Software Project Management

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Content

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Unit 01: Introduction to Software Project Management (SPM)

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Objectives

- learn about software projects and characteristics.
- understand Software Project Management (SPM) and know the activities in SPM.
- explore Software Project Management Plan (SPMP) to understand the methods and methodologies in SPM.
- investigate the problems with software projects.
- analyze the role of software project managers.

Introduction

A project is a sequence of unique, complex, and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification. A project is a well-defined task, which is a collection of several operations done in order to achieve a goal (for example, software development and delivery). A project is a group of tasks that need to be completed to reach a clear result. It defines a set of inputs and outputs which are required to achieve a goal.

Projects differ from other types of work (e.g., process, task, procedure). A project is defined as a specific, finite activity that produces a visible and measurable result under specific preset requirements. It attempts to implement desired change in an environment in a controlled way. By using projects, we can plan and do our activities. Example: Building a garage, running a marketing campaign, development of a website etc.

A project is a temporary, unique, and progressive attempt to produce a tangible or intangible result (a unique product, service, benefit, competitive advantage, etc.). Usually, it includes a series of interrelated tasks planned for execution over a fixed period and within specific requirements and limitations such as cost, quality, performance, etc. The projects can vary from simple to difficult and can be operated by one person or a hundred.

Projects are usually described and approved by a project manager or team executive. They go beyond their expectations and objects, and it's up to the team to handle logistics and complete the project on time. For good project development, some teams split the project into specific tasks so they can manage responsibility and utilize team strengths.

1.1 Key Characteristics of a Project

Project is an excellent opportunity for organizations and individuals to achieve their business and non-business objectives more efficiently through implementing change. The projects help us make desired changes in an organized manner and reduce the probability of failure. A project can be characterized as:

- Every project may have a unique and distinct goal.
- Project is not routine activity or day-to-day operations.
- Project comes with a start time and end time.
- Project ends when its goal is achieved hence it is a temporary phase in the lifetime of an organization.
- Project needs adequate resources in terms of time, manpower, finance, material and knowledge-bank.

Temporary: This fundamental characteristic means every project has a finite start and end. The start is when the project is initiated, and its concept is developed. The end is reached when all project objectives have been met (or unmet if it’s evident that the project cannot be completed– then it’s terminated).

Unique Deliverable(s): Any project aims to produce some deliverable(s) which can be a product, service, or another result. Deliverables should address a problem or need to be analyzed before the project start.

Progressive Elaboration: With the progress of a project, continuous investigation and improvement become available, allowing more accurate and comprehensive plans. This fundamental characteristic means that successive iterations of planning processes develop more effective solutions to progress and develop long-term projects.

1.2 Software Project

Software Project is the complete procedure of software development from requirement gathering to testing and maintenance, carried out according to the execution methodologies, in a specified period to achieve intended software product. Software project means the efforts undertaken to develop new software and related deliverables under the terms and conditions and in accordance with the schedule and at prices set forth.

Deliverables: Upon satisfactory completion of the work authorization, the engineer shall submit the deliverables as specified in the executed work authorization to the state for review and acceptance. While developing software, the purpose is to develop software to satisfy the needs of some users or clients.

Software project is one instance of this problem, and the development process is what is used to achieve this purpose. A process is a sequence of steps performed for a given purpose. Software projects can include:

- Application Development
- Process and Systems Re-Engineering
- System Integration
- Consulting Services
- Installation and Training

To manage a software project successfully, it's extremely important to make sure you are using the right project management software that suits your needs. Using the right tools means you get to cut out BS and focus on what matters: building products and creating value.

Given a software project, how do you approach it to ensure you have a great product? There are four main things you need to do to ensure you've got a great product:

Make sure that Your Product Actually Answers the Need of the People (Product–Market Fit): If your project is awesome, but it doesn't solve any problems, it's most probably going to fail. It's the biggest reason why Startups die a brutal death, so don't underestimate it.

Focus on the Core Features**:** It's easy to get lost in the design and nice–to–have features, what with all the possibilities modern technology gives us. But prioritize your core features and put all your efforts into ensuring they're top notch. The rest can be improved later on. So, for example, if you're creating an eCommerce site, make sure that payments work smoothly. If they don't, no number of cool visuals will save you.

Make it Easy to Use and Understand**:** The less the user has to think, the better. Everything has to be clear, intuitive, and quick to grasp, or else the users will get discouraged and switch to another software. Nowadays, nobody got time to read instructions or go through complex onboarding processes. You should also be able to summarize your project in one sentence, just like a movie pitch.

