.

   a) Resource Risk

   b) Supplier Risk

   c) Technical and architectural Risks

   d) None of these

Exercise

1. Define basic concept of project scheduling.
2. What are the benefits of project scheduling?
3. Explain techniques of scheduling project.
4. Explain Gantt chart, CPM technique with example.
5. Define basic concept of schedule control.
6. What do you understand by linear responsibility chart (LRC)?
7. Explain pert chart.
8. Explain Gantt chart, CPM technique with example.
9. Explain introduction to risk management.
10. Explain risk response planning, developing risk management plan.
11. What are the key concepts of project resource management?
12. Define trends and emerging practices in project resource management.
13. What is the concept related to HRP, acquiring resources?
14. What do you understand by the concept of developing and managing the team?
15. Define Introductory Concept of Communication Planning.

Notes

16. Why are the needs of Communication Requirement Analysis?
17. Define Different Communication Models.
18. What do you mean by Information Distribution, Managing Stakeholders?

Learning Activities

- Create an ideal Human resource plan for IT tech start-up.
- What according to you is best a manual procurement system or automated procurement system? Why?

Check Your Understanding - Answers

1. d
2. b
3. a
4. d
5. b
6. c
7. d
8. b
9. a
10. b
11. a
12. b
13. c

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Notes

Module - IV: Project Implementation

Learning Objectives:

At the end of this module, you will be able to understand:

- Project Change Control and Different Tools
- Project Monitoring with Different Tools
- Introduction to the Computer Application in Project Management
- Need for Computer Application in Project Management
- Different Software for Project Management
- Introduction to Project Contracting Process
- Tools and Techniques for Project Contracting
- Stages in Project Procurement Process
- Significance of Project Procurement, Pros and Cons of Project Procurement
- Tools and Techniques for Project Procurement
- Key Concept of Quality Assurance and Control
- Basic Concept of Performing Quality Planning
- Concept of Total Quality Cost

Introduction

The phase in which dreams and plans become reality is known as project implementation (or project execution). After evaluating, deciding, visioning, planning, applying for money, and locating a project's financial resources, this is the logical conclusion.

It's time to put a project's scope, budget, and timeframe into action after a team has decided on them. Project implementation entails overseeing a project to ensure that it achieves the goals set out in the planning phase. Project managers must properly implement a project so that the team can provide the deliverables needed to satisfy the project's clients or key stakeholders.

The process of putting a project plan into action to produce deliverables, also known as products or services for clients or stakeholders is known as project implementation. It occurs following the planning phase, during which a team decides the project's major objectives, timeframe, and budget. Implementation entails coordinating resources and tracking performance to ensure that the project stays on track and on budget. It also entails dealing with any unexpected challenges in a way that maintains the project on track.

To properly implement a project, project managers must engage with their teams on a regular basis to set and alter priorities as needed, while maintaining transparency with clients and other key stakeholders about the project's status.

Notes

According to ISO 8402:1996, i.e. Quality Management and Quality Assurance Vocabulary standard states that Quality is the totality of features and characteristics of a product or a service that bears on its ability to satisfy stated or implied needs.

According to ISO 9000:2000, i.e. the set of International Quality Standards and Guidelines for Quality Management Systems states that Quality is the degree to which a set of existing characteristics fulfill requirements.

Simply put, you can say that “quality is about meeting the customers’ requirements” and the deliverable being fit for use. When a product meets or exceeds customers’ requirements and needs one can say that the product is of high quality. Conversely, if it is not meeting its stated requirements the product is said to be of low quality.

4.1 Project Monitoring and Control with PERT/Cost

Monitoring and control mechanisms track, review, adapt, and report on the project’s progress on a regular basis. It’s critical to learn how a project is progressing and whether it’s on schedule, as well as to put approved revisions in place. This keeps the project on track, on budget, and on schedule.

Project control, according to the PMBOK® Guide (Project Management Body of Knowledge), is a “project management function that involves comparing actual performance to planned performance and taking appropriate corrective action (or directing others to take this action) that will yield the project’s desired outcome when significant differences exist.”

4.1.1 Introduction to Project Change Control

IT was known as data automation or data processing from the 1950s to the 1980s. A widely held concept of project management at the time was that the project team should aim to complete the project exactly as planned on time and in the budget. The difficulty with this viewpoint was that project teams were rarely able to achieve their initial project objectives, especially when using new technology. Stakeholders rarely agree on the project’s scope or what the final product should look like up front. Early on in a project, time and cost predictions were rarely correct.

Most project managers and top executives learned in the 1990s that project management is a continuous process of communication and negotiation regarding project objectives and stakeholder expectations. This perspective assumes that changes occur throughout the project life cycle and that modifications are frequently advantageous to some projects. If a project team member discovers a new hardware or software solution that can meet customers’ expectations in less time and money, the project team and key stakeholders should be willing to make significant adjustments to the project.

Changes will occur in all projects and handling them is a critical aspect of project management, particularly for IT projects. Many IT initiatives necessitate the use of continuously updated hardware and software. To continue the example from earlier in this section, the first strategy for ordering the server might have found a model that was cutting-edge at the time. If the server was ordered six months later, it’s likely that

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a more powerful server would be available for the same price. This case exemplifies a favourable shift. The server manufacturer listed in the project plan, on the other hand, could go out of business, resulting in a negative change. IT project managers should be prepared for such shifts and incorporate some flexibility into their project planning and execution. Customers for IT projects should also be willing to accomplish project goals in a variety of methods.

Some improvements may be necessary, but they are too extensive to be included in the current project. Remember that projects have scope, time, cost, and other objectives, and that modifications can have an impact on those objectives. For example, if the company wants to reach its time and cost targets, it must keep track of changes to the project's scope. Organizations frequently decide to document some change requests and incorporate them into a project upgrade.

It is critical that projects have a formal change control mechanism, even if project managers, project teams, and clients are flexible. This formal system is required to plan for change management.

Change Control System

A change control system is a formal, documented procedure that outlines when and how official project documents can be modified. It also specifies who is authorised to make modifications, what paperwork is necessary for these changes, and whether the project will use automated or manual tracking systems. A change control system typically consists of a change control board, configuration management, and a change communication mechanism.

A change control board (CCB) is a formal group of individuals charged with approving or rejecting project changes. A CCB's main responsibilities are to offer rules for preparing change requests, reviewing change requests, and managing the implementation of changes that have been accepted. This board could include essential stakeholders for the entire organisation, with a few members rotating based on the specific needs of each project. Overall change control should be improved by establishing a formal board and a framework for handling changes.

CCBs, on the other hand, can have some disadvantages, such as the length of time it takes to make decisions on suggested modifications. CCBs often meet once a week or once a month, and they may not make decisions in that time. Some businesses have efficient processes in place for making quick decisions about minor project adjustments. A "48-hour policy" was developed by one organisation, in which task leaders on a significant IT project would obtain agreements on crucial decisions or adjustments within their competence and authority within 48 hours. The person in charge of the area most affected by the decision or modification then had 48 hours to seek approval from upper management. If for some reason the project team's choice could not be implemented, the top management consulted would have 48 hours to reverse the decision; otherwise, the project team's decision would be approved. This method is efficient for dealing with the numerous time-sensitive decisions or adjustments that IT project teams must make.

Another key aspect of integrated change control is configuration management. Configuration management guarantees that the project's product descriptions are

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accurate and thorough. It entails determining and controlling the functional and physical design aspects of products, as well as the documentation that supports them. Configuration management for major projects is typically given to members of the project team, who are referred to as configuration management specialists. Their role is to define and document the functional and physical features of the project's products, to control any modifications to those qualities, to record and report changes, and to audit the products to ensure that they meet the project's requirements.

Communication is another important aspect of change management. To identify and manage project changes, project managers should employ written and oral performance reports. On software development projects for example, most programmers must modify a database copy of the master file; to maintain version control, programmers must "check out" the file to change it. When two programmers have access to the same file, they must work together to combine their modifications.

Oral and informal communication, in addition to written or formal communication, are equally vital. Depending on the scope of the project, some project managers hold stand-up meetings once a week or even every morning. A stand-up meeting's purpose is to quickly deliver the project's most important information. Every morning, the project manager for example, might have a stand-up meeting with all of the team leaders. Every Monday morning, there may be a stand-up meeting with all interested parties. Participants must stand throughout meetings, which keeps sessions brief and compels everyone to concentrate on the most essential project activities.

Why is effective communication so important for success? One of the most aggravating parts of project transition is that not everyone is in sync and aware of the most up-to-date project information. Again, the project manager is responsible for integrating any project changes in order to keep the project on schedule. The project manager and team members must devise a procedure for promptly contacting everyone who is affected by a change. E-mail, real-time databases, cell phones, and the Internet make sharing the most up-to-date project information simple.

Suggestions for performing integrated change control are shown in the table below. As previously said, project management is a continuous process of communication and negotiation. Change management should be planned for, and appropriate tools and procedures, such as a change control board, configuration management, and excellent communication, should be used. Defining procedures for making timely decisions on small adjustments, using written and oral performance reports to help detect and manage changes, and using software to help plan, update, and control projects are all beneficial. An IT steering committee can also represent the full IT portfolio, which is important in change management, especially when resources must be shifted to meet authorised changes. Furthermore, changes in the IT steering committee's strategic direction can have an impact on existing initiatives, resulting in adjustments.

Table Suggestions for performing integrated change control

Notes

View project management as a process of constant communication and negotiation.
Plan for change.
Establish a formal change control system, including a change control board (CCB) and IT steering committee.
Use effective configuration management.
Define procedures for making timely decisions about smaller changes.
Use written and oral performance reports to help identify and manage change.
Use project management software and other software to help manage and communicate changes.
Focus on leading the project team and meeting overall project goals and expectations.

To ensure that the project is completed successfully, project managers must also give strong leadership. They must avoid becoming overly involved in project management changes. Project managers should delegate much of the detailed work to project team members, allowing them to focus on providing overall project leadership. To guide their team and business to success, project managers must keep their eyes on the broad picture and execute excellent project integration management.

4.1.2 Different Tools for Project Change Control

Manual or automatic tools can be employed to help with configuration and change management. Change control is concerned with identifying, recording, and approving or rejecting changes to project papers, deliverables, or baselines, whereas configuration control is concerned with the specification of both deliverables and procedures.

The project stakeholders' needs, as well as organisational and environmental factors and/or restrictions, should guide tool selection. The following configuration management operations should be supported by tools:

- Identify configuration item. Identification and selection of a configuration item to serve as the foundation for defining and verifying product configurations, labelling items and documents, managing changes, and maintaining responsibility.
- Record and report configuration item status.Each configuration item's data is recorded and reported on.
- Perform configuration item verification and audit. Configuration verification and audits guarantee that a project's configuration items are appropriately composed and that relevant modifications are properly registered, assessed, approved, tracked, and implemented. This guarantees that the configuration documentation's functional criteria are met.

The following change management actions should also be supported by tools:

- Identify changes. Identifying and selecting a process or project document change item.
- Document changes. Creating a proper change request to document the change.

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- Decide on changes. Approving, rejecting, deferring, or making any other decision about modifications to project papers, deliverables, or baselines.
- Track changes: Verifying sure changes are recorded, evaluated, approved, and tracked, as well as conveying the final outcomes to stakeholders.

Change requests and the decisions that arise are likewise managed using tools. Additional communication considerations should be made to assist the members of the change control board (CCB) in their duties, as well as to distribute decisions to the right stakeholders.

A change control system is any system that has been created to ensure that the process of making changes is not done haphazardly and without thinking, but rather is thoroughly considered and signed off on by a responsible person. The change control system often includes not only the specific parts involved in deciding whether to approve, reject, or postpone any changes, but also all of the processes that should be used. Some of the elements involved in a properly functioning change control process for example, include a previously documented Change Control Policy, an established Change Control Board, an established core of Change Management Tools, and, in some cases, a Quality Assurance team and an Asset Management Team. In addition to providing set rules for the usual process of making changes, the Change Control System should also have measures in place for any emergency changes that may occur.

Change control operations, like so many other areas of work activity throughout an organisation, are carried out by building and maintaining processes that describe each step required to complete an activity accurately and efficiently. The method for implementing changes on a project is essentially a list of tasks that must be completed in order to execute those changes, and can thus be handled as a process. The only way to truly control change is to create a change process that can be documented and implemented consistently. The project manager can then use this approach at any level throughout the project to oversee the implementation and measure the impact of the change on project work activities.

Propose, implement, communicate, and measure are the four major processes that make up the change process.

1. Propose

a) Gather data. Reviewing information gathered from work activities, analysing it for compliance with work activity standards, and deciding whether corrective action is required is the first stage in determining whether change is required. Changes should always be based on actual facts collected from work activities, not on the opinions or hearsay of people who are not directly involved in the work activity in question. It is critical that the information analysis clearly identifies the need for rectification and that the veracity of the data is not questioned.

b) Define the need for a specific change. After determining that a work activity requires correction, the data and analysis can be utilised to develop the details and scope of a suggested modification. This step in the change process is critical because it highlights what the data truly says in a way that

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individuals evaluating the need for change can understand. It's also crucial to mention what the expected outcome of the action will be.

c) Propose change. Following the identification of a clear need for change, the change must be articulated and presented in the form of a proposal. This can take the form of a change order form, which is a concise statement that outlines the details of the modification. It can also be complicated and thorough, necessitating a full written proposal explaining all of the details, as well as charts, graphs, and other supporting material, in order to effectively articulate the breadth of change. The development of the proposal is the final form that specifies how the contents of the change will be documented and conveyed to people who will be reviewing the change for approval.

d) Validate and sign off. The proposal should be sent to a group of people who are familiar with the work activity so that they may assess the material in the proposal and decide whether it is an appropriate course of action. It may be established that offline testing is required to validate a proposed change's outcome. In other circumstances, subject matter experts' recommendations for alternative courses of action may deliver a similar result with less risk, impact on schedule, or cost. It is critical that the team sign off on this document once the change has been verified to ensure that the change has been examined and approved; this information can then be reported in project progress updates.

2. Implement

a) Conduct changes. Implementation, depending on the sort of change required, can be a challenging hurdle to overcome after a proposed change has been accepted. There may be resistance in some circumstances since people are prone to rejecting change. The cause for this could be a simple fear of the unknown or a lack of information about how the suggested change will create the desired result. It is preferable for the project manager to notify people who will be implementing the change ahead of time so that they can ask questions and receive details that will assist them understand how and why the change is being implemented. The project manager must additionally communicate that work activity performance is noncompliant and that a modification is required to bring work activity performance back into accordance with baseline expectations. The project manager should recognise the significance of earning the trust and buy-in of the resources who will be implementing the change, since this can be a critical factor in the success of the change.

b) Manage scope of change. The project manager and/or the people in charge of implementing the change must keep track of the specifics that define the scope of the change. This activity is critical because individuals who are implementing the change may perceive some things differently than those who have a better understanding of the scope of the change. Only if the modification is done exactly as it was documented and planned will it be successful, therefore details must be carefully managed during implementation.

c) Publicise changes. When the change is complete, the project manager and/

or the accountable personnel for the change should document that all steps have been performed and that the change process has been confirmed. This task is critical so that the staff who are performing the work activity, as well as other project personnel and stakeholders, are aware when the modification is complete. It's critical that the change process has a defined end point so that data collection and analysis can be documented from there and represent the impact that the change was intended to have. A final signoff officially verifying that the change has been completed may also be a requirement of the change process.

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3. Communicate

a) Establish who needs to know. A second group of people who are interested in knowing if the change is complete must be developed, much as the first group of people who must analyse and sign off on the proposal. This group may include the original people who were reviewing the idea, as well as functional managers, executives, and other support employees who need to know if the change was successful.

b) Determine appropriate method of communication. Individuals receiving this information must be able to understand it, depending on the type of information used in the original proposal and the information acquired to confirm that a modification has been accomplished. This method can be used for simple forms of communicating work activity status reflecting a change if the change can be clearly defined in a memo or email. If the change is more complicated and necessitates a much more extensive and sophisticated proposal, equal levels of specific material must be provided in formats that can be effectively communicated to others. Information may not be communicated within the same location, so additional creative means of communication may be required if people are in different places.

4. Measure

a) Compare to original baseline. Another crucial aspect of the adoption and completion of a work activity change is to keep assessing the activity and comparing performance to the original baseline. This stage is necessary to ensure that a modification is generating the desired result and that work performance is being measured in accordance with the project baseline. Any change must be validated for success, or to identify whether other problems have arisen as a result of the change, or whether the change simply did not deliver the desired result and should be reversed. It's crucial to remember that simply making a change doesn't always increase work activity performance, and in some circumstances, it can even cause new issues. Because this is the management function she utilises to bring work activity performance back into harmony with the project baseline, it is critical that the project manager validates that a modification provides the intended result.

b) Determine sustainability. The determination of a change's long-term viability is the final step in the change process. In some cases, changes have a long-term impact on the performance of work activities, and the change can be considered permanent and long-term. In other circumstances, adjustments

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may have a short impact, but continued data measurement and analysis reveal variations in performance, raising doubts about the change's long-term viability. This information is critical because the project manager must evaluate and comprehend the validity of a change in order to determine if it should be maintained or reversed. In certain circumstances, a change may just require modest tweaks to improve its outcome and long-term viability. This emphasises the need of tracking any variations or variances in performance once a change has been introduced by monitoring, gathering, and analysing data on work activity performance.

5. **Control Tools and Techniques**

a) Control tools and procedures, like monitoring tools that acquire and analyse data, are primarily concerned with the actions that will be taken to redirect project activity in order to improve performance that is consistent with the project baseline. It's vital to remember that control tools and approaches don't always include analysis functions; instead, they recommend specific actions that the project manager can do to increase control.

b) We'll go through a few tools and strategies that can be utilised to keep track of project work activities in the sections below. Some strategies can be used to regulate both the schedule and cost components of work operations, whereas others are used for scheduling, cost, and quality control only. Because some of the tools described here can be used in both development and control, they were also addressed when generating the schedule and budget. It is assumed that, as a result of monitoring work activities, information gathering and analysis show that change is required and that a control tool should be used in the selection and implementation of control tools.

c) The triple constraint, as previously explained, is made up of three key aspects of the project: schedule/time, cost, and the quality of the delivery. The ultimate goal of the project manager as he or she initiates project activities and monitors them in order to gather data for analysing work activity performance is to keep work activity to a baseline timeline, budget, and expected quality for the project deliverable. To maintain a baseline schedule, budget, and level of quality, the project manager requires tools to undertake control actions that influence project activity.

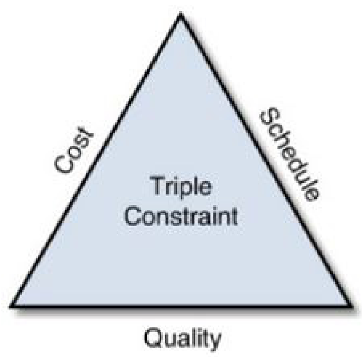

Figure: Triple constraint

Contingency Control

Typically, when designing a project management plan, the project manager considers contingencies in both the schedule and the budget to build either buffers or padding, or risk event planning. The majority of the time, contingency planning is done at the start of a project. If contingencies are needed, they can be allocated as part of the baseline in this fashion. A new contingency can be imposed and even included in a baseline adjustment through the change control process if a new risk event is found throughout the course of a project.

Managing how and when contingencies are used is the most important control factor in having them scheduled throughout the project life cycle for either schedule or budget considerations. Because the purpose of a contingency is to provide control, it should only be utilised when it is absolutely necessary. If time buffers are built into some paths of a network diagram, they should only be used if they are absolutely necessary to keep on schedule. It's vital for the project manager to communicate schedule padding for work activities with discretion, because employees doing the task will take advantage of the extra time if they know it's there. This is how the project manager keeps contingencies under control by only revealing their availability when it's absolutely necessary and limiting their use. Schedule contingencies can be a useful tool if used at the correct time and for the right reason, but it is the project manager's responsibility to do root cause analysis if information indicates that a work activity is over budget or behind schedule. The warning is not to just turn on contingency planned buffering whenever something goes wrong. The best method to keep contingencies under control is to use them only as intended and only as a last option.

Schedule Control

The actual time spent doing a work activity is the first part of the triple constraint that the project manager must regulate. This assignment can be relatively straightforward given a simple work activity, or it can be highly difficult given an exceedingly complicated work activity, depending on the size and complexity of the project. Only after the information obtained on a work activity has been reviewed and suggests that a parameter of activity time, cost, or quality has migrated beyond acceptable bounds does the project manager need to exercise control. Because a control often necessitates a change of some kind, it is also advised that a proposal be prepared, examined, and accepted regarding the type of control that will be applied. The project manager can improve her schedule in a variety of ways by using the tools and strategies for scheduling control mentioned in the following sections, based on what is available within the organisation and project constraints.

Critical Chain Method

To regulate the project schedule, the critical chain method (CCM) is a control tool that applies buffers inside a network of project activities at precise locations. The critical chain is most successful in resource utilisation and optimization because it employs the critical path approach of network diagramming project activities. Buffers are activity items that are connected inside a path and are labelled as nonwork activities yet have a duration. The fundamental goal of using buffers is to balance pathways in order to achieve scheduled convergence corrections to other paths. Within the network of activities, buffers can be used in two main areas:

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Feeding buffers—These buffers are placed on specific paths where they are needed to influence the cumulative schedule lengths for that path.

Project buffers—These buffers are placed on the primary or critical path to control the project schedule's total duration.

Resource Levelling

The use of resources and how certain resources can provide obstacles or limits is one of the most typical issues measured on work activities. Human resources, capital equipment, buildings, accessible funds, and contractual equipment or services brought in from outside for use on project operations are all examples of resources. Because all of these resources are selected and scheduled at the start of the project, their availability and successful usage when they are needed on a work activity may not always go according to plan.

Schedule Crashing

If resource levelling or smoothing is not an option, another method of schedule control is to change the actual duration of a work activity by adding resources; this is known as schedule crashing. The project manager simply raises the amount of a specific resource on a work activity to improve the duration of that activity, which normally involves additional project expense. The important aspect of this strategy is that it chooses the least expensive resource that can reduce the schedule time the most.

Fast Tracking

If it is decided that the duration of a sequence of activities is too long and must be shortened to preserve schedule, fast tracking is a method of reducing schedule within a certain path of work tasks. This technique shortens the overall length of a network path by switching work activities from serial to parallel execution.

Cost Control

Controlling the cost of work activities is the second aspect of the triple constraint. Because numerous employees or departments may be involved with cost parts of project operations, this work can be significantly more challenging for the project manager. The acquisition of supplies, as well as the possible contracting of external resources, might have an impact on the real costs of work operations. Because the project budget is generally based on projections, signed contracts, or historical cost information, these facts are all gathered and documented at the start of the project. They can influence the accuracy of these projections over time, depending on how lengthy the project life cycle is. Only estimates signed in contracts or based on official quotations from vendors or suppliers should be considered valid if used within the quote's time range. These cost control items may usually be engineered at the start of the project to ensure that the costs do not alter as the project progresses.

Individuals in the procurements department may introduce organisational processes that were not accounted for when original estimates were produced, and these processes may influence the actual price paid for particular things that must be bought, therefore project managers must be aware of this. Individuals entrusted with purchasing products are another area of control, so clear expectations about what the real expenditures must be kept to in order for work activities to stay on budget must be communicated. If man-hours are tracked and this information is factored into the project's baseline of work activity costs, the project manager must oversee or "control" the amount of work being done in order to stay within budget; however, this can lead to more issues with the type of labour used and what is actually accomplished in the work activity.

4.1.3 Project Monitoring with Different Tools

The word "monitor" comes from a Latin word that means "to warn," and "evaluate" comes from the verb "to value." A management information system's monitoring is an essential component. Managers require data in order to maintain track of a development programme and manage its progress. A management information system is a method for obtaining the "right" information in the "right" quantity, at the "right" time, and making it available to the "right" person or people. In most organisations, an information system is created to meet the information needs of management.

(1) diagnostic information (why a situation is as it is), (2) implementation information (physical and financial or input information), (3) utilisation information, (4) impact information, (5) situation information, and (6) information for evaluation are all included in a management information system.

A monitoring system is a subsystem of a management information system that consists of a number of distinct components. The monitoring unit, as well as other formal and informal sources, provide information to top management. This has an impact on programme execution, leads to better programme planning, and assures programme sustainability. This, in turn, contributes to institutional growth.

Basic concepts and elements in monitoring

Basic Concepts in Monitoring

Monitoring and assessment is based on four concepts. They correspond to operational investment (e.g., per-family investment), operational efficiency (e.g., number of visits, meetings, demonstrations, and trials per development worker), technical efficiency (e.g., output, and value added), and extension-induced changes (e.g., income, and income distribution)

The monitoring domain encompasses capability, effectiveness, and efficiency. The evaluation domain includes impact.

- Capability refers to a program's control over physical, financial, and human resources, which allows it to serve its customers (e.g., mothers, children). Outreach, intensity, technical proficiency, and physical and financial resources are all indicators.
- Effectiveness is defined as "the extent to which objectives are met." It is the ability of an effort to achieve a goal in order to produce the desired or expected outcome. Every developmental project must evaluate effectiveness in order to achieve the target outcome in the time frame allotted. It is critical to keep track of the project's success.

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- Efficiency implies working as efficiently as possible while wasting the least amount of time and effort. Efficiency, according to Lon Roberts, is "the degree of economy with which the process uses resources, particularly time and money." Monitoring efficiency is critical since it prevents resource waste and ensures that the project is completed on time.
- A simple indicator, such as the Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR), Minimum Levels of Learning (MLL), and Learning Achievement, can be used to assess the impact. Such metrics serve as the final litmus test for each sectoral program's performance.

Basic Elements in Monitoring

Let us now go over the various aspects of monitoring in greater depth. The following fundamentals (project structure) must be properly grasped in order to study Monitoring and Evaluation. To begin, a program's goal is to convert a set of resources into desired outcomes.

INPUTS are resources, and OUTPUTS are outcomes (This term is used here in a generic sense though it has more specific connotation which will be discussed later). The following is the sequence of inputs to outcomes:

Input: Goods, funds, services, manpower, technology, and other resources offered with the anticipation of OUTPUTS in a project.

Results: Certain things happen right away, and certain things happen later, while certain things happen in the between (intermediate). Agribusiness project outcomes can be classified into three basic categories based on their sequence: productivity, production, and income.

Output (Immediate results): Specific items or services that an activity is intended to generate from its inputs in order to meet its goals (in case of agriculture it will lead to increased irrigation, fertiliser use, health facility created etc).

Effect: The usage of project outputs in excess of the achievement of projected effects in a project will result in the desired impact – intermediate results. Effects are described as outcomes in modern M&E literature.

Impact: Project Effects Outcomes (broad long-term objectives: improving living standards and eliminating poverty on an individual and community level) - Final Results The effects for a community or region, rather than on individuals, are referred to as impact. It could be direct or indirect, as well as primary, secondary, or tertiary education.

Types of Monitoring

There are two forms of monitoring, most likely:

1. Beneficiary Contact Monitoring: The key to successful overall project monitoring is Beneficiary Contact Monitoring. The first key component of a management information system is physical and financial monitoring, which measures a project's provision and delivery of services and inputs. Project managers, on the other hand, need to know if their services are being used and how they are being integrated.

   Beneficial interaction tracking is implemented:

Maintain records for each participant (creditability, health, education, nutrition, and similar projects) and analyse them on a regular basis to track the service's penetration and the development of a clientele.

- To design a regular survey schedule that will allow managers to track a project's progress and the answers of its beneficiaries.
- To obtain statistically meaningful results from these surveys formal sampling techniques must be applied.
- To alert management to noteworthy success stories or issues through informal interviews.

2. Process Monitoring: As previously said, project implementation begins with the allocation of inputs/resources in order to achieve particular outcomes. Certain procedures, actions, and the accomplishment of certain events will be required for the conversion of inputs into outputs. This occurs in the order listed below.

   Process: It refers to the manner in which activities are carried out. Processes are ongoing and span multiple activities. Rapport building for example, is relevant to SHG formation activities, training, and so on.

   Milestones: This is a set of accomplishments that leads to the completion of a stage of a project (an event).

   Activities: These are the steps we take to complete the task. Activities always have a beginning and a conclusion, as well as figures associated with a budget.

   Output: This is what a project produces before it is completed.

Process monitoring is a method of ensuring that processes are guided to reach the desired outcomes while maintaining high quality. Process monitoring would be valuable and successful as long as the attention is not only on the inputs and outputs, but also on how the results are delivered and quality indicators are established and tracked.

The terms "process monitoring" and "progress monitoring" are frequently used interchangeably. Process monitoring focuses on important processes that are directly related to the project's objectives, as opposed to traditional progress monitoring, which focuses on physical, financial, and logistic aspects of projects. Progress monitoring for example, looks at the number of training sessions held or the % of work completed on a water supply scheme, whereas process monitoring assesses the quality of training or the level of community involvement in the identification, design, site selection, and construction supervision. Both progress and process monitoring are included in an ideal M&E system.

Process monitoring alerts project managers to the types of modifications that are required to improve project responsiveness to community requests, maximise effect, and increase the likelihood of long-term success. It assesses the effectiveness and quality of project interventions and outcomes.

Tools of Monitoring

The following tools are commonly used for monitoring purposes:

- Regular progress report

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Field personnel should produce progress reports and keep records at the District and Block levels that include physical and financial progress, coverage by blocks, group composition (SC/ST/Other), activities, and so on.

It is often easy to make a quick assessment of whether and to what extent the scheme's initial activities have been accomplished, and whether it is running successfully within the assigned budget, using the financial and physical status report. Funds disbursed for the plan can be compared to other data/schemes.

- Monitoring staff performance

(review) Monitoring employee performance can help ensure that people are being used effectively to complete tasks. All project participants should meet on a regular basis to discuss their progress, compare it to aims and objectives, and discuss difficulties and potential modifications.

- Tour reports by field staff

The most helpful information about the qualitative features of a programme is frequently gathered through tour reports given by field employees; this is especially true when the project is small and the participants have limited education and literacy.

- Participant observation

The field personnel may choose to stay in the communities and closely watch the groups in order to gain sensitive, first-hand information.

- Reports from visitors

All visitors to the project area (Project Director, State Level Officials, Researchers, etc.) are required to provide a brief report on their impressions of the schemes by the project team. These can provide insight/information on new developments, allow for the sharing of ideas, and aid in the development of the programme.

- Interviews

Members of the group and community leaders should be asked about their attitudes regarding the plan and the behavioural changes that have resulted as a result of it.

- Participatory Monitoring

Beneficiaries are become partners in monitoring and evaluation in this most recent technique. Project personnel and beneficiaries discuss and evaluate their performance together in order to better understand how they performed, what issues they faced, and what their future holds. The project team primarily assists in the formulation of acceptable questions and the elicitation of responses. For example, the group could be asked to make inferences from bank records, savings books, and so on.

- Key informants

We must endeavour to interact with other people who may be good sources of knowledge, such as teachers, postmasters, Kirana Shops, SHGs, and so on, in addition to our normal interactions.

- Complaints / grievances

Many times, complaints and grievances from the general public and the target group in particular might shed information on the scheme's actual performance. As part of the monitoring process, every project should include such a source of information.

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Techniques of Monitoring

Earned Value Analysis: Is a method of assessing overall performance through the use of an aggregate performance metric. Multiplying the projected percent physical completion of work for each job by the intended cost for those tasks yields the earned value of work accomplished for those tasks in progress. The money that should be spent on the assignment so far is the result. This can be compared to the real expenditure:

The following are the most common estimating methods:

a) The 50-50 guess. After the task is started, 50% is assumed, and the remaining 50% is assumed when the work is finished.

b) The 0-100 percent rule: This rule states that no credit will be given to work until the assignment is completed. This is a very conservative rule that causes delays in project completion.

c) Proportional rule: To compute percent complete, divide planned time-to-date by total scheduled time. This is a well-known rule.

Critical Ratio Technique: is used in large projects when the critical ratio for all project activities is calculated. The crucial ratio is calculated using the following formula:

(Actual Progress)/(Scheduled Progress) =(Budgeted Cost)/(Actual Cost)

If the ratio is 1, everything is definitely on track, but if it is less than 1, extra inquiry is required.

4.2 Computer Applications in Project Management

The advancement of computer hardware and software technologies has aided the evolution of the information sector while also altering the project management strategy. Project management development will become a trend if modern management concepts are combined with new computer technologies. There's also a new topic on how to properly utilise computer technology in project management.

To summarise the situation, traditional project management software has its drawbacks. On the one side, significant advancements and convergence in hardware technology allow computers to perform better, be smaller, and cost less. The computer has become widely used in all aspects of life. The development of network databases, computer networks, and software development, on the other hand, allows for the application of computer transferring to system integration and network based. The project management software will develop in the future with a focus on system integration and network-based systems.

4.2.1 Introduction to the Computer Application in Project Management

Project management methods and procedures lend themselves to easy computerization. The use of computers in business and industry in our country was

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initially met with considerable opposition, as people believed that the majority of applications would be in the field of finance and accounting, resulting in a high rate of unemployment. As a result, most computer suppliers were eager to include software with their hardware that would allow them to run non-financial and non-accounting applications. PERT / CPM is one example of such an application.

Even for the IBM 1401 computer, which used punched cards as inputs, programmers for conducting time calculations and generating bar charts were available. Since then, both computer hardware and software have substantially improved, allowing advanced project management applications to be carried out. Today, a wide range of programmers may be found in instructional books, journals, and big software companies. These programmes were created expressly for a wide range of computers, from microcomputers (PCs) to minicomputers and mainframe systems.

Simultaneously, the area of project management has grown to incorporate a number of tools and strategies, such as resource levelling, minimum cost crashing, and a project management information system. All of these elements are commonly included in project management integrated software.

As you may recall, the success of a project is heavily reliant on an effective monitoring and control system. Finding out the state of a project after it has started, comparing it to the original network design, identifying deviations, deciding on remedial actions, and expressing these decisions on the network are all part of this process. This is referred to as "updating." Any manual updating of a real-world network necessitates a great deal of redrawing of the original network and recalculation of time, cost, and resources.

Even for a medium-sized project, these computations and other manual chores proved to be too large, and it was thus impossible to complete these exercises at the appropriate intervals. As a result, project management technologies' potential was largely underutilised. With the growth of computers and computer software in project management, it became possible to put the complete project network, including resources and expenditures, into a computer.

The first computerisation task is time-consuming in terms of data preparation and activity entry, and there is a lot of manual labour required. However, once a network has been computerised, any changes, alterations, or upgrades to the network become relatively simple, and one is free to update the network at any time. The relining of blast furnaces for example, was one of the first applications of computerised networks in the steel industry. Even though project management was employed in the early 1960s, when the first three public sector steel facilities underwent blast furnace relining, it took anything from 120 to 150 days.

Manual upgrading could only be done once a month when it was done manually. It became possible to have weekly updates after the introduction of computers. This supplied management with more timely and precise information on the project's status, allowing them to take corrective action at an early stage. When a review meeting was scheduled for 2 p.m. on any given day, the actual status on the ground at 6 a.m. on the same day could be collected and processed in the computer, and the results, which included the expected completion date, activities delayed, and their impact on the overall project, were available for managerial considerations.

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As a result, it is evident that computers provide a way for providing timely and precise feedback to management, and that they are especially well suited for medium and large projects where human computations are inconvenient.

Apart from simple time calculations, computer programmes can also be used to perform resource levelling, cost crashing, and the production of other user-oriented reports. Computer software has progressed from its simple beginnings as a network computation of time, expenses, and resources to a sophisticated project management information system that provides users with many levels and degrees of control.

Computer technology has been an increasingly essential aspect of project management in recent years, with widespread application in a variety of industries. The e-commerce industry, which is dependent on computer technology, is rising. Computer application technology, in general, has the necessary functions and capabilities. There are distinct qualities for different software. It is capable of providing consumers with corresponding services based on current computer technology that is high in efficiency and speed. Information management has steadily gained recognition and significance as a key component of project management. During the project's development, a considerable volume of project-related data information will be generated using modern computer application technology. It contains technical data, regulatory data, and information on the economy, management, and other topics. The application of computer application technology in a systematic manner can help to increase management efficiency and quality.

Information management is an important aspect of the overall management of a general project. When the project is put into action, it requires planning, operation, and other tasks. As a result, project management entails a great deal of effort, such as gathering information on the project contract. Contract written documents, construction drawings, test reports, permit documents, photos, audio and video, model materials, and other information pertaining to project personnel, project management, economic planning, technology, and laws and regulations, among other things, are included. It is clear where information management stands in engineering project management. In actual management work, it is not uncommon to discover that the quantity of papers necessary for annotation and processing is enormous, posing significant challenges in finding and saving files.

Because most engineering project resources and timelines are subject to change, project management staff must use dynamic project management to stay on top of the most up-to-date information. For example, the creation of a database to collect and sort a huge amount of data and information generated by management activities, in which management professionals are focused on management information volume, project quality, capital chain, human resources, and other elements. It is beneficial to incorporate computer application technology into management activities in order to tackle difficulties that arise during the project's real building. Managers can use computer application technology to promote dynamic management, record and analyse real-time data generated by the project, and draw conclusions from the analysis of the data to track the overall progress of the process, allowing them to maintain reasonable control over project cost and quality. It is possible to reach a win-win situation between economy and technology.

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4.2.2 Need for Computer Application in Project Management

In project management, project management software is used. Strong system management can boost job efficiency even further in terms of successful project management. It covers a wide range of topics, including project construction data computation labour done solely by humans, which is extremely inefficient in today's project management. Only human and material resources will be employed to achieve linked resource management regulation and control, which will have a significant impact on project management optimization. Computers may be used to make detailed drawings of projects, which is particularly significant for overall project planning, using modern productivity tools to replace traditional management control methods. Furthermore, the optimal configuration of current resources can be used to aid in the formulation of the project plan and serve as a reference point for future building operations.

This type of computer-assisted drawing adjustment work can help to optimise the design of connected construction projects to a considerable extent, as well as provide more reference for specific details. Simultaneously, project management software is used to perform a deep adjustment of the construction project planning, which is conducive to network resource planning and design, as well as giving the most valuable application to existing resources. The efficient control of the current construction cost may be achieved by optimising the configuration of the project construction, using the existing cost to organise the planning, and changing the required resources through the design of the planning. It serves as a more crucial point of reference for the project's construction and ensures that the project's construction is completed efficiently.

In project management, office automation software is used. In terms of project management today, there are a lot of important contents in some projects' documentation and information processing, and it's tough to modify the relevant content of the project's construction to the present circumstances. The introduction of office software to computer application technologies has considerably aided project construction. Office automation has been used in more construction projects as a basic technology. Office software can be used to speed up the processing of project data and information, as well as perform rigorous image and text analysis.

Office software can be adjusted in conjunction with the creation of project-related data, resulting in relatively clear organisational data. In terms of contemporary project management, meticulous analysis should be carried out in accordance with the organisation plan and design work in order to achieve resource optimization. It is vital to pay close attention to the project management unit's timely implementation of various data and to provide associated technical training in line with office automation processes.

The organisation design for the project's construction must be implemented in conjunction with the necessary project management duties. The quality of the construction project can be improved by using a mix of automated office software and a data chart to change the planned jobs. Controlling project costs and reports may considerably increase the scientific level of project construction while also allowing management to make necessary adjustments. It's extremely possible that some faults will arise if simply office software is utilised to handle the project's creation. As a result, it's critical to successfully change according to the project's relevant content and supply

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the necessary data foundation for future development planning. The use of office automation software in manufacturing project management ensures that future project construction is well prepared.

Improve project management efficiency and quality. Previously, construction projects relied solely on human resources to complete work control and information management tasks. This type of management is obviously quite closed, and there is very little communication among the project's grassroots workers. With the advancement of technology, computer application technology has steadily penetrated project management, considerably assisting project management efficiency. It is primarily focused on the open form of information data flow, which gives a broader platform for increasing project management efficiency. Using computer application technology, you can get feedback on essential data, quickly identify the key problems in project construction, and solve them with existing resources and technology. It may effectively cut production costs and give more vital help for future project management by combining project construction and computer application technology to adjust, according to the requirements of construction and the major content of project construction.

Reduce the project construction cycle, use project construction standards to adapt the corresponding technical data, and improve the project construction standards. At the same time, existing computer application technology can be used to build a coordinated quality management information system, collect and organise data in project information, and perform processing analysis based on the uniformity of data resources for the entire project construction process. More effective data for the quality management of future projects can be offered by creating relevant data resource information. Adjustment in accordance with project management job requirements can provide more useful data and information for project quality control.

Construction technology and construction quality can benefit from the use of computer application technology. We can generally determine that the main process oriented to the whole has to be fully integrated with computer technology for in-depth analysis when it comes to the adjustment of computer application technology in project construction and construction technology. The related data and information can be identified via computer application technology feedback, allowing the relevant material to be regulated based on the data information. The proper gathering and modification of project data is facilitated by the processing of existing data materials. For future project management, it is critical to establish a solid and thorough project information and data component. In order to optimise project management, adequate research in computer application technology must be implemented.

CPM / PERT Time Calculations

As we mentioned at the outset, critical route calculations lend themselves well to computerization. The following are the necessary inputs for these calculations:

-- The start node (I node) number

-- End node (J node) number

-- Duration

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-- Description of the activities

-- Resource requirement

-- Cost

-- Agency responsible

Resources Calculations

The capacity to manage resources is the next advancement of a computer software in project management. Each task may necessitate a specific amount and type of resources, all of which can be entered into the application. After the time calculations are completed, the computer can provide two schedules: one is the earliest start schedule, which assumes that all activities will begin as soon as possible. The other is a start time that is as soon as possible. All activities are assumed to begin at the latest possible time in this timetable. The computer can be designed to calculate the required resource over time based on one of these two schedules for a certain resource. The software simply adds the required resource's requirement to all of the activities scheduled for that day that consume that resource. Let's say you want to learn more about the requirement for a specific crane. All that is necessary is for the number of such cranes to be required for each operation to be entered. Based on this data, the computer can calculate the number of cranes required from the start of the project to the end. If three activities are scheduled on a given day, each of which necessitates the use of one such crane, the computer will calculate that three such cranes are required on that day. The simplest output that may be obtained from the computer in this manner is a resource needs profile.

The need for resources will follow a cyclical trend. However, it can be said that for an early start date, the resource requirements will be higher at the start of the project and will gradually decrease. In contrast for a late start schedule, resource requirements will be minimal at first, gradually increasing to a peak at the end of the project. Both of these requirements aren't the best choices because the peak would be substantially higher than the average.

Cost Calculations

Cost information for each activity can also be handled by project management software. Cost data can be divided into two categories. The first is the basic cost of completing the task in the projected time, while the second is the additional cost of shortening the duration of the activity per unit time. This information should be supported by the amount of time required to complete the task. The "normal cost," the "cost slope," and the "crash duration" for an activity are all terms used to describe this information.

Scheduling and Updating

The majority of computer programmes are capable of printing project schedules. There are two types of schedules. The first is a tabular listing of all actions with the activity name, while the second is a bar chart. The true value of computerisation is derived from updates. Project management software is built to accept changes in an existing network. The durations of activities, their sequencing, the splitting up of an activity into two or three components, the introduction of new activities, and so on are all examples of alterations. Additions, alterations, and deletions are the most common types of modifications. After these changes are made, we will have a new updated network in the computer, which can be used to generate new activity plans, bar charts, resource levelling, and cost schedules, among other things. The Project Manager and his team will then use these new schedules as the foundation for all subsequent execution, monitoring, and control.