Test the Hell Out of it**:** Start testing your product as soon as possible and in many ways. It's best to involve professional Quality Assurance testers, but also stakeholders and— most importantly— the end–users. Take their feedback into heart, even if it hurts. Remember that in the end your product is made for these users, not for you (unless it's a personal project, of course).

1.3 Software Projects vs Other Types of Projects

Many techniques in general project management also apply to software project management, but some characteristics of software projects have been identified that make them particularly difficult: -

- Invisibility: When a physical artifact such as a bridge is constructed the progress can be seen. with software, progress is not immediately visible. Software project management can be the process of making the invisible visible.
- Complexity: Per dollar, pound or euro spent, software products contain more complexity than other engineered artifacts.
- Conformity: The 'traditional' engineer usually works with physical systems and materials like cement and steel. These physical systems have complexity but are governed by consistent physical laws. Software developers must conform to the requirement of human clients. It is not just that individuals can be inconsistent. Organizations, because of lapses in collective memory, in internal communication or in effective decision making, can exhibit remarkable, 'organizational stupidity'.

- Flexibility: That software is easy to change is seen as a strength. However, where the software system interfaces with a physical or organizational system, it is accommodated with the other components rather than vice versa. Thus, the software systems are particularly subject to change.

1.4 Software Project Management

The tasks of an IT company engaged in software development can be seen split in two parts:

1. Software creation
2. Software project management

SPM is a process of managing, allocating and timing resources to develop computer software that meets necessities. SPM is an art and discipline of planning and supervising software projects. Software projects are planned, implemented, monitored, and controlled.

It is a procedure of managing, allocating and timing resources to develop computer software that fulfills requirements. SPM covers everything from gathering client requirements to developing, testing, documenting, and delivering your software on time. SPM is a subset of traditional project management that helps you plan, execute, track, control, and complete software projects. SPM covers everything from gathering client requirements to developing, testing, documenting, and delivering your software on time. SPM is a subset of traditional project management that helps you plan, execute, track, control, and complete software projects.

Usually, managing projects in software development involves:

- Gathering client requirements
- Building software products
- Testing their functionalities & usability
- Preparing documentation
- Making product modifications based on customer input
- and more….

SPM defines the methods and regulation used to define goals, plan and monitor tasks and resources, identify and resolve issues, and control costs and budgets for a specific project is known as project management. Software Project Management (SPM) includes the tools, techniques, and knowledge essential to deal with the growth of software products.

1.5 Software Engineering vs Software Project Management

Software Engineering is:

- Designing the software architecture
- Designing the software
- Converting complex logic/algorithm to code
- Testing and debugging software

SPM is the process of overseeing and coordinating software development projects. This includes everything from planning and budgeting to development and testing. In order to be successful, software project managers must have a strong understanding of the software development process and be able to communicate with all members of the development team effectively. SPM is:

- Understanding software requirements and converting that to project requirements.
- Preparing plans to accomplish the work that needs to be done to meet those requirements.
- Estimating cost, effort, duration, resources required for the project.
- Managing all the above aspects to take the project to conclusion.

Need for Software Project Management

Software is said to be an intangible product. Software development is a kind of all new stream in world business and there's very little experience in building software products. Most software products are tailor made to fit client's requirements. The most important is that the underlying technology changes and advances so frequently and rapidly that experience of one product may not be applied to the other one. All such business and environmental constraints bring risk in software development hence it is essential to manage software projects efficiently.

Such type of business and environmental constraints increase risk in software development hence it is essential to manage software projects efficiently. It is necessary for an organization to deliver quality products, keep the cost within the client's budget constrain and deliver the project as per schedule. Hence in order, software project management is necessary to incorporate user requirements along with budget and time constraints.

It is an essential part of the software organization to deliver a quality product, keeping the cost within the client's budget and deliver the project as per schedule. There are various factors, both external and internal, which may impact this triple factor. Any of three-factor can severely affect the other two.

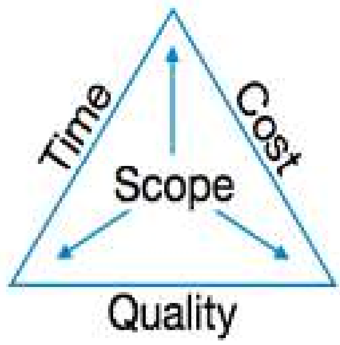


Figure 1: Triple Constraints for Software Projects

The image in Figure 1 above shows triple constraints for software projects. It is an essential part of software organization to deliver quality product, keeping the cost within client's budget constrain and deliver the project as per scheduled. There are several factors, both internal and external, which may impact this triple constrain triangle. Any of three factors can severely impact the other two. Therefore, software project management is essential to incorporate user requirements along with budget and time constraints.

SPM enables you to:

- Create a clear blueprint for software project execution.
- Maximize the utilization of available project resources.
- Improve team collaboration and communication.
- Track, monitor, and control project progress.
- Deliver completed software solutions on time.
- Ensure that software development efforts stay within budget.
- Perform better stakeholder management.
- Provide better customer satisfaction.

SPM has some focus areas it can tackle, and the broad upsides included are:

Planning**:** The software project manager lays out the complete project's blueprint. The project plan will outline the scope, resources, timelines, techniques, strategy, communication, testing, and maintenance steps. SPM can aid greatly here.

Leading**:** A software project manager brings together and leads a team of engineers, strategists, programmers, designers, and data scientists. Leading a team necessitates exceptional communication, interpersonal, and leadership abilities. One can only hope to do this effectively if one sticks with the core SPM principles.

Execution**:** SPM comes to the rescue here also as the person in charge of software projects (if well versed with SPM/Agile methodologies) will ensure that each stage of the project is completed successfully. measuring progress, monitoring to check how teams function, and generating status reports are all part of this process.

Time management**:** Abiding by a timeline is crucial to completing deliverables successfully. This is especially difficult when managing software projects because changes to the original project charter are unavoidable over time. To assure progress in the face of blockages or changes, software project managers ought to be specialists in managing risk and emergency preparedness. The risk mitigation and management is one of the core tents of the philosophy of SPM.

Budget**:** Software project managers, like conventional project managers, are responsible for generating a project budget and adhering to it as closely as feasible, regulating spending and reassigning funds as needed. SPM teaches us how to effectively manage the monetary aspect of projects to avoid running into a financial crunch later on in the project.

Maintenanc**e:** Software project management emphasizes continuous product testing to find and repair defects early, tailor the end product to the needs of the client and keep the project on track. The software project manager makes ensuring that the product is thoroughly tested, analyzed, and adjusted as needed.

1.6 Activities in Software Project Management

There are several activities involved in Software Project Management including:

- Project Planning and Tracking **-** The development process of a software project can be broadly divided into two distinct phases: the planning phase and the execution phase. In the planning phase, all the necessary tasks are identified and scheduled. The development team then works on completing these tasks in the execution phase. It is important to track the progress of analysis phases of programming to ensure that the project is on track. Tracking allows managers to see where the project stands in progress and identify potential issues. There are a variety of tools that can be used for tracking, such as Gantt charts and project management software.
- Project Resource Management **-** To successfully manage a software development project, it is important to have a clear understanding of the required resources. This includes both human and material resources. Human resources include the development team, as well as any other individuals who are involved in the project. The material resources include things like computers, software, and office supplies. It is important to have a clear understanding of what resources are required to avoid any potential issues.
- Scope Management**:** One of the most important aspects of project management is scope management. This is the process of ensuring that all the work required to complete the project is included in the scope. There are a variety of tools that can be used to help with scope management, such as project templates and WBS (work breakdown structure) charts.
- Estimation Management**:** Estimation is the process of determining how long a project will take to complete and how much it will cost. This is an important part of project management, as it allows managers to set realistic expectations for the project. A variety of tools can be used for estimation, such as historical data and bottom-up analysis. It is also important to have a clear understanding of the development process to make accurate estimates.
- Project Risk Management**:** Risk management is the process of identifying and assessing risks that could potentially impact the project. This includes things like schedule delays, cost overruns, and scope creep. There are a variety of tools that can be used to help with risk management, such as risk registers and SWOT analysis.
- Scheduling Management**:** Scheduling is the process of creating a schedule for the project. This includes things like identifying when each task will be completed and who will be responsible for completing it. Scheduling is an important part of project management, as it allows

managers to ensure that the project is on track. There are a variety of tools that can be used for scheduling, such as Gantt charts and project management software.