Multiple Levels in Project

The majority of large and complex projects are managed on three levels. The first level of management is concerned with managers who are directly accountable for the implementation of certain actions on the ground. They are fascinated by the tiniest aspects of each job to be carried out. The Project Manager and his immediate team members are responsible for the entire project at the second level. They are likewise interested in sufficient specifics, but it is neither practical nor desirable for them to go through every detail of each action in great detail. Consider the basic task of constructing a multistorey building's RCC framework. The first-level managers must dig into such specifics as bar bending schedules, reinforcement positioning and fixing, carpentry work for placing the shuttering work in place, casting each lift for each column, and so on. The Project Manager, on the other hand, is interested in the complete project, which includes a few similar civil works as well as a significant number of other operations such as structural fabrication, design, manufacture, tendering, and order placement. As a result, it is critical for the Project Manager to analyse each action in its whole. He might only be able to keep track of the construction of each floor's columns and the casting of the relevant slabs.

Project Management Information System A comprehensive PM software incorporates all of the aforementioned elements to create a Project Management Data Base, which the software uses to send essential information in the form of reports to various levels of Project Management. We get a computerised Project Management Information System when the Management Information System is integrated with all of the other technical capabilities outlined above.

Reports A PMIS-integrated PM software is meant to provide a variety of reports and graphs to aid decision-making. These software can generate a variety of special purpose and exception reports that are not included in the Project Data Base, in addition to schedules, bar charts, necessary resources, cost schedules, and so on. Reports could be requested for activities to be carried out by certain agencies, activities scheduled for the coming week fortnight, or month, key activities that have been postponed, field reports to be utilised for actual progress monitoring, and so on. These report-generating tools include computations and processing for "what if" scenarios. The Project Manager may choose to investigate the impact of increasing a vital resource by a set amount on project completion.

4.2.3 Different Software for Project Management

The Critical Path Method of network scheduling was devised by Dupont Chemical in collaboration with mainframe computer maker Remington Rand (Univac) in the 1950s (CPM). This technology was put to the test in 1958 when a huge new chemical

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factory was built. Parallel to this, the US Navy and Lockheed Aerospace developed the automated Project Evaluation Review Technique (PERT) for the Polaris Missile programme, which was run on an IBM mainframe. Until the early 1980s, when PC computers began to sweep across industry and government circles, mainframe and minicomputers dominated the project management software market.

Purpose of project Management software

Estimation plan

"Describe the project's cost and schedule, as well as the methodology, tools, and procedures utilised to estimate the project's cost, schedule, resource requirements, and associated confidence levels." In addition, to re-estimate the project's cost, timeline, and resources requirements."

Staffing plan

"Specify the quantity of staff required per skill level, project stages in which the quantities of personnel and types of skills are required, and the duration of the requirement." This should also include the sources of staff people, such as internal transfers, new hires, or contracted personnel."

Resource acquisition plan

"Outline the strategy for procuring and releasing the resources, as well as employees, required to accomplish the project successfully." A description of the resource acquisition and release process, as well as the assignment of responsibility for all areas of resource acquisition, should be included in the resource acquisition strategy. Acquisition and release plans for equipment, computer hardware and software, training, service contracts, transportation, buildings, and administrative and janitorial services should all be included in the plan."

Project staff training plan

"Specify the training required to ensure that the project's required skill levels are available in sufficient numbers." The training programme must include the categories of training to be delivered, the number of individuals to be trained, training admission and exit criteria, and the manner of training."

Project work plans

"Detail the project's work activities, timetable, resources, budget, and procurement."

Work activities

Define the numerous work activities that will be carried out during the project. A work breakdown structure should be used to illustrate the work activities, as well as factors such as required resources, projected duration, work products to be created, work product acceptance criteria, and predecessor and successor work activities for each work activity.

Schedule allocation

The plan should include periodic milestones that can be measured against objective indicators to determine the scope and quality of work products completed at certain points. Milestone charts, activity lists, activity Gantt charts, activity networks, critical path networks, and PERT are examples of techniques for illustrating scheduling linkages.

Resource allocation

Personnel by skill level and considerations such as computing resources, software tools, unique testing and simulation facilities, and administrative support may all be considered when allocating resources. For each work activity, a distinct line item should be provided for each type of resource.

Budget allocation

The expected cost of activity employees must be included in the activity budget, as well as costs for travel, meetings, computing resources, software tools, specific testing and simulation facilities, and administrative support, as necessary.

Requirement management plan

Specify the control methods for monitoring, reporting, and regulating changes to product requirements, as well as the consequences of changes to requirements on project schedule, budget, resources, risk, and performance throughout the project's life cycle. Traceability, prototyping and modelling, impact analysis, and reviews are all techniques that can be used to regulate requirements.

Schedule control plan

Specify the control mechanisms that will be used to track the progress of work accomplished at major and minor project milestones, compare actual progress to anticipated progress, and take corrective action if actual progress does not meet expectations.

Budget control plan

Specify the control mechanisms that will be used to track the cost of completed work, compare planned costs to budgeted costs, and take corrective action when actual costs differ from anticipated costs.

Quality assurance plan

Specify the mechanisms for measuring and controlling the quality of the work processes and the end products. Provisions for vendor valuation and control must be included in the quality assurance strategy. Quality assurance of work processes, verification and validation, collaborative reviews, audits, and process assessment are examples of quality control systems.

Subcontractor management plans

This will include strategies for identifying and managing any subcontractors who

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may contribute work to the project. Each subcontractor plan must include processes such as requirements management, technical progress monitoring, schedule and budget control, product acceptance criteria, quality assurance, and measurement and risk management. The project closeout plan should include all of the plans needed to complete the project in a timely manner. A staff reassignment strategy, a plan for archiving project materials, a plan for post-mortem debriefings of project personnel, and the development of a final report that includes lessons learned and an analysis of project objectives met should all be included in the closeout plan.

Risk management

This document will detail the risk management strategy for identifying, assessing, and prioritising project risks. This subclause also specifies the procedures for contingency planning, as well as the techniques for tracking the various risk factors, evaluating changes in risk factor levels, and responding to those changes.

Configuration management

This document will outline the project's configuration management strategy, including the techniques for identifying, controlling, tracking, evaluating, and releasing configurations. Procedures for initial baselining of work products, logging and analysis of change requests, change control board procedures, tracking of changes in progress, and procedures for notifying concerned parties when baselines are first established or later changed are also included in the configuration management processes.

Documentation

This will comprise the project's documentation plan, as well as plans for generating non-deliverable and deliverable work items. The documentation plan must identify the organisational entities responsible for supplying input information, preparing, and assessing the various documents. Requirements specifications, design documentation, traceability matrices, test plans, meeting minutes, and review reports are examples of non-deliverable work deliverables. Source code, object code, a user's manual, an on-line help system, a regression test suite, a configuration library and configuration management tool, principles of operation, and a maintenance guide are examples of deliverable work products.

Quality assurance

The relationships between the quality assurance, verification and validation, review, audit, configuration management, system engineering, and assessment activities should be indicated in the quality assurance plan.

Measurement

Specify the methods, tools, and strategies that will be utilised to gather and keep track of project metrics. The measurement strategy must include the stated data needs, the measures to be gathered, the definitions of each measure, and the processes for validating, evaluating, and reporting the data.

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Review and audits

Specify the project review and audit timeline, resources, and methodologies and processes to be employed. Joint acquirer-supplier reviews, management progress reviews, developer peer reviews, quality assurance audits, and acquirer-conducted reviews and audits should all be included in the strategy.

Verification and validation

This should include the project's verification and validation plan, which should cover the scope, tools, procedures, and responsibilities for the verification and validation activity. Traceability, milestone reviews, progress reviews, peer reviews, prototyping, simulation, and modelling should all be specified as part of the verification planning process. Testing, demonstration, analysis, and inspection should all be specified as part of the validation planning process.

Procurement plan

This section will detail the items and services that will be purchased for the project, as well as how they will be acquired. It must identify the types of contracts to be used, who will conduct the procurement, where standard procurement documents can be found, the deadline for procuring each commodity and service, and the lead periods required to complete the procurement process.

Scope change control plan

This section explains how to spot activities that are outside the scope of the project and what to do if such activities are discovered or requested.

Product delivery

This will include delivery plans for the project's product(s), as well as the product delivery approach, the required information flow both within the project and to all external organisations required to support the delivery, packaging and physical delivery plans, and all associated customer documentation such as operation manuals, maintenance manuals, and training materials.

Different Software for Project Management

Primavera

Primavera is one of the most popular flowering plants. For organization-wide project management scalability, the Project Management module is a complete, multi-project planning and control software built on SQL, Oracle, and SQL Server Express server databases.

Features:

- Scheduling

The Critical Path Method is a strategy for calculating project schedules (CPM). The duration of activities and the relationships between them are used in CPM to compute the project schedule.

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- Tracking

This feature allows the Project Manager to access, display, and change project data in a variety of forms, which helps him do schedule, cost, and resource evaluations.

- Activity

For open projects, several activity operations such as add, view, edit, and delete can be performed on defined activities.

- Reports
- Resources
- Work Breakdown Structure (WBS)
- Expenses

Pros

- A facility for efficient assessment and overview.
- Cost-cutting.
- Resources that are shared.
- Primavera users complimented the system's strict and disciplined task logic in particular.
- The most effective is Primavera P6, which allows the user to create a theoretically endless number of criteria as priority rules.
- Robust and simple to use.
- Provide a single solution for managing project size and defining the project's level of complexity.

Cons

- The defect management issue in the beginning was that the scrum team members prioritised development features over bug solutions. They needed to devote one full sprint at the end to correcting the issues that were left unfixed earlier in order to fix all of the flaws.
- Reduce the amount of tracking you do.
- Primavera is much more expensive than other similar applications.

MS Project

Microsoft Project was created to help project managers keep track of their work by automatically requesting and logging status updates from team members and alerting them if they are late or incomplete. It quickly became the industry standard for PC-based project management software.

Pros

- User interface that is easy to utilise.
- Flexibility and simplicity.

- The management should be aware of the costs of each job and material resource.
- In a project plan, the capacity to track real work.
- The Project Guide will assist you in properly setting up your project plan for the amount of tracking you desire.
- You should save a baseline before recording actual work in a project plan. This creates a "snapshot" of your initial project plan, which you may compare to real progress afterwards. This is one approach to determine whether or not your project is on track.
- Making a new project plan saves a lot of time.

Cons

- There is no evidence that new Project users should set too many semi-flexible or stiff limits on their projects' activities. Your scheduling freedom will be significantly limited as a result of these limits.
- Tracking tasks that are measured in minutes or hours may not be feasible or even doable.

GanttProject

GanttProject is a desktop application for project scheduling and management that runs on a variety of platforms. GanttProject is a multi-application platform for project management and planning. GanttProject runs on any operating system, saves the schedule in an XML file format that can be turned into HTML Webpages, and GanttProject conducted the scheduled activities by integrating through the e-Hub implemented workflow.

Pros:

- It works with any operating system.
- It's simple to use.
- Gantt chart feature that is simple to use.
- Baselining.
- Freeware.

Cons

- There are no planning features accessible to assist the project manager.
- There is no resource levelling or crucial route depiction.
- The resource strains are the only ones that are visible.
- There are much too few instances of Blob in GanttProject.

Redmine

During the initial agile implementation in MIMOS, the Redmine project management web application tool was implemented to assist the team and capture requirements. It contains a list of all product backlogs. Redmine is a web-based project

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management system. Redmine is more of a general project management application that does not support agile or scrum methodologies. User stories and tasks were submitted through a ticketing system.

Pros:

- Redmine is adaptable rather than stiff.
- Because each ticket has its own web page, we can manage the current status and description of each ticket in Redmine.
- Software Configuration Management is supported by Redmine.
- Support for multiple languages.
- Support for multiple databases.
- Changes are shown graphically in Redmine.

Cons

- Redmine does not have any special Agile or Scrum support.
- There isn't any source code management.
- The burn down charts are not generated automatically.
- The burn down charts are automatically generated by Rally and RTC, but not by Redmine.

4.3 Contract Management

Every project's activity revolves around the contract. Contract management is becoming more and more important in project management and in business in general. Contract administration is becoming more and more of a problem for many commercial and project managers. Different contracts will be structured, negotiated, concluded, and fulfilled for various projects. We deal with the management of contractual relationships on the one hand, and contracts and their management on the other.

4.3.1 Introduction to Project Contracting Process

A contract is a legally enforceable agreement between two or more parties. In any contract, there are some standards that must be met. Contracts are created by a variety of agencies, and depending on the necessity, there are various distinct sorts of contracts. A contract is an essential feature of any business partnership between two parties. The contracting process is crucial in deciding the arrangement's success.

As organisations seek to increase efficiency and production without increasing their workforce, the contract's function is becoming increasingly significant. As contracts become increasingly popular, it is critical for businesses to remember that they should always try to save time rather than add to their workload. The easiest way to avoid the contracting process becoming a time sink is to automate it as much as feasible.

Contract management, also known as contract administration, refers to the procedures that a company uses to oversee all parts of a contract. A contract management software may streamline the contracting process while also reducing risk and ensuring compliance. More companies are discovering the benefits of contract management platforms and implementing them to improve efficiency, lower costs, and reduce risk.

Contract management is the process of overseeing a project's contracts from pre-award through completion. Contract management ensures that the project's budget and resources are aligned with the project's overall goals. An important project management technique is tracking contracts as they advance and recognising and handling any issues that arise.

Contract management, as part of project management, works with vendors, sellers, and/or suppliers, as well as procurement management according to contract terms and conditions.

Contract management systems can reduce the amount of effort required to get to contract generation and subsequent contract management stages. Contract software frequently includes a contractor database, as well as the ability to prepare RFPs and undertake bid analysis. Contract systems assist project organisations in awarding contracts, sending letters of regret to those who were not chosen, and managing contractor modifications and billing all within the programme once a contractor has been hired.

The Phases of Contract Management

- Phase 1: Contract Creation

  Contract management systems must be able to include established procedures with precise specifics related to company goals. This stage of contract management entails determining the contract type and assigning responsibility for each assignment. Resources, objectives, and staffing are all part of the planning process, as is a run-through of anticipated project risks and challenges.

  It's critical to be organised and prepared, as well as to keep in mind that contracts are legally enforceable documents.

  Determine the needs and objectives that led to the contract's creation. It will be easier to make decisions as a result of this.

  Contracts should be written to reduce risk, so it's crucial to plan ahead for any potential issues and ensure that the contract addresses them.

  It's also crucial to ensure that the company is financially secure on all levels, as well as to establish any price structures for clients.

- Phase 2: Contract Negotiation

  All project contracts should be written in such a way that they reflect the organization's goals and values. Negotiation aids in the formation of trust between the contracting parties. After the basic contract is set out, line items are discussed, altered, updated, or altogether removed during the negotiating process.

  Even if a contract is well-written, there will almost certainly be a negotiation phase.

  Researching and anticipating the opposing party's issues ahead of time will make the negotiating phase go more smoothly.

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Both parties can utilise a contract management tool to amend and view changes to the document.

- Phase 3: Contract Approval

  Multiple signoffs from numerous managers and departments, as well as contractors and vendors, are frequently required for contract approval. Before a definitive agreement is reached, all parties may be required to provide their assent to the contract's specifications.

  After all parties have agreed on the deal, the contract must be approved by the proper parties.

  Most contract management solutions allow you to set up an automatic task to notify the necessary parties that the contract needs to be reviewed and approved.

- Phase 4: Contract Finalization

  The signing of contracts by all parties involved is the final stage in getting the project started. To eliminate delays, the ability to swiftly obtain signatures from all parties involved, regardless of distance or location, is critical.

  Signatures are collected to execute the contract once all parties have agreed to it. Often, this can be done electronically.

- Phase 5: Contract Change Management

  Once work begins on a project, modifications are almost certain to occur throughout the lifecycle. Changes to the project must be properly handled, and all changes must be disclosed to the necessary stakeholders. All data and information on contract deadlines, budgets, and expenditures, among other things, must be tracked and communicated across the teams involved.

Renewals

Renewals that are missed can have a negative impact on business relationships and cause organisations to lose money.

It's critical to start the renewal process early enough to ensure that all processes are completed on time.

Importance of Contract Management

Key project business strategies, procedures, and relationships are established and defined by project contracts. Effective contract administration may help businesses and project organisations compete more effectively on a worldwide scale, particularly for companies with distributed teams and/or different time zones and cultures.

Contract management helps decrease project risk by assuring compliance when and as needed, because project contracts include payment terms, negotiations, procedures, service expectations, and compliance duties. Contract management that is effective also allows project groups to monitor and measure their progress. Management can make better project decisions and take action sooner with contract management solutions that provide real-time visibility into all contract components across time.

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Initiated contracts must reflect the objectives, timetable dates, project budgets, and resources available. Regulations, standards, and potential risks should all be included. A contract management tool connects all aspects of the project to one another, providing an audit trail during revisions and ensuring communication with the right people at the right time.

Contract management enables project organisations to consider how project productivity, performance, labour, and inventory affect their overall growth and profitability. It manages communication, tracking, change management, and other duties.

Contract Management Challenges

Contracts are made up of many phases and sections. This implies that keeping track of and maintaining all of the components of a contract can be difficult, especially when there are hundreds of contracts on a project. Large and complex contracts including joint ventures, many contractors, and subcontractors are common in global projects and megaprojects.

Handling contract administration operations by hand can lead to a slew of issues, including:

Contract Execution: Poor contract management frequently results in misplaced or missing files, and final contract approvals and signatures take much longer.

Contract Tracking: To avoid delays, it's critical to keep track of signed contracts that are subsequently passed on to other team members or departments who may not be familiar with them. Overspending occurs as a result of project delays.

Contract Revisions: It's critical to manage contract revisions both before and after contract approval if you want your project to succeed. Version control and timely, proven delivery are aided by having a technology in place to track changes across time zones, geographies, and teams. All of this helps to reduce risk, delays, and errors, among other things.

Contract Compliance: Contracts help to ensure that the agreed-upon parameters are followed. Effective contract management provides compliance and regulation throughout the project, allowing firms to avoid legal complications and penalties.

Contract Management System Benefits

An effective contract management tool ensures a professional approach to contract management that improves risk management, increases profitability, and gives a clear return on investment (ROI) on contract management activities' cost vs benefit. Implementing contract management software for example, increases customer relationship quality and maintains an open line of documented contract communication. This helps to avoid contract escalation and dispute.

Other advantages of contract management include:

- Streamlines your RFP process
- Vendor and bid management

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- Improves bid analyses
- Transforms contract administration
- Contract change management
- Procurement and resource planning
- Enhances communication and collaboration
- Audit trail and documentation records
- Compliance
- Delivering projects on-time and within budget

Contract management software, such as PRISM Contracts, gives businesses contract automation, a single source of truth that can be audited, and a real-time picture of project and contract activity.

The use of an integrated system for contract management and project controls warns project managers to potential cost or schedule overruns. Contract bids are collected, bid analysis is performed, and contracts are awarded more efficiently in projects with integrated contract management and cost management systems. Contract modifications can be made, and new commitments can be forwarded to the project's cost management team for reporting. A strong contract management system will also be able to assess contract performance and calculate accurate progress.

4.3.2 Tools and Techniques for Project Contracting

The management of contracts with customers, vendors, suppliers, and workers is referred to as contract management or contract administration. When working with diverse groups of individuals, an organisation can wear different hats—sometimes as a vendor, sometimes as a client, and sometimes as a provider. The contract management divisions are highly specialised groups. Finance and legal departments are frequently represented.

A contract is a legally binding agreement between two or more parties, such as individuals, businesses, organisations, or government bodies, under which they trade goods or services of value. Contracts also place limitations on the contracting parties' behaviour during the term of the contract.

Because it is utilised to transfer delivery risk from the parent organisation to the contracted supplier, a contract can also be used as a risk management tool. 'Centralized Contracting' refers to a single contracting office that manages all of the organization's contracts. Each project of the organisation is assigned a contract administrator in 'De-centralized Contracting.'

The following are the main characteristics of a contract:

- A contract can be written, using formal or informal terminology, or it can be totally verbal, with the former being the preferable option. The conditions of a contract—that is, who, what, where, when, how, and which of the agreement—define each party's legally binding promises.
- The acceptance standards for the contracted goods or service are explicitly stated in a contract. Only if all of the provisions of a contract are met is it considered fulfilled.

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- It also includes remedies for settling disagreements that may emerge during the contract's term. The actions—or inactions—of the contracting parties that constitute a breach of the contract, as well as force majeure conditions, are clearly defined in the contract's provisions.
- Because it transfers risk from the buyer to the seller, a contract can be utilised as a risk management tool. Contracts are often handled by an organization's centralised contracting office, which handles all project contracts entered into by the organisation, or by dispersed contract administrators, one of whom is assigned to each project it executes.
- To prove a contract's validity, its provisions must comply with the legal criteria governing contracts.
- A seller could be referred to as a contractor, subcontractor, vendor, service provider, or supplier in a contract.
- A buyer may be referred to as a client, customer, prime contractor, contractor, acquiring organisation, governmental agency, service requestor, or purchaser in a contract.
- A contract is also known as an agreement, an understanding, a subcontract, or a purchase order, depending on the context.
- When a teaming agreement contract is included, the buyer and seller's roles are pre-determined. A teaming agreement is an agreement between two or more commercial organisations to work together as a team to complete the tasks of a specific project.
- If a buyer expects a seller to start working on a high-priority, business-critical project right away, the seller will need a 'letter of intent' or 'letter of contract' from the buyer.

Different Contract Types

Contracts come in a variety of shapes and sizes, depending on the payment conditions. These are the following:

Fixed-price Contract (Lump-sum Contract): This form of contract has a set total fee for the entire project, and the scope of the project is usually well-defined. There is no dispute about the scope of the contract between the parties engaged because the buyer knows what he is purchasing and the seller knows what he is selling. A Fixed Price Contract with Economic Price Adjustment (FP EPA) is a fixed price contract that takes into account price changes due to inflation and market conditions, which is especially important when the project term is extended.

Cost-reimbursable Contracts: This type of contract entails the seller being reimbursed for his or her actual expenditures, plus a fee that often represents the seller's profit. This sort of contract has a few subcategories:

Cost-Plus-Fee (CPF) or Cost-Plus-Percentage of Cost (CPPC): The seller gets reimbursed for the permitted costs of doing the contract job, plus a fee determined as an agreed-upon proportion of the costs (this is the seller's profit).