- Project Communication Management: Communication is a key part of project management. This includes things like sending updates to stakeholders, as well as communicating changes to the development team. There are a variety of tools that can be used to help with communication, such as project management software and email. It is also important to have a clear understanding of all the software development stages to communicate with stakeholders effectively.
- Configuration Management: Configuration management is the process of managing the development team's work. This includes things like keeping track of code changes and managing development tools. Configuration management is an important part of project management, as it allows managers to keep track of the project's progress.

  A variety of tools can be used for configuration management, such as version control software and development platforms. It is also important to have a clear understanding of the development process to manage the development team's work effectively.

Sub-activities in Software Project Management

SPM consists of eight tasks:

- Problem identification
- Problem definition
- Project planning
- Project organization
- Resource allocation
- Project scheduling
- Tracking, reporting and controlling
- Project termination

In problem identification and definition, the conclusions are made as approving, declining or prioritizing projects. In problem identification, the project is recognized, defined and justified. In problem definition, the use of the project is clarified. The main product is project proposal.

In project planning, it explains a series of actions or steps that are needed to for the growth of work product.

In project organization, the functions of the personnel are incorporated. It is done in corresponding with project planning.

In resource allocation, the resources are allocated to a project in order that the goals and objectives are attained.

In project scheduling, resources are allocated so that project objectives are attained within a sensible time span.

In tracking, reporting and controlling, the process engage whether the project results are in accordance with project plans and performance specification. In controlling, suitable action is taken to correct improper deviations.

In project termination, the concluding report is submitted, or a release order is signed.

Different Types of Management in SPM

Conflict Management: Conflict management is the process to restrict the negative features of conflict while increasing the positive features of conflict. The goal of conflict management is to improve learning and group results including efficacy or performance in an organizational setting. Properly managed conflict can enhance group results.

Risk Management: Risk management is the analysis and identification of risks that is followed by synchronized and economical implementation of resources to minimize, operate and control the possibility or effect of unfortunate events or to maximize the realization of opportunities.

Requirement Management: It is the process of analyzing, prioritizing, tracking, and documenting requirements and then supervising change and communicating to pertinent stakeholders. It is a continuous process during a project.

Change Management: Change management is a systematic approach for dealing with the transition or transformation of an organization's goals, processes, or technologies. The purpose of change management is to execute strategies for effecting change, controlling change, and helping people to adapt to change.

Software Configuration Management: Software configuration management is the process of controlling and tracking changes in the software, part of the larger cross-disciplinary field of configuration management. Software configuration management includes revision control and the inauguration of baselines.

Release Management: Release Management is the task of planning, controlling, and scheduling the build-in deploying releases. Release management ensures that the organization delivers new and enhanced services required by the customer while protecting the integrity of existing services.

1.7 Downsides of Software Project Management

SPM has several drawbacks, including resource loss, scheduling difficulty, data protection concerns, and interpersonal conflicts between Developers/Engineers/Stakeholders. Furthermore, outsourcing work or recruiting additional personnel to complete the project may result in hefty costs for one's company. Numerous issues can develop if a software project manager lacks the necessary expertise or knowledge.

- Costs are High: Consider spending money on various kinds of project management tools, software, & services if one engages in SPM strategies. These initiatives can be expensive and time-consuming to put in place. Because your team will be using them as well, they may require training. One may need to recruit subject matter experts or specialists to assist with a project, depending on the circumstances. Stakeholders will frequently press for the inclusion of features that were not originally envisioned. All these factors can quickly drive up a project's cost.
- Complexity will be Increased: SPM is a multi-stage, complex process. Unfortunately, some specialists might have a propensity to overcomplicate everything, which can lead to confusion among teams and lead to delays in project completion. They may also become dogmatic and specific in their ideas, resulting in a difficult work atmosphere. Projects having a larger scope are typically more arduous to complete, especially if there isn't a dedicated team committed completely to the project. Members of cross-functional teams may lag far behind their daily tasks, adding to the overall complexity of the project being worked on.
- Overhead in Communication: Recruits enter your organization when we hire SPM personnel. This provides a steady flow of communication that may or may not match a company's culture. As a result, it is advised that you maintain your crew as small as feasible. The communication overhead tends to skyrocket when a team becomes large enough. When a large team is needed for a project, it's critical to identify software project managers who can conduct effective communication with a variety of people.
- Little or no Space for Creativity: Team leaders either place an excessive amount of emphasis on management processes or impose hard deadlines on their employees, requiring them to develop and operate code within stringent guidelines. This can stifle innovative thought and innovation that could be beneficial to the project. When it comes to SPM, knowing when to encourage creativity and when to stick to the project plan is crucial. Without SPM personnel,

an organization can perhaps build and ship code more quickly. However, employing a trained specialist to handle these areas, on the other hand, can open new doors and help the organization achieve its objectives more quickly and more thoroughly.

1.8 Software Project Management Plan (SPMP)

Project management refers to the process of applying skills, knowledge, techniques, and tools to project activities to fulfill the requirements of the project. It is usually broken down into project management phases, including project initiation, project planning, project execution, project monitoring, and project closure.

Software Project Management Plan (SPMP) is a document that outlines the expectations of those working on the project. Just like a regular project management plan, it addresses the scope, business objectives, schedule, stakeholders, and budget for the project.

However, the difference between the SPMP and other project plans is that the SPMP is directed specifically at software development and its life-cycle, and the specific players that are part of this life-cycle.

Software Project Management Plan (SPMP) gives an overview of the purpose, scope, and objectives of the project. It also contains sections regarding the assumptions and constraints, the project deliverables, the summary of the schedule, and the plan for change in the SPMP. Once project designing is complete, project managers document their plans during a software package project management set up (SPMP) document.

SPMP document ought to discuss an inventory of various things. The list is used as a doable organization of the SPMP document. SPMP typically has many stakeholders, just as a regular project would. A stakeholder is anyone who has some type of interest in your project, such as employees, customers, vendors, community members, etc. However, there are a few key players in the SPMP stakeholder group that one must understand as their definitions outside of the software world may be different.

There are typical stakeholders' roles as discussed below:

Stakeholder	**Description**
Business Analyst/Systems Analyst	The role of this analyst is to gather requirements from the client who is requesting new software or improvements to existing software. They need to be experts in their field to ensure that what the customer is asking for can actually be created. These analysts work closely with the software architects to ensure requirements are clear and reasonable.
Software Architects	Many times, we think of architecture as it relates to a physical building. In software, an architect's responsibility relates to creating code, planning design features, and identifying the specifications for the project. Just like building architects, software architects also create blueprints and models; however, their documents relate to the designs of software and applications.
Software Developers	A software developer is responsible for taking the blueprints and models provided by the software architect and using specific program languages (e.g., python, java) to create the programs that implement the software design or application.
Software Testers	A software tester is responsible for reviewing the work done by the developers to ensure that it meets the requirements that were agreed upon between the analyst and the client. They typically review each requirement, ensure that a requested feature exists in the software or application developed, and then ensure any business rules that relate to this feature are programmed into the system correctly.

Stakeholders	A stakeholder in a software project can be anyone who has an interest in the project and who may be affected by the outcomes of the project. For example, if the software project involves choosing a new vendor both the old and new potential vendors would be stakeholders. The old vendor will need to remove their products and do their own close-out for the software or application, and the new vendor will need to install their products and manage maintenance.

It is important to note that in many cases, software projects have people working on the project team from different companies. For example, an organization may have a software project management team made of different employees located in different countries (they subcontract jobs depending on the specialty needed) and multiple vendors (one who is responsible for the code using specialized COBOL programming for Legacy systems, one who is responsible for coding Python for the new system, etc). It is not typical for everyone working on the project to work for the same company, that is actually a rare case.

Software projects can be very complex and having a SPMP is essential. According to the Project Management Body of Knowledge (PMBOK) a project management plan (PMP) provides standards for managing projects, such as documenting the planning assumptions and decisions that the group makes. Using the PMP style of PMBOK, provides control over a project, which is essential for it to be successful.

According to the Project Management Body of Knowledge (PMBOK), a project management plan is a formal, approved document used to guide both project execution and project control. There are nine areas of focus for the SPMP structure. The 9 subsidiary management and knowledge areas of focus include: Integration Management, Scope Management, Schedule Management, Quality Management, Resources Management, Communications Management, Risk Management, Procurement Management, and Stakeholders Management.