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Cost-Plus-Fixed-Fee (CPFF): The seller gets reimbursed for allowed costs associated with doing the contract work, as well as a fixed fee established as a percentage of the expected project costs (this is the seller's profit). Unless the project scope changes, the set fee does not alter with real expenditures.

Cost-Plus-Incentive-Fee (CPIF): The seller gets reimbursed for authorised costs incurred in doing the contract work and receives a pre-determined fee, an incentive bonus, based on meeting specified performance objective levels set forth in the contract, which is similar to a performance bonus. If the final costs are lower than predicted, both the buyer and the seller benefit from the cost savings, according to a pre-negotiated sharing formula established in the contract. In some cases, instead of incentives, fines may be imposed if the cost or time exceeds the contract's specified units.

Time and Material (T&M) Contracts: T&M contracts are a hybrid type of contract that incorporates elements of both cost-reimbursable and fixed-price contracts. The vendor is paid per unit of time (say, $X per hour), regardless of the volume of work completed.

Tools and Techniques

Make-or-Buy Analysis

A make-or-buy analysis is a general management strategy for determining whether specific work should be completed by the project team or purchased from outside sources. When a capacity exists within the project organisation but is committed to other projects, the project may need to source such effort from outside the organisation to achieve its schedule commitments.

Budget restrictions may have an impact on whether or not to build or buy. If you decide to buy, you must also decide whether you want to buy or lease. All relevant costs, both direct and indirect support costs, should be considered in a make-or-buy analysis. The buy-side of the analysis for example, comprises both the direct costs of purchasing the goods and the indirect costs of supporting the purchasing process and the purchased item.

During the buy analysis, available contract types are also taken into account. The appropriate contract types are determined by the buyer and seller's risk sharing, while the precise contract terms and conditions codify the degree of risk assumed by the buyer and seller. Other types of contracts are defined in some jurisdictions, such as contract types based on the obligations of the seller rather than the consumer, and contract parties are required to select the relevant form of contract as soon as the applicable law has been agreed upon.

Expert Judgment

Expert judgement is frequently utilised to evaluate the process's inputs and results. The criteria that will be used to evaluate seller proposals can also be developed or modified using expert purchasing judgement. Expert legal advice may be sought from legal counsel to help with specific procurement difficulties, terms, and conditions. This type of judgement, which includes both business and technical competence, can be

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applied to both the technical specifics of the acquired items, services, or results as well as other parts of the procurement management processes.

Market Research

Market research entails a look at the industry as well as individual vendor skills. To identify market capabilities, procurement teams can use information gathered at conferences, internet reviews, and a range of other sources. The team may also fine-tune specific procurement targets to take advantage of maturing technologies while balancing the risks of a limited number of vendors capable of providing the goods or services required.

Meetings

Without additional information exchange meetings with possible bidders, research alone may not provide particular information to build a procurement plan. The organisation acquiring the material or service may profit from collaboration with potential bidders, while the supplier can influence a mutually beneficial strategy or product.

4.4 Project Procurement Management

The act of obtaining products, materials, and/or services is known as procurement. As a result, project procurement entails getting all of the project's goods and services. The practices required to ensure that project procurement is successful are referred to as project procurement management.

There are three main steps in project procurement management. These are the following:

- Purchases should be planned.
- Carry out procurements
- Procurement administration (or control)

4.4.1 Stages in Project Procurement Process

Purchasing goods and services from a third party is referred to as procurement. In the government, the phrase procurement is generally used; in the private sector, the terms purchase and outsourcing are commonly employed. Suppliers, vendors, contractors, subcontractors, and sellers are names used to describe organisations or individuals who provide procurement services; of these categories, suppliers are the most often used. Many IT initiatives necessitate the usage of items and services obtained from outside the company. An outside source, according to the Project Management Institute, is a source that is not part of the project team. This means that the project team can be a supplier to another group within the organisation, or the project team can be a supplier to another group inside the organisation. Many IT departments in organisations compete directly with outside vendors, and they must follow the same requirements definitions, statements of work, and bids. Regardless of who offers the services to whom, the principles and techniques of solid project procurement practices are good to follow.

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The process of documenting project procurement decisions, outlining the approach, and finding possible sellers is known as plan procurement management. The main advantage of this method is that it determines whether or not to purchase goods and services from outside the project, and if so, what to acquire, how to acquire it, and when to get it. Other components of the performing organisation or other sources may be used to obtain goods and services.

The methods for acquiring products and services from outside the performing organisation are included in project procurement management. For the sake of simplicity, all goods and services, whether single or multiple, shall be referred to as "products."

For the sake of simplicity, goods and services shall be referred to as "products" whether they are one or many. gives an outline of the following major processes:

- Procurement Planning is the process of deciding what to buy and when to buy it.
- Documenting product requirements and identifying possible sources is part of the solicitation planning process.
- Solicitation is the process of acquiring quotes, bids, offers, or proposals, as needed.
- Source Selection entails selecting from a pool of potential sellers.
- Contract Administration—managing the seller's connection.
- Contract close-out entails the completion and settlement of the contract, as well as the resolution of any outstanding issues.

Managing project procurements and acquisitions necessitates effective collaboration between the project manager and the buying department during the planning and management of procurements. The Implementation Plan's project procurement management section determines how "the ordered products necessary for creating deliverables may be supplied on time and within the specified budget." It's worth noting that the "Procurement Management" portion of the Implementation Plan will only be required for projects involving significant buy-in of expertise or capital goods. It is sufficient to include a procurement item list and a vendor list in the project execution plan for any other projects with a low level of procurement spend.

A Project Procurement Process (also known as a "Project Procurement Management Process") is a method for establishing relationships between an organization's purchasing department and external suppliers in order to order, receive, review, and approve all procurement items required for project execution. Contractual ties with suppliers are managed. The process is designed to assure timely delivery of purchased items that have been chosen and acquired in accordance with the purchasing department's specifications and needs, which have been approved by the project manager.

The following are the five major steps in the procurement process:

- Specification. The purchasing department collaborates with the project manager to generate and approve a list of purchase goods required for project implementation. External vendors must be informed of the permitted items by the department.

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- Selection. This stage of the project procurement process necessitates the department locating possible suppliers who can procure the required items in accordance with the specifications. The department must establish vendor selection criteria for this purpose, which may include factors such as delivery, service quality, cost, and part performance.
- Contracting. In order to assure "on-time" delivery of the ordered materials within the given project budget, the department must engage with the suppliers on delivery dates and payment terms. A purchase contract should include all of the terms and conditions. A comprehensive delivery plan should also be agreed upon with the procurers and approved by the purchasing department.
- Control. The purchasing department's ability to control the delivery and payment processes is critical to the procurement management process' success. The department can supervise the process and assure its completion by scheduling regular meetings with vendors, following delivery status, verifying ordered products against approved product requirements, and making required revisions to the procurement contract.
- Measurement. The final step in the project procurement management process is to assess the efficacy and success of the entire process using a system of performance indicators and measurements. The project manager must implement such a system, and the buying department must use it to track the progress. KPIs, intermediate results of staged delivery, procurer performance, adherence to product specifications, communications with suppliers, and other topics can be discussed at special meetings and workshops. Any deviations or gaps should be reported to the project manager, who will make the required revisions to the procurement strategy.

4.4.2 Significance of Project Procurement, Pros and Cons of Project Procurement

Procurement Management is now widely employed in practically every firm on the planet. Everything has become automated in this technological age. As a result, information technology has become prevalent in all parts of life, from business to daily life. Information technology is regarded as one of the most important factors in achieving efficiency and effectiveness. It makes everything appear simple and straightforward for any activity. It aids in the reduction of costs, time, and resources.

Information technology has also been used to support the business process in all facets of an organisation or firm. One of the major impacts that a company can have is in the procurement process. The procurement department is one of the firm divisions that has a lot of clout when it comes to controlling costs, timelines, and resources. Procurement is thought to account for over 60% of all costs associated with business processes. It requires the organisation to be astute in planning and maintaining the expenditures that will be incurred; in addition, time and resources must be considered.

To balance the increased demand with the company's desire to be as efficient and effective as feasible. As a result, procurement management is one of the options for improving the efficiency and effectiveness of corporate processes, particularly procurement.

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Procurement management aids the organisation in making the best purchase decisions possible. Procurement management is fundamentally linked to supply chain management. Because procurement managers are also in charge of direct purchases, such as supplies. This allows the organisation to save time by not having to perform the purchasing manually. Procurement management, on the other hand, handles indirect purchasing, also known as operational purchasing in the organisation. It helps to decrease costs, times, and resources that would otherwise take a lot of money, time, and resources if done manually rather than automatically.

Procurement management has used several innovative best practices that have aided the organisation in achieving its objectives of generating numerous benefits while reducing costs. It's fascinating to see how procurement management may help and achieve cost, time, and resource reductions when there are so many costs, times, and resources to be saved.

External Resources

Taking inventory of the resources currently accessible inside the company is not part of project procurement. Instead, project procurement entails locating and procuring outside-of-the-company resources that are required to properly finish a project, whether they are commodities or services.

Outsourcing

Outsourcing is a method of project procurement that has become well-known to some. An organization's manpower may simply be insufficient to finish a project on schedule, necessitating a sudden increase in workers. An organisation will outsource work to a third party rather than go through the process of employing and training new employees. The outsourced help can be used by the originating organisation for as long as they need it, giving them flexibility. Additionally, the firm is spared the costs of hiring and terminating workers as project demands change.

Expert Skills

Project procurement will enable a company to enlist the assistance of experts in specific fields. It may not be feasible for a company to hire a group of structural engineers for example, if the engineers' services are only required on occasion. Project procurement enables an organisation to use specialised capabilities from other companies or experts to execute a project as needed. Outsourced support may also contain technology that the original firm does not have but that is required to finish a certain job. By contracting out with multiple firms in need of their services, these outsourced organisations can afford to have the technology and specialised professionals.

Maintaining Focus

Maintaining an organization's focus, or the values outlined in its mission statement, as well as the strategic objectives derived from the mission statement, will guarantee that it moves forward with purpose. In order to keep this concentration, a business may need to purchase goods or services from other sources rather than producing them. A car manufacturer for example, will purchase tyres from a tyre manufacturer rather than developing their own tyre line, allowing them to concentrate on vehicle production.

Pros and Cons of Project Procurement

Pros

- Negotiate Best Prices

One advantage of managing the procurement process is that it allows individual staff to build expertise in negotiating with vendors for the best costs. Procurement management enables the department leader to identify individuals with the best negotiation skills, further develop those capabilities, and assign this job to those employees. These employees discover what each vendor looks for in a customer-supplier relationship and figure out how to deliver these components while still securing the best bargain possible for the organisation.

- Supplier Evaluation

Another advantage of procurement management is the ability of the organisation to evaluate suppliers. Each supplier is evaluated before doing business with them, and they are re-evaluated on a regular basis. Employees evaluating suppliers take into account the quality of the supplier's products, their capacity to satisfy the company's demands, the credit terms available, and the supplier's willingness to meet the company's special requirements. Employees at the company rank each supplier, allowing them to identify preferred suppliers and eliminate those who aren't.

Cons

- Added Expense

The cost of controlling the purchase process is a disadvantage of utilising procurement management. A specific manager in the procurement department must spend her weekday managing the procedure. This entails assessing employee performance to find strengths and weaknesses, assigning duties to those people, and recognising employees who are eager to learn more. The manager will spend less time on other obligations if she spends more time managing this procedure.

- Less Flexible

Another disadvantage of managing the procurement process is the company's and employees' lack of flexibility. When new purchasing opportunities develop, the organisation must follow established procedures, such as supplier evaluation, before proceeding with the commercial partnership. If a new supplier offers a wonderful discount on supplies for example, the company must follow the specified procedures before taking advantage of the offer.

Traditional Method:

Advantages:

- Before the building contractor was engaged, the design was entirely designed, and the cost was detailed.
- Clients will receive a highly customised building as a result of this strategy.
- Separate parts for design and construction will provide distinct responsibilities.

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Disadvantages:

- It's difficult to assign blame for mistakes and omissions.
- Different contracting parties can generate an adversarial climate.
- Unexpected factors may cause the project's ultimate cost to differ from the original bid price. However, with appropriate planning, this can be kept under control.

Design and Build Method:

Advantages

- Design and construction are the responsibility of the manager as a single point of contact. A single point of contact for the client should be established. This strategy is preferable to others in which the client hires separate designers and contracts for construction. If the claim is successful, the contractors, designers, and architects all blame each other for their mistakes.
- Price assurance: Design and build procurement methods have a higher level of price certainty than other procurement methods. Many design and construction firms provide a guaranteed maximum price (GMP). For late instructions from architects, a design and build contractor cannot claim loss and expenditures. This type of claim can be submitted via a typical procurement approach. Professional fees are also lower and are determined by the functions of the professionals.
- Speed: The design and build technique can easily achieve this by commencing work on site early than traditional forms of contract. This is referred to as single point of contract since the contractor does not communicate design and supply information. The contractor will be able to control the budget and programmes using this way. As a result, the construction procedure will most likely be faster.
- Buildability: Because the contractor is in charge of both design and construction, the project is more likely to be built than other types of procurement.

Disadvantages

- Design quality: The design and construct approach is not an exact procurement method in which excellent design quality is not given a high priority due to the architects' uncertainty.
- Additional design fee: If the client wants independent advice on design matters involving the building contractor, the customer will have to pay an additional fee to the contractor's design team.
- Inflexibility: Once a contract proposal has been agreed upon, the client's ability to adjust his requirements is limited; otherwise, the cost implications will be prohibitive.
- Claims: Because it is a single point of responsibility, it is difficult to make a claim.

Management Contracts:

Advantages:

- This technique enables the client to get a Guaranteed Maximum Price (GMP) from the managing contractor for the project's construction component.
- It's utilised to speed up the project's progress. The danger of delay will be mitigated by meeting deadlines.

Disadvantages:

- When compared to the design and construct system, the project cost in this system is higher.
- When the guaranteed maximum price (GMP) is reached, the management contractor's role as a consultant to customers is jeopardised.

Framework Agreement:

Advantages:

- For the duration of the framework agreement, only one tender will be accepted.
- Cost and administrative efforts are reduced.
- Contractors can learn about competitive supply through initial tendering, and they should provide competitive prices for the estimated value of the business.
- The contracting authority will deliver a wide range of supplies in a short period of time, reducing stock holding for items as well as time and equipment maintenance and repairs.
- With the supplier, a long-term working relationship might be developed.

Disadvantages:

- This is a closed system; new providers cannot be admitted once the framework agreement has been established.
- If the structure of the competitive reopen is not effectively designed in the framework agreement, it can be regarded onerous.

Public Private Partnerships:

Advantages:

- Value for money
- Risk transfer
- Long term nature of contract
- Performance measurement of contracts.
- Private sector management skills
- Cost efficiency
- Time to delivery saving
- Reduction on the public treasury

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- Board support
- Improved cost calculations

Disadvantages:

- Insecurity
- Higher transaction cost
- Higher capital cost
- Inefficiencies
- Culture gap
- Short term rigidities

4.4.3 Tools and Techniques for Project Procurement

Make-or-buy analysis (a sort of data collection), expert opinion, and market research are some of the tools and approaches available to assist project managers and their teams in planning procurement management (a type of data gathering).

Make-or-Buy Analysis

Make-or-buy analysis is a general management strategy for determining whether a company should manufacture a product or provide a service in-house or outsource it. This type of study is calculating the internal expenses of delivering a product or service and comparing them to the cost of outsourcing. Consider a corporation with 1,000 laptop-wielding foreign salespeople. The organisation might compare the cost of delivering such services using internal resources against the cost of buying the same services from an outside source using make-or-buy analysis. If supplier quotes were lower than the company's internal predictions, the training and user support services would have to be outsourced. Another typical make-or-buy dilemma, albeit more complicated, is whether a corporation should design its own application or buy software from a third party and tweak it to meet the company's needs.

Many businesses utilise a make-or-buy analysis to determine if they should buy or lease items for a project. Assume that a project necessitates a piece of equipment with a $12,000 purchase price and $400 per day operational costs. Consider the possibility of leasing the identical piece of equipment for $800 per day, including operational costs. You may use an equation to identify when the purchase price matches the lease price and evaluate whether it is more cost effective to lease or buy the equipment. The number of days you need the piece of equipment is denoted by d in this example. The formula would be

$800/day = $12,000+$400/day

Subtracting $400/day from both sides, you get

$400/day = $400/day

Dividing both sides by $400, you get

d= 30

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In other words, in 30 days, the purchase price would equal the leasing price. If you only require the equipment for a few days, leasing is a better option. You should buy the equipment if you require it for more than 30 days. Leasing is generally less expensive for short-term purposes, but more expensive for long-term demands.

Expert Judgment

When it comes to arranging purchases and acquisitions, experts from both inside and outside a business can help. As part of sound business practice, project teams frequently need to consult specialists within their firm. Internal experts may argue that the corporation in the preceding scenario would be unable to provide training and support for the 1,000 laptop users since the service includes so many people of varying skill levels in so many different places. Experts at the organisation may also be aware that the majority of their competitors outsource this type of work and are familiar with qualified outside vendors. Contracts for outsourced work are legal arrangements, therefore it's also a good idea to seek legal advice.

Experts from outside the company, such as potential suppliers, can also offer expert advice. Suppliers might for example, recommend that salesmen buy the laptops themselves at a lower price. Exiting employees would own their laptops, and incoming employees would purchase a laptop through the programme, which would solve problems that would normally arise during staff turnover. An internal expert may then recommend that employees earn a technology incentive to help offset what they may perceive to be an additional cost. Many procurement choices benefit from expert judgement, both internal and external.

Market Research

In order to plan procurements, market research is critical. Because there are so many prospective suppliers for goods and services, the project team must choose carefully. Some businesses keep a list of preferred vendors with thorough information on them. Many conferences are organised where attendees can see and debate new items, and there is a plethora of information available online.

Data analysis

Make-or-buy analysis is one of the data analysis approaches that can be employed in this process, although it is not the only one. A make-or-buy analysis is used to decide whether project work or deliverables should be completed by the project team or purchased from outside sources. The organization's current resource allocation and their skills and talents, the need for specialised expertise, the desire to avoid expanding permanent employment obligations, and the necessity for independent expertise are all factors to consider when making the make-or-buy option. It also entails assessing the risks associated with each buy-or-make choice.

In order to decide whether to include something as part of the project or acquire it externally, make-or-buy analysis may utilise payback period, return on investment (ROI), internal rate of return (IRR), discounted cash flow, net present value (NPV), benefit/cost analysis (BCA), or other techniques.

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Source selection analysis

Before settling on a selection process, it is vital to assess the prioritisation of the conflicting demands for the project. Because competitive selection methods may necessitate a significant upfront investment of time and resources on the part of sellers, it is a good practice to include the evaluation method in the procurement documents so that bidders are aware of how they will be evaluated. The following are some of the most commonly used selection methods:

- Least cost. For procurements of a standard or routine character, where well-established norms and standards exist and a definite and well-defined output is desired, which can be implemented at various costs, the least cost technique may be appropriate.
- Qualifications only. When the time and cost of a full selection procedure would be excessive due to the low value of the purchase, the qualifications only selection approach is used. The buyer creates a short list of bidders and chooses the one with the best credibility, qualifications, experience, competence, specialist areas, and references.
- Quality-based/highest technical proposal score. If the technical proposal is acceptable, the selected firm is asked to submit a proposal containing both technical and cost details, and is then invited to negotiate the contract. Technical proposals are first evaluated using this method depending on the quality of the technical solution given. If their financial proposal can be discussed and accepted, the seller with the highest-ranked technical proposal is chosen.
- Quality and cost-based strategy. Cost can be factored into the seller selection process using the quality and cost-based strategy. In general, when the project's risk and/or uncertainty are higher, quality should take precedence above cost.
- Sole source. The buyer requests technical and financial proposals from a specific supplier, which are subsequently negotiated. Because there is no competition, this strategy should only be used when absolutely necessary and should be considered an exception.
- Fixed budget. The fixed-budget method entails informing invited sellers of the available budget in the RFP and selecting the highest-ranking technical solution within the budget. Due to a financial constraint, vendors would tailor the scope and quality of their offer to fit that budget. As a result, the buyer must check that the budget matches the SOW and that the seller can complete the tasks within the budget. Only use this strategy if the SOW is clearly specified, no changes are expected, and the budget is set and cannot be exceeded.

Meetings

Without additional information exchange meetings with possible bidders, research alone may not provide particular information to build a procurement plan. The organisation acquiring the item or service may profit from collaboration with possible bidders, while the supplier can influence a mutually beneficial approach or product. Meetings can be used to define the procurement management and monitoring plan.

4.5 Quality Assurance related to Project Implementation

Quality simply refers to the suitability of a product for its intended use and its adherence to specifications. Quality Assurance (QA) focuses on how well the project's procedures work together to produce high-quality project deliverables. It entails satisfying requirements, improving project work over time, and eliminating project flaws.

4.5.1 Key Concept of Quality Assurance and Control

It's one thing to devise a strategy for ensuring project quality; it's quite another to ensure the delivery of high-quality goods and services. The phrase "quality assurance" is frequently used to describe the actions involved in meeting a project's relevant quality criteria. All quality assurance efforts, as well as product design and process enhancements, are included in managing quality. The quality management plan, project papers, and organisational process assets are all important inputs for controlling quality.

Many businesses recognise the importance of quality management and have entire departments dedicated to it. They have extensive procedures in place to ensure that their products and services meet a variety of quality standards. They also understand that they must provide those items and services at a reasonable cost. Good companies build their own best practices and assess the best practices of other organisations to continuously improve the way they do business in today's competitive business environment. Kaizen is a Japanese phrase that means "improvement" or "change for the better," and it has been utilised in many organisations since World War II ended. Another well-known phrase is lean, which refers to analysing operations in order to increase customer value while reducing waste.

Several quality planning tools can also be used to manage quality. Experiment design, as mentioned under quality planning, can also aid in the assurance and improvement of product quality. By comparing specific project procedures or product features to those of other projects or products within or outside the performing company, benchmarking produces recommendations for quality improvement. For instance, if a competitor's EIS has an average downtime of only one hour per week, it could be a goal to aim for.

A quality audit is an important tool for maintaining quality. A quality audit is a structured review of specific quality management activities that can help identify lessons learned and improve performance on current or future projects. Quality audits can be scheduled or random, and they can be performed by in-house auditors or third parties with expertise in specific areas. Industrial engineers frequently do quality audits by assisting in the development of specific quality indicators for a project, which they subsequently implement and analyse throughout the project. For example, the Northwest Airlines Resnet project (which can be found on the Companion website for this work) is a great illustration of how quality audits may be used to highlight a project's major goals and then measure progress toward those goals. The Resnet project's major goal was to create a new reservation system that would enhance direct airline ticket sales while also reducing the time it took sales personnel to process client calls. Resnet's project manager and project team were able to supervise various elements of the project by focusing on accomplishing these targets thanks to the measuring tools used to track them. The project manager was able to justify further investments in Resnet by measuring progress toward increasing direct sales and minimising call times.

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Controlling Quality

Because there are so many prominent tools and strategies in this field, many individuals simply think of quality control when they think of quality management. Before diving into these tools and processes, it's crucial to understand the difference between quality control and quality planning and management.

Although one of the key goals of quality control is to improve quality, acceptance decisions, rework, and process adjustments are the main results of this process.

- Acceptance decisions assess whether or not the project's products or services will be accepted or rejected. They are called validated deliverables if they are approved. Rework is required if project stakeholders reject some of the project's products or services. For example, in the chapter's opening case, the executive who backed the construction of the EIS was clearly dissatisfied with the system and recruited an outside consultant, Scott Daniels, to lead a team to evaluate and repair the quality issues.
- Rework is the process of bringing rejected things into compliance with product specifications, specifications, or other stakeholder expectations. Rework is frequently the outcome of requested adjustments and approved defect repair, as well as suggested defect repair or corrective or preventive activities. To avoid the need for rework, the project manager must aim to perform an excellent job with quality planning and quality assurance. The medical equipment company had to spend more money on rework because the EIS did not fulfil all of the stakeholders' quality standards in the first case.
- Process adjustments Based on quality control measurements, fix or prevent further quality issues. Organizational process assets and the project management plan are frequently updated as a result of process changes. For example, the consultant in the first situation, Scott Daniels, would suggest that the medical equipment company buy a faster server for the EIS to fix the response-time issues. Because this change would necessitate extra project-related activity, it would necessitate revisions to the project management plan. Scott was also retained by the corporation to devise a strategy for avoiding future IT project quality issues.

It is a procedure in which we measure actual performance, compare it to a standard, and take corrective action if observed performance deviates from the standard. It is a method for achieving quality objectives in a methodical way. Total Quality Control, according to Fiegenbaum, is "an effective system for integrating the quality development, quality maintenance, and quality improvement effects of various groups in an organisation to enable production to be carried out at the most cost-effective level while achieving customer satisfaction."

Processes are vulnerable to variance, which is why quality control is necessary. Materials, tools, machinery, labour, working conditions, operator competence; anything that is involved in the manufacturing of a product might cause differences. Some differences can be corrected right away, while others cannot, and their causes are difficult to track down. This results in a decrease in product performance and a drop in quality. By minimising variation, quality control aims to match the desired performance. The manufacturing methods are bound to change throughout time. Because deviations

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can occur at any stage of production, implementing quality control at all levels of production is both cost-effective and scientific.

The Command Prior to user acceptance and final delivery, a quality process is used to assess the completeness, compliance, and fitness for use of a product or service. This is accomplished by quantifying all actions, traits, and variables utilised to ensure adherence to the standards established during the planning stage.

Throughout the project, quality control should be undertaken to formally verify that the sponsor's and/or customer's acceptance requirements have been met with trustworthy data. The degree of quality control and implementation varies by industry and project management style; for example, quality control procedures in the pharmaceutical, health, transportation, and nuclear industries may be more stringent than in other industries, and the effort required to meet the standards may be greater. Control Quality activities for example, may be conducted by all team members throughout the project life cycle in agile projects. Quality control activities are performed at defined periods, toward the end of the project or phase, by specified team members in waterfall model-based projects.

4.5.2 Basic Concept of Performing Quality Planning

The PMBOK Guide defines planning as "the process of identifying and refining objectives, as well as selecting the best of the different courses of action to achieve the objectives that the project was undertaken to address." 1 The quality planning stage begins with a commitment and approval to proceed with a project and concludes with a kick-off meeting of project participants, which indicates the commencement of project execution. In the five-stage project quality process model, quality planning comes after quality initiation.

Management actions will be far more involved on some projects than on others, as they will be on all five stages. Larger, more difficult, and unknown projects will necessitate more detailed preparation than smaller, more straightforward, and more familiar enterprises.

First Project Quality Pillar: Customer Satisfaction

Several actions related to customer satisfaction should be accomplished at each project level, as well. The identification of customer satisfaction standards and trade-off values is the first step in project quality planning. The odds of finishing a high-quality project are substantially higher if the project sponsor, manager, and core team thoroughly comprehend these two customer desires. To avoid strategic uncertainty and operational disagreement, the project sponsor, project manager, and core team must identify the levels of decision-making authority.

- Determine Customer Satisfaction Standards

  Because the customer is the final arbiter of the project's quality, the project team must be aware of the customer's expectations. Asking external and internal customers directly is the greatest method to get this information.

  The team must then apply this knowledge to create project output specifications as well as the process steps that will be used to achieve the desired standard. This

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process is aided by the customer standards matrix, which includes information on customer criteria for project quality acceptance, techniques for measuring criteria compliance, and thorough information on realistic project quality targets.

The core team can request that the customer(s) indicate the main criteria by which they will assess the project's quality. Customers should next explain how they will measure each criterion and what their satisfaction standard will be for each one. Customers will frequently be unaware of these criteria in advance, necessitating a facilitated discussion with the core team.

- Determine Customer Trade-off Values

Customers will rank the various project objectives in order of importance. The project manager should ask each external and internal customer to rank the cost, time, quality, scope, contribution to the organisation, and contribution to society among the project objectives. The project manager should use the project customer trade-off matrix to determine which objectives should be improved if at all possible, which objectives must be preserved, and which objectives can be sacrificed if necessary.

Many clients would initially refuse to confess that they would be willing to sacrifice any goal. As a result, the project manager must have an open discussion with each client group to assure them that the project team would do everything possible to meet all six objectives. However, judgments will undoubtedly need to be made during the course of the project due to unanticipated eventualities, and knowing which objectives are more important will assist the project manager make decisions that the majority of customers will likely accept.

If priorities conflict, the project manager and sponsor must decide which client groups are more important. External paying clients and top management are typically regarded as very significant. More thought may be required at this point if major variances in priority emerge among various client groups.

In addition, the project team should think about any planned product enhancements, especially if the sponsor or a majority of customers want to improve performance. In any case, both current and future projects are likely to gain if the project team starts thinking about product and process changes early. Customers' goals for improvement (cost, schedule, quality, scope, value to the company, and/or contribution to society) should guide the team's thinking as it strives for continuous improvement.

- Determine Levels of Decision-making Authority

One of the most common causes of quality issues is that project participants are unaware of who has the authority to make specific decisions. This issue can be mitigated if the appropriate decision-makers have the time, information, and expertise to make decisions and understand their jobs. The project decision responsibility matrix is a technique for determining three decision-making aspects pertaining to specific issues: (1) who must be informed, (2) who is authorised to make recommendations, and (3) who is authorised to make decisions.

Responsibility for providing recommendations and being informed should be indicated for each issue that has to be resolved. One major decision-maker per issue is preferred (others may disagree), with the project manager being notified about practically every issue. While all project participants have responsibilities, the project manager is ultimately in charge of quality and must be aware of what is going on.

Second Project Quality Pillar: Process Improvement

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To avoid making mistakes, carpenters are advised to measure twice and cut once. Similarly, project managers are encouraged to devote more time to preparing their work procedures in order to minimise quality issues in the future. During the project quality planning stage, many process-related issues should be resolved.

To establish whether and to what extent incremental improvement, competitive parity, or breakthrough domination are desired with distinct processes, an initial assessment and prioritisation of process improvement needs based on root cause analysis is required. Then, to completely address the diagnosed problems and opportunities, a quality management plan must be designed. Following that, both the project's procedure and its outcome should be planned at the same time. The customer value supply chain, as well as the inputs each will give, must be identified. Every procedure must be qualified. Finally, planning is an iterative process that necessitates a lot of replanning. Good process planning contributes significantly to project quality.

Third Project Quality Pillar: Fact-Based Management

Several data concerns must be fixed while all of the project planning and replanning is going on. The team must determine the data that needs to be collected, create a project communications plan, and document the lessons learned for project participants.

1. Identify Data to Collect

Gathering data that can be gathered and processed into the facts needed to make smart project decisions is an important aspect of making fact-based judgments. Metrics is the science of deciding what data to gather, how to define the data, how to collect the data, analyse the data, and use the data in decision-making. In a good metrics system, you should:

- Variables are defined in terms of how they are used.
- The two types of variance are normal and pathological.
- All project stakeholders are aware of the current status of the project. Metrics are practical and easy to obtain.
- Metrics are collected on a regular basis.
- Metrics are accepted by management.

The SIPOC model is a good place to start when determining some key measures, such as customer satisfaction requirements. This can be used to both identify and define targets for measures to collect. Projects might be carried out within a single company or across numerous companies. In either case, the project metrics must be consistent with those of the parent company and any other parties participating.

2. Develop Project Communications Plan

Faulty communication is a primary source of project quality issues. Keeping all project participants up to date maximises the firm's resources and keeps momentum going. It is critical for a project core team to design and implement a comprehensive project communications plan to reduce the risk of making mistakes. Most people receive significantly more messages than they require, so the solution is more valuable, specific information rather than more information.

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The PDCA model can be applied to project communications in a variety of ways. The project core team first determines who needs to know what information, when they need it, and in what format they want. The team then implements the communication plan (Do). The team should seek feedback (Check) on the quality and completeness of the information being delivered through the communications strategy as soon as possible and as often as possible. Finally, the team should improve the communication plan in response to the input.

3. Collect and Share Project Quality Planning Stage Lessons Learned

Lessons learnt should be recorded at regular intervals during the project, at the very least at the end of each stage, to aid in the better execution of subsequent stages. At the end of the planning step, the plus delta tool can be used to collect the lessons learnt. Lessons learnt should then be applied to future stages of the present project and new initiatives, as well as contributing to the organization's learning capacity through sharing.

4. Project quality pillar: empowered performance

The importance of all four project quality pillars cannot be overstated. The first three (consumer satisfaction, process improvement, and fact-based management) strengthen and support the fourth (customer satisfaction, process improvement, and fact-based management) (empowered performance). To put it another way, doing a good job on the first three pillars helps empower individual performance, and excellent individual performance via empowerment is what leads the other three pillars to be successful.

The commitments of the core team and other project stakeholders to embrace the comprehensive project plan are the determinants of empowered performance that must be accomplished at the end of the project quality planning stage. Once the core team members have reviewed the complete plan and decided to commit to it, they will market the project plan to the other project stakeholders informally. A formal project kick-off meeting, on the other hand, is a helpful public ritual for addressing organisational concerns and solidifying organisational support.

1. Core Team Commits to Project Plan

Unless and until the core team agrees to the project plan, empowered performance will not energise the project. This is the moment to make any adjustments to the project plan that the team members consider are necessary. Replanning will always be necessary, both to add more information and to adapt to client changes or other changing circumstances. Nonetheless, before they can persuade the sponsor, clients, and other stakeholders to commit, the core team members and the project manager must each personally commit to the detailed project plan. Because the project manager and the core team were so deeply dedicated, many prudent sponsors have approved project designs that they believed were less than perfect. In such cases, the sponsor's faith in the team is frequently rewarded since the team discovers methods to overcome hurdles.

2. Plan and Conduct the Project Kick-Off Meeting

The kick-off meeting is used to make the transition from project planning to project execution. The core team, which has done a lot of the planning, is now sharing it with everyone who will be working on the project, including suppliers, ad-hoc workers, and so on. The project's activities should be discussed in broad terms, and participants should be able to ask as many questions as they want.

3. All Key Project Stakeholders Commit to Project Plan

It is beneficial to anticipate and have detailed answers to the following questions to maximise the chance of commitment from all key project stakeholders:

- Why this project?
- Why now?
- Are financial resources adequate?
- Are human resources adequate?
- How thoroughly do you understand the customers?
- How likely is it that customer requirements will change?
- How often and by how much will they change?
- Are appropriate data identified?
- Is the data gathering and analysis system adequate?
- Have customer rights been described?
- Are standards identified or developed by which the project will be judged?
- Are both deliverables and work processes to create them as simple as practical?
- How does the rest of the organization benefit from this project's success?
- How does society benefit from this project's success?

4.5.3 Concept of Total Quality Cost

Total Quality Management (TQM) is a modernization of the old management approach. TQM is a tried-and-true method for ensuring survival in worldwide competitiveness. Only through changing the management function can the entire organization's culture and activities be modified. For the most part, TQM is common sense. We have analysed the three terms.

Total: Made up of the whole

Quality: Degree of excellence, a product or service provides

Management: Act, art, or the manner of handling, controlling, directing etc.

Therefore, TQM is the technique of managing the whole, to achieve all round excellence.

Quality management is a key concern for organisations today, despite the fact that the concept of quality is not new. Many organisations throughout the world are implementing Organizational Development (OD) programmes to improve quality awareness and modify employee attitudes. The efforts to understand, apply, and promote TQM are primarily motivated by changes in the global economy, changing market conditions and customer expectations, and increasing competitive challenges, all of which necessitate ongoing organisational excellence. Total quality management is

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a continuous endeavour to improve quality. Many major organisations have recognised the critical role that TQM can play in addressing these issues.

TQM is not a strategy, but rather a collection of techniques aimed at improving an organization's performance. It's better suited to a more advanced manufacturing and service economy.

Dr. Edwards Demmings and J.M Muran introduced the concept of total quality management to the Japanese in the 1950s. His ideas were taken by the Japanese, who expanded them further through time. They applied process improvement to administrative tasks and service sectors, ensuring that the quality idea had a positive impact on the entire system. Because they were able to lower their prices while improving the quality of their products, Japanese industry was able to achieve unprecedented success.

Several North American manufacturers followed Japan's lead in the 1980s and expanded the use of comprehensive quality concepts to include staff motivation, measurement, and rewards. Total Quality Management is a term that describes a combination of quality management methodologies and organisational behaviour concepts.

The main concepts of overall quality management, according to Mike Hick (2005), are:

- continuous process improvement
- customer focus
- defect prevention
- universal responsibility

Continuous improvement is a process that begins at the top and works its way down. It is conceived and directed from the top down, but it is carried out from the bottom up. The renovation projects are chosen with care and precision. Problem areas must be identified, prioritised, essential processes must be chosen for improvement, and project team improvement targets must be established. This is a bottom-up approach that necessitates the participation and dedication of the employees.

Employee Involvement and Empowerment

The effectiveness of the quality management strategy is contingent on a well-trained, motivated, and empowered workforce.

Employee involvement in the operation and process improvement is defined as management actively encouraging employee participation in the operation and process improvement. Empowerment entails more than just participation. It means that management understands that giving employees training and the correct information puts them in the best position to regulate their own work processes. As a result, they should be given the authority to do so.

Employee involvement and empowerment can be achieved through a variety of methods. To achieve continual improvement in work, suggestion schemes, delegating, and advances in job design are used.

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Problem Solving

People with good problem-solving skills are essential for quality management. The business is enhanced by a constant process of recognising problems, fixing them, and implementing solutions. Identifying the core causes of an issue and taking steps to correct the situation is what problem solving entails. It's crucial to keep track of how much quality costs. If something can't be measured, it can't be managed, according to an old adage. Quality cost measures give you the data you need to figure out where the extra expenses are coming from. Then, in order to lower them, improvement projects might be targeted. To keep information for quality control, a computerised data base is required.

Procedural Improvement

TQM entails incremental improvements. System failure analysis is a sophisticated method of determining the fundamental cause of minor system problems. Errors are attempted to be corrected in order to improve the overall process.

Quality Teams

TQM places a premium on specialised, well-coordinated teamwork. Individuals have a variety of benefits that teams do not. Subject matter experts can address various aspects of the problem. The team's composition is crucial in this situation. A well-formed team can bring a considerably more diverse set of expertise to bear on a problem. The goal is to ensure that the value of the product improves. Cost reduction is not the same as value enhancement. When costs are cut, the product is usually made cheaper. The goal of value improvement is to reduce expenses while continuing to improve the product in terms of quality and customer satisfaction. The product's cost structure is examined in relation to client requirements, and efforts are made to eliminate or minimise any needless expenditures.

Advantages / benefits of TQM

TQM has various advantages over traditional quality management methods, some of which are listed below:

1. TQM assists in focusing precisely on market needs.

   To please the customer, the traditional method to quality control concentrates on the technical intricacies of a product. The consumer, on the other hand, desires more fulfilment, which is sometimes missed in the old method. The requirements differ from one person to the next, as well as from one location to the next. Because TQM focuses on the concept of universality, it aims to abstract market satisfaction perceptions and so aids the organisation in better identifying and meeting market requirements.

2. In every sector of action, TQM makes it easier to aspire to be a top-quality performer.

   It is a well-known reality that negative employee attitude and a non-participative organisational culture are the greatest obstacles to an organization's success, growth, and prosperity. Through the promotion of a participative work culture and efficient teamwork, TQM focuses on bringing about attitudinal and cultural transformation. This increases employee interest in the workplace by satisfying higher levels of

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teamwork and stronger human demands for recognition and self-development. As a result, an employee's performance is not limited to the product or service areas, but also reflects in other areas.

3. It channelises the procedures necessary to achieve quality performance

   Quality in the genuine sense is not something that can be attained overnight. It necessitates a systematic, long-term planning and strategic approach that focuses on defining quality policies, goals, and objectives, and effectively communicating these to all members of the organisation. By employing statistical quality control (SQC) and statistical process control (SPC) techniques, as well as developing and using an evaluation system, organisations can channel their efforts toward achieving the desired and objective quality performance.

4. It aids in the critical and continual examination of all processes in order to eliminate non-productive activities and waste:

   The company is continually striving to improve productivity because it leads to cost savings and increased profits. The development of quality improvement teams that meet on a regular basis, as well as a methodical strategy that aims to eliminate non-productive work, all contribute to this effort. A continuous effort to identify and solve problems aids in waste reduction. As a result, the well-being culture enhances housekeeping, cost efficiency, and safety.

5. It equips organisations with the tools they need to thoroughly comprehend the competition and design an efficient combat strategy.

   Increased rivalry has emerged from dynamic changes in the global market and the open market policies adopted by a significant number of organisations. For many organisations, survival has become the primary concern. Understanding the competition and developing and implementing appropriate strategies to address the issue is critical for today's businesses. TQM gives an organisation an advantage in meeting competition because it helps to understand the pulse of the consumer and hence the market.

6. It aids in the development of good communication and acknowledgment procedures.

   Another foundation of many organisations is ineffective procedures and communication, which leads to misunderstandings, confusion, low productivity, duplication of efforts, poor quality, low morale, and so on. TQM brings together people from various levels of management, allowing for more effective communication and engagement.

7. It assists in receiving the method required to produce a never-ending improvement approach. Efforts to improve quality cannot be limited to a specific time frame. To meet the dynamic difficulties, they must be continual. TQM places a strong emphasis on continuous and periodic assessment in order to meet the necessary challenges.

   As a result, the organisations profit from a wide range of advantages. Many of these are quantitatively quantifiable. However, intangible benefits such as improved work life quality and a variety of others are not quantified. Simultaneously, it must be determined if they occur or not in order to show or deny the concept's efficacy. This can be determined through a well-planned research effort or by conducting an opinion poll on a regular basis.

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TQM in India

TQM is a generally established strategy for reaching the highest quality standards in all areas of business, but it has been found that Indian businesses have done little to implement or even understand it.

For future sustainable survival and development in the competitive world, it is vital to evaluate the organization's human resources, which play a revolutionary role in improving collective performance of organisations, work groups, and people. Total quality management (TQM) approaches have been used to socio-economic policies, along with the concept of sustainable development. It is primarily used in the context of a regular company concern. "The management of losses and gains coming from the degradation of environmental elements that affect the ability of life, any life, to survive, now or in the future" is how sustainable development is described.

The Indian government has liberalised imports and exports and implemented a number of measures to protect Indian companies. These are only temporary solutions. Indian industries will need to take steps to establish systems, processes, and procedures so that the products and services they create are not only comparable in quality and cost to those produced worldwide, but maybe better in quality and cost.

Traditional culture has strangled Indian organisations, and they are resistant to adopt scientifically based progressive management practices. The sooner India embraces modern manufacturing processes and integrates total quality management (TQM) into all systems and subsystems, the better for Indian businesses. This needs to be taken into account on a long-term and permanent basis.

The pioneering work of Deming, Juran, and Cross in comprehensive quality management yielded great cost savings in Japanese and American businesses, but Indian industries, regrettably, were unaware of this phenomenon. The enthusiasm in the United States was so great that the federal government created "Beldridge Wards," which is defined as a "blue map" for guiding any organisation to its highest degree of performance. These characteristics are strategic in nature, and their application in the Indian context must be researched for acceptance in all areas. Lower-level plans must provide real value through development and implementation throughout time in order to achieve optimal TQM. To stay up with industrial, social, and cultural development, the plan must be reviewed on a regular basis.