- Integration management: This is the phase in the project solidifies. Components within the project are joined together. In this phase, the charter and management plan are developed. Project knowledge, project work, and change control are part of this area. Finally, the project close phase belongs in this component of project management. It involves developing the charter and project plan, managing, controlling and monitoring work, and ending the project.
- Scope management: In this area, the scope outlines the approved work breakdown structure and describes how any changes to it will be handled. The scope is defined, validated, and controlled. Not only is the scope planned out, but requirements are gathered, and a work breakdown structure is created. This is an organized hierarchy that outlines the project and divides it into workable chunks. It ensures that the scope is clearly defined and controlled and managing the collection of requirements from stakeholders.
- Schedule or time management: In the schedule management area, we define how the details of the work plan will be updated to show progress on a regular recurring basis. Here, the sequence of activities and their duration are outlined. The schedule is then developed and managed. It involves managing and controlling the scheduled timelines, defining the different tasks that need accomplished (and their sequence), and understanding estimation.
- Quality management: It isn't enough to deliver a project on time and on budget. Just slamming something in will result in serious issues down the line. Thus, there is a need for quality management in projects. The purpose of quality management is to plan, manage, and control quality throughout the project life cycle. It includes managing quality through different quality assurance techniques and how to stay in control of the quality.
- Resources management: It might seem like costs and resources should be equal. However, they are vastly different. In this area, the goal is to estimate resource needs, acquire resources (people, money, knowledge, equipment, etc.), and manage the project team. It involves managing and obtaining the resources for the project in order to maximize effectiveness.

- Communications management: It focuses on the methods and frequency of project communications to the different stakeholder groups. This includes managing, monitoring, and planning team and organizational communications. It handles providing explanations of how to effectively communicate with different stakeholders.
- Risk management: Identifying risks and how to plan and respond to them.
- Procurement management: Managing the procurement (contracting) process.
- Stakeholders' management: Identifying the different types of stakeholders and managing and ensuring engagement.
- Cost Management Plan: No project is without expense. This knowledge area explains what measures will be in place to create a budged, monitor and control costs, and find areas where costs can be reduced or eliminated.

Software Project Management Plan (SPMP) Document Structure

Organization of the software package Project Management set up (SPMP) document.

1. Introduction:
- Objectives
- Major Functions
- Performance Issues
- Management and Technical Constraints
2. Project Estimates:
- Historical Data Used
- Estimation Techniques Used
- Effort, Resource, Cost, and Project Duration Estimates
3. Schedule:
- Work Breakdown Structure
- Task Network Representation
- Gantt Chart Representation
- PERT Chart Representation
4. Project Resources:
- People
- Hardware and Software
- Special Resources
5. Staff Organization:
- Team Structure
- Management Reporting
6. Risk Management Plan:
- Risk Analysis
- Risk Identification
- Risk Estimation
- Risk Abatement Procedures
7. Project Tracking and Control Plan
8. Miscellaneous Plans:
- Process Tailoring
- Quality Assurance Plan

- Configuration Management Plan
- Validation and Verification
- System Testing Plan
- Delivery, Installation, and Maintenance Plan

1.9 Methods and Methodologies in SPM

The Merriam-Webster Dictionary defines 'methodology' as "a body of methods, rules, and postulates employed by a discipline" or "a particular procedure or set of procedures." In the field of project management, this would be a set of rules and processes that define how you manage a project.

The project management methodology is a set of principles and practices that guide you in organizing your projects to ensure their optimum performance. Basically, it's a framework that helps you to manage your project in the best way possible. The project management is so important to organizations and teams, but in order for it to be really effective, you need to make sure you're correctly mapping your project management methodology to your team type, project, organization, and goals.

In this section, we emphasize a number of commonly used software development methodologies. We consider both thick and thin (also called 'lightweight') methodologies. The thick methodologies we consider are RUP, SSADM and PRINCE2. XP, SCRUM and Crystal Clear are measured as thin methodologies. When discussing each methodology, we will focus on the management and business features of the methodology.

Methodologies in SPM

Rational Unified Process (RUP)

It is a software design methodology formed by the Rational Software Company. The Rational Software Company was obtained by IBM in 2003. RUP is a thick methodology; the entire software design process is explained with high detail. RUP is hence particularly applicable on larger software projects. The RUP methodology is common enough to be used out of the box, but the modular nature of RUP-it is designed and documented utilizing Unified Modeling Language (UML)–also makes it easy to adapt the methodology to the particular needs of a single project or company. One of the main differences between RUP and other methodologies like SSADM is that RUP doesn't use a waterfall approach for software development. The phases of requirements, analysis, design, implementation, integration and testing are not done in strict sequence. In RUP, an iterative approach is used: a software product is designed and built in a series of incremental iterations. Figure 2 shows one iteration of a RUP project in a graphical way.