In a highly competitive world, it is time for Indian industries to adopt the total quality management concept, regard TQM as a "mega" factor, identify various factors or areas formulate simple systems for each area, and implement TQM concepts by empowering people with the vision, ability to plan, and identify key result areas, resulting in the development of desired organisational culture and employee growth. High-level leadership and a commitment-oriented mindset at all levels will go a long way toward attaining overall quality management in any organisation with a focus on market competitiveness.

Summary

- The term IT was used from the 1950s until the 1980s. The project team should complete the project exactly as intended, on schedule, and within budget. The

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issue with this perspective was that, especially when adopting new technology, project teams rarely achieved their initial goals.

- A change control system defines when and how official project documents can be updated. It also states who is authorised to make changes, what paperwork is required, and whether automated or manual tracking mechanisms will be used. A change control system includes a change control board, configuration management, and change communication.
- CCB is a formal committee of people entrusted with approving or rejecting project changes. A CCB's major responsibilities are to provide guidelines for developing, reviewing, and implementing change requests. This board could include key stakeholders from across the organisation, with a few rotating to meet the demands of each project.
- Configuration management is an important part of integrated change control. Configuration management ensures complete and accurate product descriptions. It involves determining and controlling product functionality and physical design, as well as supporting documentation.
- In a change control system, a responsible person reviews and approves changes before they are implemented. In addition to selecting whether to approve, deny, or postpone changes, the change control system often contains all processes that should be used.
- Propose, implement, communicate, and measure are the four major processes that make up the change process.
- Tools and methods for controlling project activity are concerned with measures that will be performed to improve performance in keeping with the project baseline.
- The first of the triple constraints that the project manager must control is actual work time. Depending on the project's scale and complexity, this task can be simple or quite tough.
- The second part of the triple constraint is cost control. Because several individuals or departments may be involved in project cost operations, the project manager's job can be more difficult.
- A monitoring system is a component of a management information system. Other formal and informal channels supply information to upper management. This influences programme execution, improves programme planning, and ensures programme sustainability.
- Four concepts underpin monitoring and assessment. It refers to operational efficiency (number of visits, meetings, demonstrations, and trials per development worker), technical efficiency (output and value added), as well as extension-induced improvements (e.g., income, and income distribution).
- There are two forms of monitoring, most likely:

  a) Beneficiary Contact Monitoring,

  b) Process Monitoring.
- Project management software is used so that strong system management can

further improve project management efficiency. It includes human-only data computation labour, which is wasteful in today's project management.

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- The tools that are commonly used for monitoring purposes:
  a) Regular progress report,
  b) Monitoring staff performance,
  c) Tour reports by field staff,
  d) Participant observation,
  e) Reports from visitors,
  f) Interviews
  g) Participatory Monitoring,
  h) Key informants,
  i) Complaints / grievances.
- Resources Calculations is the capacity to manage resources is the next advancement of a computer software in project management.
- The majority of computer programmes are capable of printing project schedules. There are two types of schedules. The first is a tabular listing of all actions with the activity name, while the second is a bar chart.
- The Critical Path Method of network scheduling was developed in the 1950s by Dupont Chemical and Remington Rand (Univac) (CPM). In 1958, a massive new chemical factory was created using this method. Parallel to this, the US Navy and Lockheed Aerospace developed the Polaris Missile automated Project Evaluation Review Technique (PERT) on an IBM mainframe. Until the early 1980s, mainframe and minicomputers dominated the project management software market.
- Primavera is one of the most popular flowering plants. For organization-wide project management scalability, the Project Management module is a complete, multi-project planning and control software built on SQL, Oracle, and SQL Server Express server databases.
- GanttProject is a cross-platform desktop programme for project planning and management. GanttProject is a project management and planning software. As addition to running on any operating system, GanttProject saves schedules in XML files that can be transformed into HTML web pages.
- A contract is a legally enforceable agreement between two or more parties. In any contract, there are some standards that must be met.
- The phases of Contract Management:
  1) Contract creation,
  2) Contract Negotiation,
  3) Contract Approval
  4) Contract Finalization,
  5) Contract Change Management.

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- Contracts are made up of many phases and sections. This implies that keeping track of and maintaining all of the components of a contract can be difficult, especially when there are hundreds of contracts on a project.
- An effective contract management tool ensures a professional approach to contract management that improves risk management, increases profitability, and gives a clear return on investment (ROI) on contract management activities' cost vs benefit.
- A Project Procurement Process (also known as a "Project Procurement Management Process") is a method for establishing relationships between an organization's purchasing department and external suppliers in order to order, receive, review, and approve all procurement items required for project execution.
- Make-or-buy analysis is a broad management method for choosing whether to produce or outsource a product or service. This sort of research compares the internal costs of supplying a product or service to the cost of outsourcing.
- A quality audit is an important tool for maintaining quality. A quality audit is a structured review of specific quality management activities that can help identify lessons learned and improve performance on current or future projects.
- Total Quality Management (TQM) is a management modernization. TQM is a tried-and-true strategy for global survival. The management function is the only way to change the organization's culture and operations.

Glossary

- CCB: Change Control Board
- CCM: Critical Chain Method
- IMR: Infant Mortality Rate
- MMR: Maternal Mortality Rate
- MLL: Minimum Levels of Learning
- HTML: Hyper Text Markup Language
- XML: Extensible Markup Language
- MIMOs: Multiple Input Multiple Outputs
- ROI: Return On Investment
- FP EPA: Fixed Price Contract with Economic Price Adjustment
- CPF: Cost-Plus-Fee
- CPPC: Cost-Plus-Percentage of Cost
- CPFF: Cost-Plus-Fixed-Fee
- CPIF: Cost-Plus-Incentive-Fee
- T&M: Time & Material
- GMP: Guaranteed Maximum Price
- IRR: Internal Rate of Return

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- NPV: Net Present Value
- BCA: Benefit/Cost Analysis
- TQM: Total Quality Management
- OD: Organizational Development

Check your Understanding

1. A_ _ _ _ _ _ _ is a formal, documented procedure that outlines when and how official project documents can be modified.
   a) SDLC
   b) Change Control System
   c) TQM
   d) Contingency control
2. A_ _ _ _ _ _ _ is a formal group of individuals charged with approving or rejecting project changes.
   a) Change Control System
   b) Risk Management
   c) TQM
   d) Change Control Board (CCB)
3. The_ _ _ _ _ _ _ is a control tool that applies buffers inside a network of project activities at precise locations.
   a) Change Control System
   b) Change Control Board
   c) Critical Chain Method (CCM)
   d) None of the above
4. A _ _ _ _ _ _ _ _is a subsystem of a management information system that consists of a number of distinct components.
   a) Change Control System
   b) Monitoring System
   c) Both a and b
   d) Project Management System
5. _ _ _ _ _ _ _ _is a method of ensuring that processes are guided to reach the desired outcomes while maintaining high quality.
   a) Process Monitoring
   b) Beneficiary Contact Monitoring
   c) TQM
   d) Project Monitoring

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6. _ _ _ _ _ _is a desktop application for project scheduling and management that runs on a variety of platforms.
   a) Gantt chart
   b) PERT
   c) GanttProject
   d) None of the above
7. _ _ _ _ _ _ _ refers to the procedures that a company uses to oversee all parts of a contract.
   a) Contract management
   b) Project Planning
   c) Project Management
   d) None of these
8. ______is a tried-and-true method for ensuring survival in worldwide competitiveness.
   a) CPM
   b) TQM
   c) Quality Assurance
   d) All of the above
9. An organisation will outsource tasks rather than hire and train new staff is termed as_ _ _ _ _.
   a) Outsourcing
   b) External Resources
   c) Expert Skills
   d) None of the above
10. A _ _ _ _ _ _is a general management strategy for determining whether specific work should be completed by the project team or purchased from outside sources.
    a) Expert Judgement
    b) Market Research
    c) Make-or-Buy Analysis
    d) Meetings

Exercise

1. Explain project change control.
2. What are the different tools for project change control?
3. Explain project monitoring with different tools.
4. Define computer application in project management.
5. What is the need for computer application in project management?
6. Define different software for project management.

7. Explain introduction to project contracting process.
8. What are the tools and techniques for project contracting?
9. Explain in detail stages in project procurement process.
10. What do mean by significance of project procurement, pros and cons of project procurement?
11. What are the tools and techniques for project procurement?
12. What are the key concepts of quality assurance and control?
13. What do you understand by the basic concept of performing quality planning?
14. Explain concept of total quality cost.

Learning Activities

- What according to you is the best quality?
- What according to you is the best technique for project contracting?

Check Your Understanding - Answers

1. b
2. d
3. c
4. b
5. a
6. c
7. a
8. b
9. a
10. c

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Notes

Module - V: Project Monitoring and Control

Learning Objectives:

At the end of this module, you will be able to understand:

- Process of Performing Qualitative Risk Analysis
- Key Concept of Quality Assurance and Control
- Introduction to Project Change Control
- Different Tools for Project Change Control
- Information Distribution, Managing Stakeholders
- Method of Performance Reporting
- Errors during Project Handling
- Handling Errors during Project Handling
- Quality Control through Minimizing Errors during Project

Introduction

We may simply identify the controlling responsibilities by looking at a controller's job description. Let's take a closer look at the governing responsibilities.

Supervising: Controlling is a high-priority function of management since it is one of the most important functions. The controller will be in charge of leading or supervising activities. They are in charge of a variety of operations as well as low-level personnel. With motivational techniques, they must maintain a healthy and positive environment. The controller is responsible for launching integration strategies, personality development programmes, and team-based fun events, among other things.

Financial Decisions: This is one of the most significant regulating tasks because financial difficulties will determine the organization's beginning and finish. Taking financial decisions is not an easy process, and it necessitates the presence of a more responsible and skilled individual. Among the responsibilities are budgeting, allocating finances, acquiring funds, and implementing various innovative financial systems and cost-cutting approaches, among others.

Financial Statements: One of the roles of the controlling responsibilities is to record and submit reports of all financial transactions. For regular intervals of time, the lower level controlling staff will send reports to the higher financial supervisors. This aids in the maintenance of transparency, the avoidance of unnecessary expenses, the ability to make spontaneous judgments and manage overspending, and the ability to plan for cost reductions within existing resources.

Collaboration: It is the responsibility of all the regulating responsibilities at the middle level. Here, the controller must work with or spend more time with the employees, attempting to collaborate messages from lower-level employees to higher-level employees and vice versa. To increase efficiency, these controllers must establish a congenial climate within the firm and among the personnel. In order to be intelligible and helpful with the organization's management, the controller must cooperate with stakeholders and financial audit officers.

Knowledge: It is divine to have knowledge. Because the controller interacts with all departments in the company, they may need a basic understanding of several topics. Aside from this, the controller must have thorough understanding of taxation, financial concerns, audits, pricing and expenses, accounting methods, and so on. The controller is the only one who can make spontaneous decisions without relying on others and thoroughly understand the scenario.

Quality management made its debut in project management in the late 1980s or early 1990s. No one can deny that project management has evolved into a quality-driven process. Everyone wants 'quality' project delivery, not just project delivery.

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Six Sigma, often known as lean implementation, is a methodology for ensuring that projects have no faults. Quality management has evolved as a major aspect in project management because all projects strive for continuous improvement and the elimination of errors. In reality, the PMBOK Guide defines project quality management as a knowledge area of project management.

5.1 Level of Responsibility for Control: Business and Product Quality Controls

Among the four functions of management, controlling is one of the most important. To succeed in the corporate world, every manager must learn and grasp planning, organising, controlling, and decision-making. Each function has its own set of responsibilities and significance. Let's take a closer look at the role of controlling and its obligations.

Controlling is a managerial function that is defined as the process of monitoring various activities in an organisation, distributing authority and work to all levels of personnel, and keeping track of any unanticipated deviations and their cures for the organization's growth. The controller is the person who is in charge of this action. Controlling obligations are the responsibilities that a controller has in an organisation.

5.1.1 Process of Performing Qualitative Risk Analysis

To establish the extent and priority of identified hazards, qualitative risk analysis evaluates their likelihood and impact. This section explains how to create a prioritised list of hazards using a probability/impact matrix. It also shows how to use the Top Ten Risk Item Tracking technique to create an overall project risk ranking and follow trends in qualitative risk analysis. Finally, the role of expert judgement in risk assessments is discussed in this section. It's worth noting that other organisations simply categorise dangers as high, medium, or low and colour code them as red, yellow, or green based on their severity. Using the methodologies given in this section, qualitative risk analysis can be considerably improved.

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Although quantitative risk analysis is frequently performed after qualitative risk analysis, the two processes can be performed together or independently. The team may only undertake qualitative risk analysis on specific projects. Which risk analysis methodologies are utilised depends on the nature of the project and the amount of time and money available. Large, complicated projects using cutting-edge technologies frequently necessitate a thorough quantitative risk assessment. This section focuses on employing decision tree analysis, simulation, and sensitivity analysis as quantitative risk analysis and modelling tools.

Decision Trees and Expected Monetary Value

When future outcomes are uncertain, a decision tree is a diagramming analysis tool that can help you choose the best course of action. Calculating predicted monetary value is a frequent use of decision tree analysis. The product of a risk event's probability and its monetary worth is the expected monetary value (EMV). Figure 11-7 uses the dilemma of which project(s) an organisation should pursue to illustrate this concept. Assume Cliff Branch's company is debating whether to submit a proposal for Project 1, Project 2, both, or neither project. A decision tree with two branches, one for Project 1 and one for Project 2, might be drawn by the team. To aid in this decision, the company may assess the estimated monetary value.

You must assess the probabilities or chances of various events occurring in order to design a decision tree and, more particularly, to compute expected monetary value. For example, the outcome of the top branch in the picture shows a 20% likelihood (P =20) that Cliff's firm would receive the contract for Project 1, which is projected to be worth $300,000 in earnings. The firm has an 80% chance of not winning the contract for Project 1, and the outcome is projected to be $40,000, meaning the firm will have invested $40,000 on Project 1 with no reimbursement if it does not get the contract. The sum of the probabilities for each project's outcomes must equal one (for Project 1, .20 plus .80). Expert judgement is usually used to evaluate probabilities. Cliff or others in his firm should have a notion of how likely certain projects are to be successful.

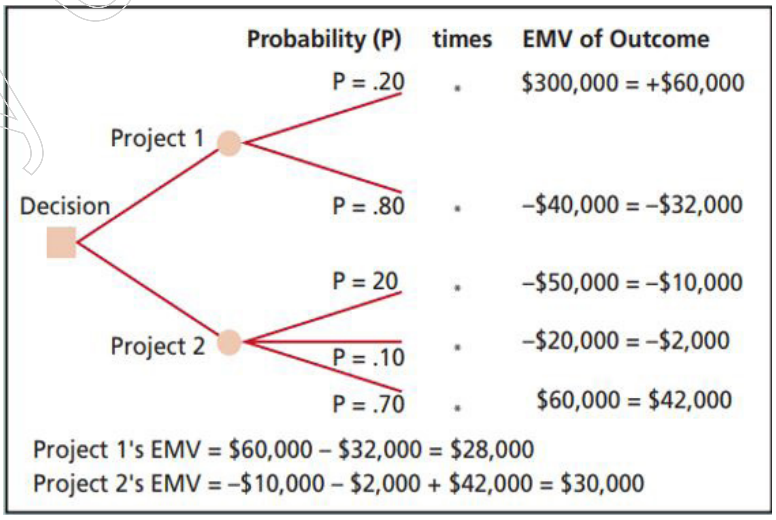

Figure: Expected monetary value (EMV) example

To figure out the EMV for each project, multiply the probability by the outcome value for each possible outcome and add the results. To calculate the EMV for Project

1, multiply the chance by the outcome for each branch and add the results from left to right. The EMV for Project 1 in this scenario is $28,000.

.2($300,000) + .8($40,000) = $60,000 - $32,000 = $28,000

The EMV for Project 2 is $30,000.

.2(-$50,000) + .1(-$20,000) + .7($60,000) = $10,000 - $2,000 + $42,000 = $30,000

You desire a positive EMV since it provides an estimate of the entire dollar value of a decision; the greater the EMV, the better. Cliff's firm would expect a favourable conclusion from both Projects 1 and 2 because the EMV is positive for both, and might bid on both. Cliff's firm should bid on Project 2 because it has a higher EMV if it has to select between the two projects due to limited resources.

Simulation

Simulation, which uses a representation or model of a system to examine its expected behaviour or performance, is a more complex technique for quantitative risk analysis. The majority of simulations are based on Monte Carlo analysis. Monte Carlo analysis simulates the outcome of a model many times in order to get a statistical distribution of the estimated findings. Monte Carlo analysis for example, can decide that a project will finish just 10% of the time by a given date, and another date for which the project will finish 50% of the time. In other words, Monte Carlo analysis can predict whether a project will be completed on time or whether the cost will be equal to or less than a certain amount.

When running a Monte Carlo analysis, you can employ a variety of distribution functions. A simplified approach is shown in the following example. The following are the basic steps in a Monte Carlo analysis:

1. Gather the most likely, optimistic, and pessimistic estimates for each of the model's variables. The project network diagram for example, would be your model if you were attempting to determine the chance of fulfilling project schedule goals. For each task, you would collect the most likely, optimistic, and pessimistic time estimates. It's worth noting that this stage is similar to gathering data for PERT estimates. Instead of using the same PERT weighted average calculation, you use a Monte Carlo simulation to accomplish the steps below.
2. Determine each variable's probability distribution. How likely is it that a variable would lie between the optimistic and most likely estimates? For example, if an expert assigned to a task gives you a most likely estimate of 10 weeks, an optimistic estimate of 8 weeks, and a pessimistic estimate of 15 weeks, you can ask about the likelihood of finishing the task in 8 to 10 weeks. The expert might say there's a 20% chance of it happening.
3. Choose a random value for each variable, such as the time estimate for a task, depending on the probability distribution for the variable's occurrence. For instance, in the foregoing case, you would choose a value between 8 and 10 weeks 20% of the time and a value between 10 and 15 weeks 80% of the time at random.
4. Run a deterministic analysis or a single pass through the model with the values you've chosen for each variable. On the first run, one of the tasks in the preceding

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scenario might have a value of 12. On the first run, all of the other tasks would be assigned a random value based on their estimates and probability distributions.

5. To get the probability distribution of the model's results, repeat Steps 3 and 4 several times. The number of iterations necessary varies depending on the number of variables and the level of confidence required in the results, but it usually ranges from 100 to 1,000. The final simulation results, using the project schedule as an example, will show you the likelihood of finishing the project within a certain time frame.

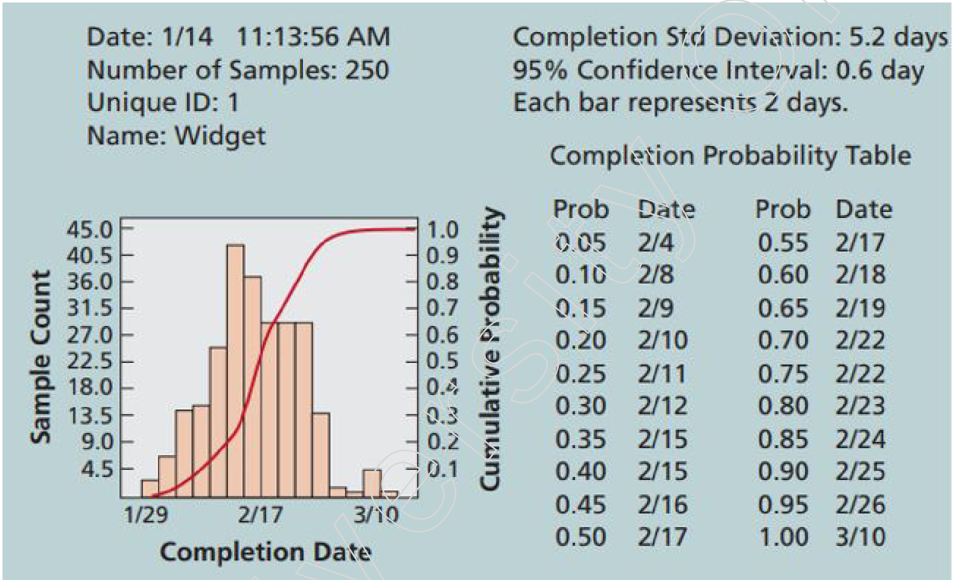

Figure: Sample Monte Carlo–based simulation results for project schedule

The results of a Monte Carlo simulation of a project schedule are shown in the diagram above. Microsoft Project and Risk+ software were used to run the simulation. A chart with columns and an S-shaped curve can be found on the left side of Figure 11-8. The sample count is indicated by the height of each column, which reflects how many times the project was finished in a specific time interval throughout the simulation run. The simulation was ran 250 times in this example, with a time interval of two working days. The first column reveals that only two times during the simulation was the project completed by January 29. The cumulative chance of finishing the project on or before a certain date is depicted by the S-shaped curve. The information is tabulated on the right side of Figure 11-8. For example, the project has a 10% chance of being completed by 2/8 (February 8), a 50% chance of being completed by 2/17 (February 17), and a 90% chance of being completed by 2/25 (February 25). (February 25).

There are several PC-based Monte Carlo simulation software packages available. Based on the simulation results, many tools indicate the primary risk drivers for a project. This allows you to pinpoint the primary source of project schedule uncertainty. For example, a large range for a task estimate could be the source of the majority of the project schedule's uncertainty.

Sensitivity Analysis

Many people are aware with sensitivity analysis, which is used to assess how changing one or more variables affects a result. Many people for example, use a sensitivity analysis to calculate their monthly payments for a loan based on varying interest rates or loan terms. If you borrow $100,000 for 30 years at 6% interest, what will your monthly mortgage payment be? If the interest rate is 7%, how much will the payment be? What will your payment be if you pay off the loan in 15 years at 5% interest?

Many professionals utilise sensitivity analysis to aid in the decision-making process for a variety of business choices, including establishing break-even points based on various assumptions. Sensitivity analysis is frequently performed using spreadsheet software such as Microsoft Excel.

Updates to project documents, such as the risk report and risk register, are the key outputs of quantitative risk analysis. The quantitative analysis also gives high-level information on the likelihood of meeting specific project goals. The project manager may be prompted to make modifications to contingency reserves as a result of this information. In some circumstances, based on the quantitative analysis, projects may be redirected or discontinued, or the quantitative analysis may be utilised to assist launch other initiatives to help the existing one succeed.

5.1.2 Key Concept of Quality Assurance and Control

It's one thing to devise a strategy for ensuring project quality; it's quite another to ensure the delivery of high-quality goods and services. The phrase "quality assurance" is frequently used to describe the actions involved in meeting a project's relevant quality criteria. All quality assurance efforts, as well as product design and process enhancements, are included in managing quality. The quality management plan, project papers, and organisational process assets are all important inputs for controlling quality.

Many businesses recognise the importance of quality management and have entire departments dedicated to it. They have extensive procedures in place to ensure that their products and services meet a variety of quality standards. They also understand that they must provide those items and services at a reasonable cost. Good companies build their own best practices and assess the best practices of other organisations to continuously improve the way they do business in today's competitive business environment. Kaizen is a Japanese phrase that means "improvement" or "change for the better," and it has been utilised in many organisations since World War II ended. Another well-known phrase is lean, which refers to analysing operations in order to increase customer value while reducing waste.

Several quality planning tools can also be used to manage quality. Experiment design, as mentioned under quality planning, can also aid in the assurance and improvement of product quality. By comparing specific project procedures or product features to those of other projects or products within or outside the performing company, benchmarking produces recommendations for quality improvement. For instance, if a competitor's EIS has an average downtime of only one hour per week, it could be a goal to aim for.

A quality audit is an important tool for maintaining quality. A quality audit is a structured review of specific quality management activities that can help identify lessons learned and improve performance on current or future projects. Quality audits can be scheduled or random, and they can be performed by in-house auditors or

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third parties with expertise in specific areas. Industrial engineers frequently do quality audits by assisting in the development of specific quality indicators for a project, which they subsequently implement and analyse throughout the project. For example, the Northwest Airlines Resnet project (which can be found on the Companion website for this work) is a great illustration of how quality audits may be used to highlight a project's major goals and then measure progress toward those goals. The Resnet project's major goal was to create a new reservation system that would enhance direct airline ticket sales while also reducing the time it took sales personnel to process client calls. Resnet's project manager and project team were able to supervise various elements of the project by focusing on accomplishing these targets thanks to the measuring tools used to track them. The project manager was able to justify further investments in Resnet by measuring progress toward increasing direct sales and minimising call times.

Controlling Quality

Because there are so many prominent tools and strategies in this field, many individuals simply think of quality control when they think of quality management. Before diving into these tools and processes, it's crucial to understand the difference between quality control and quality planning and management.

Although one of the key goals of quality control is to improve quality, acceptance decisions, rework, and process adjustments are the main results of this process.

- Acceptance decisions assess whether or not the project's products or services will be accepted or rejected. They are called validated deliverables if they are approved. Rework is required if project stakeholders reject some of the project's products or services. For example, in the chapter's opening case, the executive who backed the construction of the EIS was clearly dissatisfied with the system and recruited an outside consultant, Scott Daniels, to lead a team to evaluate and repair the quality issues.
- Rework is the process of bringing rejected things into compliance with product specifications, specifications, or other stakeholder expectations. Rework is frequently the outcome of requested adjustments and approved defect repair, as well as suggested defect repair or corrective or preventive activities. To avoid the need for rework, the project manager must aim to perform an excellent job with quality planning and quality assurance. The medical equipment company had to spend more money on rework because the EIS did not fulfil all of the stakeholders' quality standards in the first case.
- Process adjustments Based on quality control measurements, fix or prevent further quality issues. Organizational process assets and the project management plan are frequently updated as a result of process changes. For example, the consultant in the first situation, Scott Daniels, would suggest that the medical equipment company buy a faster server for the EIS to fix the response-time issues. Because this change would necessitate extra project-related activity, it would necessitate revisions to the project management plan. Scott was also retained by the corporation to devise a strategy for avoiding future IT project quality issues.

It is a procedure in which we measure actual performance, compare it to a standard, and take corrective action if observed performance deviates from the

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standard. It is a method for achieving quality objectives in a methodical way. Total Quality Control, according to Fiegenbaum, is "….an effective system for integrating the quality development, quality maintenance, and quality improvement effects of various groups in an organisation to enable production to be carried out at the most cost-effective level while achieving customer satisfaction."

Processes are vulnerable to variance, which is why quality control is necessary. Materials, tools, machinery, labour, working conditions, operator competence; anything that is involved in the manufacturing of a product might cause differences. Some differences can be corrected right away, while others cannot, and their causes are difficult to track down. This results in a decrease in product performance and a drop in quality. By minimising variation, quality control aims to match the desired performance. The manufacturing methods are bound to change throughout time. Because deviations can occur at any stage of production, implementing quality control at all levels of production is both cost-effective and scientific.

The Command Prior to user acceptance and final delivery, a quality process is used to assess the completeness, compliance, and fitness for use of a product or service. This is accomplished by quantifying all actions, traits, and variables utilised to ensure adherence to the standards established during the planning stage.

Throughout the project, quality control should be undertaken to formally verify that the sponsor's and/or customer's acceptance requirements have been met with trustworthy data. The degree of quality control and implementation varies by industry and project management style; for example, quality control procedures in the pharmaceutical, health, transportation, and nuclear industries may be more stringent than in other industries, and the effort required to meet the standards may be greater. Control Quality activities for example, may be conducted by all team members throughout the project life cycle in agile projects. Quality control activities are performed at defined periods, toward the end of the project or phase, by specified team members in waterfall model-based projects.

5.2 Integrated Change Control during the Life of the Project

IT was known as data automation or data processing from the 1950s to the 1980s. A widely held concept of project management at the time was that the project team should aim to complete the project exactly as planned, on time and on budget. The difficulty with this viewpoint was that project teams were rarely able to achieve their initial project objectives, especially when using new technology. Stakeholders rarely agree on the project's scope or what the final product should look like up front. Early on in a project, time and cost predictions were rarely correct.

Most project managers and top executives learned in the 1990s that project management is a continuous process of communication and negotiation regarding project objectives and stakeholder expectations. This perspective assumes that changes occur throughout the project life cycle and that modifications are frequently advantageous to some projects. If a project team member discovers a new hardware or software solution that can meet customers' expectations in less time and money, the project team and key stakeholders should be willing to make significant adjustments to the project.

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5.2.1 Introduction to Project Change Control

Changes will occur in all projects, and handling them is a critical aspect of project management, particularly for IT projects. Many IT initiatives necessitate the use of continuously updated hardware and software. To continue the example from earlier in this section, the first strategy for ordering the server might have found a model that was cutting-edge at the time. If the server was ordered six months later, it's likely that a more powerful server would be available for the same price. This case exemplifies a favourable shift. The server manufacturer listed in the project plan, on the other hand, could go out of business, resulting in a negative change. IT project managers should be prepared for such shifts and incorporate some flexibility into their project planning and execution. Customers for IT projects should also be willing to accomplish project goals in a variety of methods.

Some improvements may be necessary, but they are too extensive to be included in the current project. Remember that projects have scope, time, cost, and other objectives, and that modifications can have an impact on those objectives. For example, if the company wants to reach its time and cost targets, it must keep track of changes to the project's scope. Organizations frequently decide to document some change requests and incorporate them into a project upgrade.

It is critical that projects have a formal change control mechanism, even if project managers, project teams, and clients are flexible. This formal system is required to plan for change management.

Change Control System

A change control system is a formal, documented procedure that outlines when and how official project documents can be modified. It also specifies who is authorised to make modifications, what paperwork is necessary for these changes, and whether the project will use automated or manual tracking systems. A change control system typically consists of a change control board, configuration management, and a change communication mechanism.

A change control board (CCB) is a formal group of individuals charged with approving or rejecting project changes. A CCB's main responsibilities are to offer rules for preparing change requests, reviewing change requests, and managing the implementation of changes that have been accepted. This board could include essential stakeholders for the entire organisation, with a few members rotating based on the specific needs of each project. Overall change control should be improved by establishing a formal board and a framework for handling changes.

CCBs, on the other hand, can have some disadvantages, such as the length of time it takes to make decisions on suggested modifications. CCBs often meet once a week or once a month, and they may not make decisions in that time. Some businesses have efficient processes in place for making quick decisions about minor project adjustments. A "48-hour policy" was developed by one organisation, in which task leaders on a significant IT project would obtain agreements on crucial decisions or adjustments within their competence and authority within 48 hours. The person in charge of the area most affected by the decision or modification then had 48 hours to seek approval from upper management. If for some reason the project team's choice

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could not be implemented, the top management consulted would have 48 hours to reverse the decision; otherwise, the project team's decision would be approved. This method is efficient for dealing with the numerous time-sensitive decisions or adjustments that IT project teams must make.

Another key aspect of integrated change control is configuration management. Configuration management guarantees that the project's product descriptions are accurate and thorough. It entails determining and controlling the functional and physical design aspects of products, as well as the documentation that supports them. Configuration management for major projects is typically given to members of the project team, who are referred to as configuration management specialists. Their role is to define and document the functional and physical features of the project's products, to control any modifications to those qualities, to record and report changes, and to audit the products to ensure that they meet the project's requirements.

Communication is another important aspect of change management. To identify and manage project changes, project managers should employ written and oral performance reports. On software development projects for example, most programmers must modify a database copy of the master file; to maintain version control, programmers must "check out" the file to change it. When two programmers have access to the same file, they must work together to combine their modifications.

Oral and informal communication, in addition to written or formal communication, are equally vital. Depending on the scope of the project, some project managers hold stand-up meetings once a week or even every morning. A stand-up meeting's purpose is to quickly deliver the project's most important information. Every morning, the project manager for example, might have a stand-up meeting with all of the team leaders. Every Monday morning, there may be a stand-up meeting with all interested parties. Participants must stand throughout meetings, which keeps sessions brief and compels everyone to concentrate on the most essential project activities.

Why is effective communication so important for success? One of the most aggravating parts of project transition is that not everyone is in sync and aware of the most up-to-date project information. Again, the project manager is responsible for integrating any project changes in order to keep the project on schedule. The project manager and team members must devise a procedure for promptly contacting everyone who is affected by a change. E-mail, real-time databases, cell phones, and the Internet make sharing the most up-to-date project information simple.

Suggestions for performing integrated change control are shown in the table below. As previously said, project management is a continuous process of communication and negotiation. Change management should be planned for, and appropriate tools and procedures, such as a change control board, configuration management, and excellent communication, should be used. Defining procedures for making timely decisions on small adjustments, using written and oral performance reports to help detect and manage changes, and using software to help plan, update, and control projects are all beneficial. An IT steering committee can also represent the full IT portfolio, which is important in change management, especially when resources must be shifted to meet authorised changes. Furthermore, changes in the IT steering committee's strategic direction can have an impact on existing initiatives, resulting in adjustments.

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Table Suggestions for performing integrated change control

View project management as a process of constant communication and negotiation.
Plan for change.
Establish a formal change control system, including a change control board (CCB) and IT steering committee.
Use effective configuration management.
Define procedures for making timely decisions about smaller changes.
Use written and oral performance reports to help identify and manage change.
Use project management software and other software to help manage and communicate changes.
Focus on leading the project team and meeting overall project goals and expectations.

To ensure that the project is completed successfully, project managers must also give strong leadership. They must avoid becoming overly involved in project management changes. Project managers should delegate much of the detailed work to project team members, allowing them to focus on providing overall project leadership. To guide their team and business to success, project managers must keep their eyes on the broad picture and execute excellent project integration management.

5.2.2 Different Tools for Project Change Control

Manual or automatic tools can be employed to help with configuration and change management. Change control is concerned with identifying, recording, and approving or rejecting changes to project papers, deliverables, or baselines, whereas configuration control is concerned with the specification of both deliverables and procedures.

The project stakeholders' needs, as well as organisational and environmental factors and/or restrictions, should guide tool selection. The following configuration management operations should be supported by tools:

- Identify configuration item. Identification and selection of a configuration item to serve as the foundation for defining and verifying product configurations, labelling items and documents, managing changes, and maintaining responsibility.
- Record and report configuration item status: Each configuration item's data is recorded and reported on.
- Perform configuration item verification and audit: Configuration verification and audits guarantee that a project's configuration items are appropriately composed and that relevant modifications are properly registered, assessed, approved, tracked, and implemented. This guarantees that the configuration documentation's functional criteria are met.

The following change management actions should also be supported by tools:

- Identify changes. Identifying and selecting a process or project document change item.
- Document changes. Creating a proper change request to document the change.

- Decide on changes. Approving, rejecting, deferring, or making any other decision about modifications to project papers, deliverables, or baselines.
- Track changes: Verifying sure changes are recorded, evaluated, approved, and tracked, as well as conveying the final outcomes to stakeholders.

Change requests and the decisions that arise are likewise managed using tools. Additional communication considerations should be made to assist the members of the change control board (CCB) in their duties, as well as to distribute decisions to the right stakeholders.

A change control system is any system that has been created to ensure that the process of making changes is not done haphazardly and without thinking, but rather is thoroughly considered and signed off on by a responsible person. The change control system often includes not only the specific parts involved in deciding whether to approve, reject, or postpone any changes, but also all of the processes that should be used. Some of the elements involved in a properly functioning change control process for example, include a previously documented Change Control Policy, an established Change Control Board, an established core of Change Management Tools, and, in some cases, a Quality Assurance team and an Asset Management Team. In addition to providing set rules for the usual process of making changes, the Change Control System should also have measures in place for any emergency changes that may occur.

5.2.3 Case Study discussing the Importance of Project Risk Management, Quality Management and Change Control Management

Packer Telecom

Background

Due to the increasing growth of the telecom business, Packer's executives realised that risk management was required for all development projects. Packer would lose market share if they were late in introducing a new product. Furthermore, if Packer is perceived as being behind the curve in terms of new product development, it may lose lucrative possibilities to "partner" with other companies.

Another issue for Packer was the amount of money spent on research and development. R&D accounts for 8 to 10% of a company's earnings on average, but it can be as high as 15% to 18% in the telecom industry. Packer spent 20% of its budget on research and development, and only a small fraction of projects that began in the conceptual stage ever made it to the commercialization stage, where Packer could hope to recoup its R&D costs. The situation was linked to a lack of adequate risk management by management.

The Meeting:

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PM: "I have spent a great deal of time trying to benchmark best practices in risk management. I was amazed to find that most companies are in the same boat as us, with very little knowledge in risk management. From the limited results I have found from other companies, I have been able to develop a risk management template for us to use."

Sponsor: "I've read over your report and looked at your templates. You have words and expressions in the templates that we don't use here at Packer. This concerns me greatly. Do we have to change the way we manage projects to use these templates? Are we expected to make major changes to our existing project management methodology?"

PM: "I was hoping we could use these templates in their existing format. If the other companies are using these templates, then we should also. These templates also have the same probability distributions that other companies are using. I consider these facts equivalent to a validation of the templates."

Sponsor: "Shouldn't the templates be tailored to our methodology for managing projects and our life cycle phases? These templates may have undergone validation, but not at Packer. The probability distributions are also based upon someone else's history, not our history. I cannot see anything in your report that talks about the justification of the probabilities.

"The final problem I have is that the templates are based upon history. It is my understanding that risk management should be forward looking, with an attempt at predicting the possible future outcomes. I cannot see any of this in your templates."

PM: "I understand your concerns, but I don't believe they are a problem. I would prefer to use the next project as a 'breakthrough project' using these templates. This will give us a good basis to validate the templates."

Sponsor: "I will need to think about your request. I am not sure that we can use these templates without some type of risk management training for our employees."

Questions:

1. Is it possible to move templates from one organisation to another, or should customising be required?
2. Is it possible to transfer probability distributions from one organisation to another? If not, how do we go about creating a probability distribution?
3. How do you check if a risk management template is valid?
4. Is it necessary for a risk management template to be forward-looking?
5. Is it possible for staff to start using a risk management template without any prior training?

5.3 Performance Reporting, Deviation from Specification

What is the definition of performance reporting? It's a crucial component of project communication management. As determined in the communication management strategy, it entails gathering and disseminating project information, conveying project progress, resource use, and forecasting future progress and status to various stakeholders.

Other processes' work outcomes are reviewed and merged into performance reports throughout the performance reporting phase. They're usually presented in tabular or graphical formats, which might be text-based, visual-based (such as charts, graphs, or tables), or a combination of the two.

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5.3.1 Information Distribution, Managing Stakeholders

Information Distribution

The process of making relevant information available to project stakeholders as planned is known as distribute information. It's done at every stage of the project's life cycle, as well as in all management activities. The execution process, which involves implementing the communications management plan as well as responding to unanticipated demands for information, is the main focus here. A variety of approaches are used to effectively distribute information, including:

- Models with a sender and a recipient. Communication obstacles and feedback loops
- Media selection. When to communicate in writing vs. orally, when to write an informal note vs. a formal report, and when to communicate face-to-face vs. through e-mail, depending on the situation.
- Style of writing Active versus passive voice, sentence construction, and word choice are all important considerations.
- Techniques for meeting management. Creating a schedule and resolving problems
- Techniques of presentation Body language and visual aids design
- Techniques for facilitation Consensus-building and problem-solving

Distribute Information: Inputs

- Project Management Plan

The communications management plan is included in the project management plan.

- Performance Reports

Performance reports are intended to disseminate project performance and status information, and they should be accessible prior to project meetings and as accurate and current as feasible.

Forecasts are modified and published as the project progresses, based on work performance metrics. This data pertains to the project's previous performance that may have an impact on the project's future performance, such as estimates at completion and estimates to complete. Earned value methods are commonly used to create forecast information, but alternative methods such as analogy with previous projects, re-estimating remaining work, including the impact of external events in the timetable, and others may also be used. This information, together with performance data and other critical data that must be disseminated for decision-making, should be available.

- Organizational Process Assets

The following are examples of organisational process assets that can influence the Distribute Information process:

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- o Policies, procedures, and guidelines regarding information distribution.
- o Templates, and
- o Historical information and lessons learned

Distribute Information: Tools and Techniques

- Communication MethodsInformation is distributed through individual and group meetings, video and audio conferences, computer chats, and other remote communication methods.
- Information DistributionTools A variety of tools can be used to transmit project information, including:
  - o Distribution of hard copies of documents, manual filing systems, press releases, and computerised databases with shared access.
  - o Web interfaces to scheduling and project management software, meeting and virtual office support software, portals, and collaborative work management tools; and
  - o Electronic communication and conferencing tools, such as e-mail, fax, voice mail, telephone, video and web conferencing, websites and web publishing.

Distribute Information: Outputs

Organizational Process Assets updates

The following are examples of organisational process assets that could be updated:

- Notifications to stakeholders. Stakeholders may be informed about addressed issues, approved changes, and the overall progress of the project.
- Reports on projects. Lessons learned, issue logs, project closing reports, and outputs from other Knowledge Areas are all included in formal and informal project reports that reflect project status.
- Presentations on a project. The project team communicates with any or all project stakeholders formally or informally. The information and presentation technique should be appropriate for the audience's demands.
- Records of the project. Correspondence, memos, meeting minutes, and other documents outlining the project are examples of project records. To the degree practicable and acceptable, this information should be kept in an organised fashion. Members of the project team can also keep track of things in a project notebook or register, which can be physical or electronic.
- Stakeholders' responses Information about project operations collected from stakeholders can be disseminated and used to adjust or improve the project's future performance.
- Documentation of the lessons learned. The causes of issues, the logic behind the corrective action selected, and other sorts of information distribution lessons learned are all documented. Lessons learnt are documented and disseminated so that they become part of the project's and performing organization's history databases.

Notes

Managing Stakeholders

Stakeholders are a crucial component of the project management process. Projects are requested, approved, rejected, supported, and opposed by stakeholders. The Project Management Institute decided to build an entire knowledge area devoted to stakeholder management in 2013 since it is so critical to project success. Many of the same concepts that apply to communications and resource management also apply to stakeholder management, but specific activities are necessary to do it effectively. The goal of project stakeholder management is to identify all people or organisations who are impacted by a project, understand stakeholder expectations, and effectively involve stakeholders in project decisions throughout the project's life cycle. To achieve stakeholder satisfaction, project managers and their teams must maintain open lines of communication with stakeholders and resolve concerns as they arise.

Projects frequently result in organisational changes, and when a project is over, some people may lose their positions. For example, a project can result in the outsourcing of work to an external group to make the organisation more efficient, or a project might result in the creation of a new system that renders some jobs redundant. These and other negatively affected stakeholders may perceive project managers as adversaries. Some people, on the other hand, may see project managers as allies if they lead a project that boosts profitability, creates new jobs, or raises remuneration for specific stakeholders. Project managers must learn to recognise, comprehend, and work with a variety of stakeholders in any instance.

The following are the four processes involved in project stakeholder management:

1. Stakeholder identification entails identifying everyone involved in or affected by the project and finding the best strategies to manage interactions with them. A stakeholder registration is the key product of this approach.
2. Stakeholder engagement planning is formulating methods for effectively including stakeholders in project decisions and activities, taking into account their needs, interests, and potential impact. A stakeholder engagement plan is the result of this approach.
3. Communicating and working with project stakeholders to meet their needs and expectations, resolving difficulties, and encouraging participation in project decisions and activities are all part of managing stakeholder engagement. Change requests, project management plan updates, and project document changes are the outcomes of this procedure.
4. Monitoring stakeholder engagement entails keeping track of stakeholder interactions and updating stakeholder engagement plans and strategies as needed. Work performance data, change requests, project management plan changes, and project document updates are all outputs of this procedure.

Stakeholders are those who are affected by or can affect a project in a positive or bad way. Some stakeholders may have limited influence over the project's work or outcomes, while others may have a significant impact on the project and its projected outcomes. Academic studies and evaluations of high-profile project failures emphasise the significance of taking a systematic strategy to identifying, prioritising, and engaging all stakeholders. The project manager's and team's ability to properly identify and engage all stakeholders can spell the difference between project success and failure.