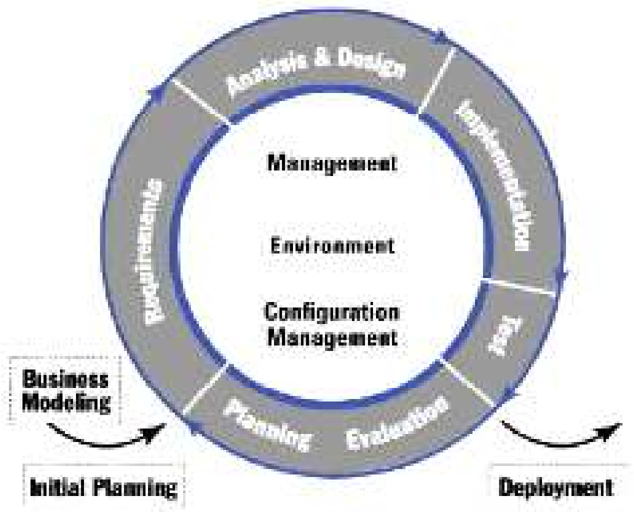


Figure 2: Iterative Approach to Software Development

Advantages

- The iterative approach leads to higher effectiveness. Testing takes place in each iteration, not just at the end of the project life cycle. This way, problems are noticed earlier, and are therefore easier and cheaper to determine. When using a waterfall approach, it can happen that, for example, software programmers must wait for the completion of the design phase before starting to implement and integrate the design. Designing and building a software project with an iterative approach resolves this problem. Integration and implementation will not only happen at the end of the project, but in every iteration. This saves time, as more team members can work more of the time.
- Managing changes in software requirements will be made simpler by using RUP. If a software project is very small, it is nearly unfeasible to define all the software requirements at the beginning of a project. It will almost always take more than one step to know what the final software product will look like, for the customer as well as for the project members. Developing with iterations makes this process of changing, requirements, that often leads to missed schedules and disappointed customers, less troublesome.
- RUP itself is software, too, and is dispersed in an electronic and online form. Team members don't need to leave their computers for RUP related activities. No more searching in big, dusty books. All facts about the software development methodology is available at the project members' fingertips. Also, the newest version of RUP is always present on the computer of each team member. And even more significant, it makes sure that every team member is using the same version of RUP. RUP is designed and documented using UML, in an object-oriented way. This makes it easy to adapt RUP to the special needs of a single project or organization.

Application Area- Due to the modular nature of RUP, it can be employed for all sorts of software projects. It is even possible to use RUP for non-software projects. Though, because of the complexity of the RUP methodology, it is used mostly for larger software projects.

SSADM

Structured Systems Analysis and Design Methodology (SSADM) is an extensively used computer application development method in the UK. Just like PRINCE, its use is often specified as a requirement for government computing projects. Today, it is more and more being adopted by the public sector in Europe.

"SSADM has been employed by the government in computing since its launch in 1981. It was commissioned by the Central Computing and Telecommunications Agency (CCTA) in a proposal to normalize the many and varied IT projects being developed across government departments. The CCTA examined a number of approaches before accepting a tender from Learmonth & Burchett Management Systems to develop a method."

Since 1981 SSADM has been further urbanized and refined and in 1990 version 4 of it was launched. SSADM is an open standard, which means that it is freely obtainable for use in industry and many companies offer support, training and Computer Aided Software Engineering (CASE) tools for it. In detail, SSADM sets out a cascade or waterfall view of systems development, in which there are a series of steps, each of which leads to the next step (Figure 3).

SSADM's steps are:

Feasibility Study**:** The feasibility study comprises of one single stage, which involves conducting a high-level analysis of a business area to decide whether a system can cost effectively support the business requirements. In the Feasibility Study an overview Data Flow Diagram (DFD) is produced together with a high-level Logical Data Structure (LDS). At this phase, the DFD will represent the existing system and the LDS may be incomplete and contain unresolved many-to-many relationships.