Notes

The process of stakeholder identification and engagement should begin as soon as feasible after the project charter has been accepted, the project manager has been assigned, and the team has begun to assemble to increase the odds of success.

As a project goal, stakeholder satisfaction should be recognised and monitored. Focus on continuous communication with all stakeholders, including team members, to understand their needs and expectations, address issues as they arise, manage conflicting interests, and foster appropriate stakeholder engagement in project decisions and activities is the key to effective stakeholder engagement.

It is an iterative process to identify and engage stakeholders for the project's benefit. Despite the fact that the processes in Project Stakeholder Management are only stated once, the activities of identification, prioritising, and engagement should be evaluated and modified on a regular basis, and at least when:

- The project goes through several stages as it progresses through its life cycle.
- Current stakeholders are no longer active in the project's work, or new stakeholders join the project's stakeholder community, or
- the organisation or the larger stakeholder community undergoes substantial changes.

5.3.2 Method of Performance Reporting

Performance reporting is another crucial technique for managing project communications. Stakeholders are kept informed about how resources are being used to meet project goals through performance reporting. It also encourages employees to report on their success. Progress or status reports are common formats for performance reporting. Many people confuse the two names, but some people differentiate between them as follows:

- The project team's accomplishments over a given time period are described in progress reports. In many projects, each team member is required to submit a monthly or even weekly progress report. Team leaders frequently compile aggregated progress reports based on data provided by team members.
- Status reports describe the current state of the project at a certain moment in time. The project's status reports detail where it stands in terms of achieving the triple constraint of scope, time, and money. How much money has already been spent? How long did it take you to complete specific tasks? Is the job being completed according to the schedule? Depending on the demands of the stakeholders, status reports can take a variety of forms.

The process of gathering and disseminating performance data, including as status reports, progress measurements, and forecasts, is known as report performance. The performance reporting process entails collecting and analysing baseline versus actual data on a regular basis in order to understand and convey project progress and performance, as well as forecast project outcomes.

For each audience, performance reports must include information at the right level. The format could be anything from a simple status report to a more detailed report. A simple status report could include performance data like percent complete or status dashboards for each region (i.e., scope, schedule, cost, and quality). The following are examples of more detailed reports:

Notes

- Analysis of past performance,
- Current status of risks and issues,
- Work completed during the period,
- Work to be completed next,
- Summary of changes approved in the period, and
- Other relevant information which must be reviewed and discussed.

A comprehensive report should also provide an estimate of when the project will be completed (including time and cost). These reports can be generated on a regular basis or on a case-by-case basis.

Report Performance: Inputs

- Project Management Plan Project baselines are detailed in the project management plan. The performance measurement baseline is a project work plan that has been approved and against which the project execution is assessed, with variances measured for management control. The scope, schedule, and cost elements of a project are commonly included in the performance measurement baseline, although technical and quality parameters may also be included.
- Work Performance Information

Information on performance results is gathered from project activities, such as:

  - Deliverables status,
  - Schedule progress, and
  - Costs incurred.

- Work Performance Measurements

Work performance data is used to develop project activity metrics, which are used to compare actual progress to projected progress. Among these include, but are not limited to:

  - Planned versus actual schedule performance,
  - Planned versus actual cost performance, and
  - Planned versus actual technical performance.

- Budget Forecasts

The Control Cost budget projection information provides information on the additional monies that are estimated to be required for the remaining work, as well as estimates for the complete project work completion.

- Organizational Process Assets

The following are examples of organisational process assets that can influence the Report Performance process:

  - Report templates,
  - Policies and procedures that define the measures and indicators to be used, and

Notes

- o Organizationally defined variance limits.

Report Performance: Tools and Techniques

- Variance Analysis

Variance analysis examines what produced a difference between the baseline and actual performance after the fact. Depending on the application area, the standard utilised, and the industry, the process for performing variance analysis may differ. The following are typical steps:

- o Check the accuracy of the data you've gathered to make sure it's accurate, consistent with previous data, and believable when compared to other project or status data.
- o Determine variations by comparing actual data to the project baseline and noting any deviations that are beneficial or unfavourable to the project's success. To quantify deviations, earned value management employs specialised formulae.
- o Determine the impact of project cost and schedule deviations, as well as variances in other project areas.

Analyse the trends in the variances, if appropriate, and record any discoveries concerning the causes of variation and the effect area.

- Forecasting Methods

Forecasting is the technique of estimating future project performance based on current results. Forecasting techniques can be divided into several categories:

- o Time series methods: Time series approaches rely on historical data to forecast future events. Earned value, moving average, extrapolation, linear prediction, trend estimate, and growth curve are examples of methods in this area.
- o Causal/econometric methods. Some forecasting methods are based on the assumption that the underlying factors that may influence the variable being forecasted can be identified. Sales of umbrellas for example, may be linked to weather conditions. After understanding the reasons, projections of the affecting variables can be developed and used in the forecast. Regression analysis employing linear or non-linear regression, autoregressive moving average (ARMA), and econometrics are examples of methodologies in this category.
- o judgmental methods. Intuitive judgments, views, and probability estimations are all included in judgmental forecasting approaches. Composite predictions, surveys, the Delphi approach, scenario building, technological forecasting, and forecasting by analogy are examples of methodologies in this area.
- o Other methods. Simulation, probabilistic forecasting, and ensemble forecasting are examples of other methodologies.

- Communication Methods

Status review meetings can be used to share and assess project progress and performance information. To distribute performance reports, the project manager typically uses a push communication mechanism.

- Reporting Systems

A reporting system gives the project manager a common mechanism for capturing, storing, and disseminating information to stakeholders regarding the project's cost, schedule progress, and performance. Software packages enable the project manager to combine reports from many platforms and distribute them to project stakeholders more easily. Table reporting, spreadsheet analysis, and presentations are all examples of distribution forms. Visual representations of project performance data can be created using graphic skills.

Report Performance: Outputs

Performance reports: Organise and summarise the data gathered, and show any analysis results in comparison to the performance measurement baseline. Reports should give status and progress information to diverse stakeholders at the level of detail specified in the communications management plan. Bar charts, S-curves, histograms, and tables are all common performance report types. Performance reporting frequently includes variance analysis, earned value analysis, and forecast data.

Periodically, performance reports are issued in a variety of formats, ranging from simple status reports to more comprehensive reports. A simple status report might merely provide performance data like percent complete or status dashboards for each region (e.g., scope, schedule, cost, and quality). The following are examples of more detailed reports:

- Analysis of past performance,
- Current status of risks and issues,
- Work completed during the reporting period,
- Work to be completed during the next reporting period,
- Summary of changes approved in the period,
- Results of variance analysis,
- Forecasted project completion (including time and cost), and
- Other relevant information to be reviewed and discussed.

Organizational Process Assets updates

Report formats and lessons learned documentation, including the causes of difficulties, reasoning behind the corrective action taken, and other types of performance reporting lessons learned, are among the organisational process assets that can be changed. Lessons learnt are documented so that they can be added to the project's and the performing organization's history databases.

Change Requests

Change requests are frequently generated as a result of project performance analysis. The following is how the Perform Integrated Change Control process handles these requests:

- Changes that bring the project's predicted future performance in accordance with the project management plan are recommended corrective measures, and

Notes

- Recommended preventive actions can lessen the likelihood of future unfavourable project performance.

5.4 Errors and Quality Control

Quality improvement, quality control, kaizen, value added management, and other quality management concepts are gaining popularity in project management these days. To assure the degree of quality in projects, a great number of firms are heavily investing in quality management personnel.

5.4.1 Errors during Project Handling

Making errors is an unavoidable aspect of the learning process. It is necessary for collecting experience, drawing the correct conclusions, and continuously improving the quality of your product or service. However, we must distinguish between mistakes that are "useful" and those that harm our firm. The following are some common project management blunders and how to avoid them.

Insufficient Resources And/Or Skills

It's one of the most typical project blunders, and it can lead to some of the most devastating outcomes. The important thing is to involve the right people with the right abilities in the project in the proper quantities.

As a result, managers must evaluate the skill sets of every single team member (including various outsourcers and contractors, who are sometimes disregarded but often perform a significant portion of the actual work) to ensure that they are well suited to the specific responsibilities. Furthermore, a sufficient number of team members should be chosen.

Individually, the significance of hiring project managers is worth mentioning. Because these professionals will have a direct impact on the team's actions, they should be carefully chosen and prepared. Experienced project managers with dependable qualifications and great soft skills are always preferred. By the way, the latter ones would be quite valuable in dealing with the next regularly encountered issue.

Communication Breakdown

Project managers may be overconfident, ignoring documented issues and failing to pay heed to input from the team. This frequently leads to delays, financial overruns, and other negative consequences. Furthermore, when workers do not feel valued, they lose incentive to do a good job. Working in a group necessitates effective multifaceted communication and team management. PMs should be able to communicate with all members of the working group, including engineers, sponsors, and other stakeholders.

Faulty Estimation of Budget and Time

This is a common blunder made by both new and experienced project managers. This is due to the difficulty of making correct judgements in this field. We consider this aspect to be mission-critical, therefore we've written a separate article about it: Software development time estimation.

Notes

The ability to prioritise activities, divide large jobs into smaller ones, clearly identify who does what and when, and, of course, have a great understanding of all project goals are all vital skills that assist to smooth this difficulty. A bottom-up approach to budget planning is an excellent technique to avoid numerous problems with budget estimation.

Paying Little Attention to Project Management Schedule

It goes without saying that when people don't know when a task is due, a shambles ensues, as do delays. That is why it is critical to set up a well-oiled process that follows the precise timeline.

It's a good idea to list all of the project's activities (such as scoping, gathering requirements, coding, and testing) and assign due dates to each of them. Furthermore, project managers should not be afraid to use specialist software that aids in the avoidance of project schedule errors.

Considering Projects in Isolation

Projects don't happen in a vacuum. They are frequently intertwined with other ongoing or already finished product development processes. Being aware of these interdependencies allows you to save time and allocate the appropriate individuals to each assignment.

In addition, an attentive PM will find new methods to learn from each working circumstance he or she encounters. Following the completion of each project, a formal closure gathering should be held to reflect on what was accomplished. Documenting and storing all of the information learned allows you to draw the correct conclusions and prevent making costly mistakes in the future.

Lack of Global Thinking

It is insufficient to consider a project's goal. Each local aim should be in accordance with the company's overall objectives. Each project should provide value to the business and support the company's overall strategy.

It is critical for this to happen that higher management keeps their finger on the pulse of the ongoing work process and demonstrates faith in its members. The backing of the C-suite is required for team motivation and productive work.

According to folklore, smart folks learn from other people's mistakes, while fools learn from their own. Let us not be fools and learn how to design good project management without incurring significant losses. Whatever method you use to learn, keep in mind that you must be prepared to deal with a variety of challenges before your IT product is released into the wild.

5.4.2 Handling Errors during Project Handling

Making errors is an unavoidable aspect of the learning process. It is necessary for collecting experience, drawing the correct conclusions, and continuously improving the quality of your product or service. However, we must distinguish between mistakes that are "useful" and those that harm our firm. The following are some common project management blunders and how to avoid them.

Notes

1. Inadequate resources and/or expertise

   It's one of the most typical project blunders, and it can lead to some of the most devastating outcomes. The important thing is to involve the right people with the right abilities in the project in the proper quantities.

   As a result, managers must evaluate the skill sets of every single team member (including various outsourcers and contractors, who are sometimes disregarded but often perform a significant portion of the actual work) to ensure that they are well suited to the specific responsibilities. Furthermore, a sufficient number of team members should be chosen.

   Individually, the significance of hiring project managers is worth mentioning. Because these professionals will have a direct impact on the team's actions, they should be carefully chosen and prepared. Experienced project managers with dependable qualifications and great soft skills are always preferred. By the way, the latter ones would be quite valuable in dealing with the next regularly encountered issue.

2. A failure in communication

   Project managers may be overconfident, ignoring documented issues and failing to pay heed to input from the team. This frequently leads to delays, financial overruns, and other negative consequences. Furthermore, when workers do not feel valued, they lose incentive to do a good job.

   Working in a group necessitates effective multifaceted communication and team management. PMs should be able to communicate with all members of the working group, including engineers, sponsors, and other stakeholders.

3. Inaccurate budget and time estimates

   This is a common blunder made by both new and experienced project managers. This is due to the difficulty of making correct judgements in this field. We believe this element is so important that we've written a separate essay on it: Time Estimation in Software Development.

   The ability to prioritise activities, divide large jobs into smaller ones, clearly identify who does what and when, and, of course, have a great understanding of all project goals are all vital skills that assist to smooth this difficulty. A bottom-up approach to budget planning is an excellent technique to avoid numerous problems with budget estimation.

4. Not paying attention to the project management timeline

   It goes without saying that when people don't know when a task is due, a shambles ensues, as do delays. That is why it is critical to set up a well-oiled process that follows the precise timeline.

   It's a good idea to list all of the project's activities (such as scoping, gathering requirements, coding, and testing) and assign due dates to each of them. Furthermore, project managers should not be afraid to use specialist software that aids in the avoidance of project schedule errors. Our review of the most effective project management software can be found here.

5. Thinking on initiatives in solitude

   Projects don't happen in a vacuum. They are frequently intertwined with other ongoing or already finished product development processes. Being aware of these interdependencies allows you to save time and allocate the appropriate individuals to each assignment.

In addition, an attentive PM will find new methods to learn from each working circumstance he or she encounters. Following the completion of each project, a formal closure gathering should be held to reflect on what was accomplished. Documenting and storing all of the information learned allows you to draw the correct conclusions and prevent making costly mistakes in the future.

5.4.3 Quality Control through Minimising Errors during Project

Errors in industry, whether human or mechanical, result in product defects. Finally, the production quality is harmed, which has a negative impact on consumer satisfaction.

Error elimination is one of a company's main tasks if it wishes to meet its quality goals. This concept applies to the implementation of a QMS (Quality Management System). Only, in order to provide and maintain true efficiency, this structure must be truly tailored to the needs of the company. A single SMQ model could be ideal for one entity but incompatible with another.

All human and material components that potentially influence production quality and customer satisfaction are included in the QMS. It necessitates the active participation of agile employees and supervisors, as well as a forceful mentality and leadership. This system will not be useful until it is linked to system approach management, as well as process and factual systematic ways to better decision-making. Finally, focusing on the client and ensuring that supplier relationships are mutually beneficial completes the list of factors that influence the QMS's performance.

The Cause and Effect of Failure Analysis is an analytical technique (a paper test) for detecting predicted failure modes of a product or process and planning for their elimination using technology and people's expertise. To put it another way, FMEA is a set of actions designed to: Recognize and analyse the potential failure of a product or process, as well as its consequences.

Determine what activities could be taken to eliminate or reduce the likelihood of potential failures.

Keep track of what you're doing.

FMEA is a "pre-event" step that requires a collaborative effort to quickly and affordably address design and production adjustments.

Design FMEA, process FMEA, equipment FMEA, maintenance FMEA, concept FMEA, service FMEA, system FMEA, environmental FMEA, and others are examples of FMEAs. For all intents and purposes, however, all of the types can be grouped into one of two categories: design FMEA or process FMEA. Equipment, service, and environmental FMEA for example, are essentially slightly modified variants of process FMEA, while system FMEA combines design and process FMEA. As a result, the remainder of this chapter will mostly focus on design and process FMEA.

Design FMEA is a tool that aids in the design process by identifying known and foreseeable failure modes and then ranking failures according to their relative impact on

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the product. Implementing Design FMEA aids in the establishment of priorities based on expected failures and severity of those failures, as well as the detection of oversights, misjudgements, and errors. Additionally, design FMEA minimises manufacturing process development time and expense by eliminating numerous potential failure modes prior to process operation and providing the relevant tests to confirm the proposed product.

Process FMEA is used to detect probable process failure modes by evaluating failures and assisting in the prioritisation of failures based on their relative impact on internal and external customers. Implementing a process FMEA aids in the identification of potential manufacturing or assembly causes so that controls for occurrence reduction and detection may be established. Design and process FMEAs also document the outcomes of the design and manufacturing processes, respectively.

Summary

- Quantitative risk analysis is typically performed following qualitative risk analysis. Qualitative risk analysis is limited to individual projects. The risk analysis methodology used depends on the project and the time and money available.
- Simulation, which examines a system's expected behaviour or performance using a model, is a more complicated quantitative risk analysis technique. Most simulations use Monte Carlo analysis. For a statistical distribution of estimated findings, Monte Carlo analysis simulates the model's output multiple times.
- Many professions use sensitivity analysis to help make business decisions, such as determining break-even points based on multiple assumptions.
- Actions taken to achieve quality objectives for a project are commonly referred to as "quality assurance." Managing quality includes quality assurance, product design, and process improvement. Project documents and organisational process assets are all significant inputs for quality control.
- A quality audit is an important quality control technique. An audit can assist identify lessons learnt and enhance performance on current or future projects.
- Varying processes necessitate quality control. The materials, tools, machinery, labour, working circumstances, and operator skill can all produce variations. Some differences can be quickly addressed, while others cannot, and their causes are obscure. This reduces product performance and quality.
- Quality control reduces variation to match desired performance. Manufacturing processes are bound to evolve throughout time. Because variations can arise at any stage of production, quality control is both economical and scientific.
- A change control system defines when and how official project documents can be updated. It also states who is authorised to make changes, what paperwork is required, and whether automated or manual tracking mechanisms will be used.
- A change control system includes a change control board, configuration management, and change communication.
- Change Control Board is a formal committee of people entrusted with approving or rejecting project changes. A CCB's major responsibilities are to provide guidelines for developing, reviewing, and implementing change requests.

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- Configuration management ensures complete and accurate product descriptions. It involves determining and controlling product functionality and physical design, as well as supporting documentation.
- Configuration and change management tools can be used manually or automatically. Config control is concerned with the specification of both deliverables and procedures, whereas change control is concerned with tracking and recording changes to project papers, deliverables, and baselines.
- In a change control system, a responsible person reviews and approves changes before they are implemented. In addition to selecting whether to approve, deny, or postpone changes, the change control system often contains all processes that should be used.
- Stakeholders are a crucial component of the project management process. Projects are requested, approved, rejected, supported, and opposed by stakeholders.
- Stakeholders are those who are affected by or can affect a project in a positive or bad way. Some stakeholders may have limited influence over the project's work or outcomes, while others may have a significant impact on the project and its projected outcomes.
- Report performance is the collection and dissemination of performance data, such as status reports, progress measurements, and forecasts. In order to comprehend and communicate project progress and performance, as well as foresee project outcomes, performance reporting requires regular data collection and analysis.
- Errors during Project Handling: a) Insufficient resources and/or skills, b) Communication breakdown, c) Faulty estimation of budget, d) Paying little attention to project management schedule, e) Considering projects in isolation, f) Lack of global thinking

Glossary

- EVM: Expected Monetary Value
- PERT: Program Evaluation and Review Technique
- CCB: Change control Board
- PLC: Project Life Cycle
- PMI: Project Management Institute
- PMC: Project Management Control
- ARMA: Autoregressive Moving Average
- Change Requests: Change requests are frequently generated as a result of project performance analysis.
- Report Performance: The process of gathering and disseminating performance data, including as status reports, progress measurements, and forecasts, is known as report performance.
- Stakeholders: Stakeholders are a crucial component of the project management process.

Notes

- Information Distribution: The process of making relevant information available to project stakeholders as planned is known as information distribution.
- CCB: A change control board (CCB) is a formal group of individuals charged with approving or rejecting project changes.

Check Your Understanding

1. _ _ _ _ _ _uses a representation or model of a system to examine its expected behaviour or performance, is a more complex technique for quantitative risk analysis.
   a. Sensitive Analysis
   b. Simulation
   c. EMV
   d. None of the above
2. A _ _ _ _ _ _is a structured review of specific quality management activities that can help identify lessons learned and improve performance on current or future projects.
   a. Quality Audit
   b. Scheduling
   c. Simulation
   d. EMV
3. A _ _ _ _ _ _ _is a formal, documented procedure that outlines when and how official project documents can be modified.
   a. CCB
   b. Project Life Cycle
   c. Change Control System
   d. None of the above
4. A _ _ _ _ _ _ _is a formal group of individuals charged with approving or rejecting project changes.
   a. Change Control System
   b. Change Control Board (CCB)
   c. SDLC
   d. All of the above
5. The process of making relevant information available to project stakeholders as planned is known as_ _ _ _ _ _
   a. Information Distribution
   b. Information Gathering
   c. Project Distribution
   d. Information Handling
6. _ _ _ _ _ _are those who are affected by or can affect a project in a positive or bad way.

Notes

a. Client

b. Project Manager

c. HR

d. Stakeholders

7. The process of gathering and disseminating performance data, including as status reports, progress measurements, and forecasts, is known as_ _ _ _ _ _

a. Project Performance

b. Report Performance

c. Individual Performance

d. None of these

8. _ _ _ _ _ _ _ organise and summarise the data gathered, and show any analysis results in comparison to the performance measurement baseline.

a. Project Reports

b. Project Cost

c. Performance reports

d. All of the above

9. _ _ _ _ _ _guarantees that the project's product descriptions are accurate and thorough.

a. CCB

b. Configuration Management

c. Project Management

d. All of the above

10. _ _ _ _ _ _is the technique of estimating future project performance based on current results.

a. Communication Method

b. Reporting Systems

c. Variance Analysis

d. Forecasting

Exercise

1. Explain the Process of Performing Qualitative Risk Analysis.
2. What are the key Concepts of Quality Assurance and Control?
3. Define Introduction to Project Change Control.
4. Explain Different Tools for Project Change Control.
5. Discuss the importance of project risk management, quality management and change control management.
6. Define information distribution, managing stakeholders.

Notes

7. What are the methods of performance reporting?
8. What are the errors faced during project handling?
9. How to handle errors during project handling?
10. Explain quality control through minimizing errors during project.

Learning Activities

1 How can one assure quality control in project management?

2 Which methods are best for performance reporting?

Check Your Understanding - Answers

1	b	2	a	3	c
4	b	5	a	6	d
7	b	8	c	9	b
10	d				

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