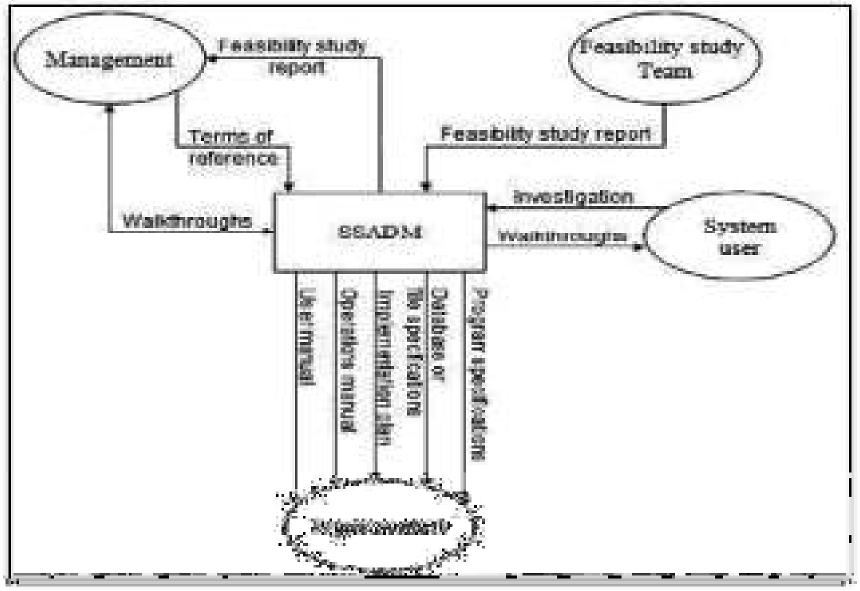


Figure 3: SSADM Process Model

Requirements Analysis:

- Investigation of the current environment: All through this stage the systems requirements are identified, and the present business environment is modeled in terms of the processes carried out and the data structures involved. In this DFDs and LDSs are used to produce detailed logical models of the current system.
- Business Systems Options (BSO): All through this stage up to six business system options are produced and presented. As a result, one of these options is adopted and polished. DFDs and LDSs are produced to support each business system option and the last chosen option. The transition from the former stage to this stage is a key part of SSADM: this is where we move from a logical model of the current system to a logical model of the required system. This means that here the DFDs and LDSs must be refined to cater to new or changed requirements.

Requirements Specification**:** The Requirements Specification comprises of a single stage which involves further developing the work carried out in the Requirements Analysis: detailed functional and non-functional requirements are recognized, and new techniques are introduced to define the required processing and data structures.

Logical System Specification:

- Technical system options: In this phase up to six technical options (specifying the development and implementation environments) are formed, one being selected.
- Logical design: In this phase the logical design of update and enquiry processing and system dialogues (menus, etc.) is carried out.

Physical Design**:** The physical design contains of a single stage in which the logical system specification and technical system specification is employed to create a physical database design and a set of program specifications.

SSADM revolves around the use of three key techniques:

1. Logical Data Modelling (LDM): This is the procedure of identifying, modelling and documenting the data requirements of a business information system. A LDM consists of a LDS and the associated documentation. LDSs represent Entities (things about which a business needs to record information) and Relationships (necessary associations between entities).

2. Data Flow Modelling (DFM): This is the procedure of identifying, modeling, and documenting how data flows around a business information system. A Data Flow Model consists of a set of

integrated DFDs supported by suitable documentation. DFDs represent processes (activities which transform data from one form to another), data stores (holding areas for data), external entities (things which send data into a system or receive data from a system) and finally data flows (routes by which data can flow).

3. Entity/Event Modelling (EM): This is the procedure of identifying, modeling, and documenting the business events which influence each entity and the sequence in which these events occur. An EM consists of a set of Entity Life Histories (ELHs) (one for each entity) and appropriate supporting documentation.

Advantages

SSADM is an open standard, which means that it is freely available for use in industry and many companies offer support, training and CASE tools for it. SSADM separates an application development project into modules, stages, steps, and tasks, and offers a framework for describing projects in a fashion suited to managing the project.

SSADM's objectives are to:

- Advance project management and control.
- Make more effectual use of experienced and inexperienced development staff.
- Develop improved quality systems.
- Make projects flexible to the loss of staff.
- Allow projects to be supported by computer-based tools such as computer aided software engineering systems.
- Create a framework for good communications between participants in a project.
- SSADM can decrease the chances of initial requirements being misunderstood and of the systems functionality straying from the requirements using inadequate analysis and design techniques.

Application Area: SSADM was initially developed to standardize the many and varied IT projects being developed across government departments. Nowadays, SSADM Version 4 can be used in all kinds of analysis and design stages of system development. SSADM can be used for practically any size of project: small (1–2 persons, less than one man year), medium (4–10 persons, 1–20-man years) and large projects. In addition, SSADM can be used to develop new projects, but it can also be used to maintain the existing systems.

PRINCE2

Projects in Controlled Environments (PRINCE) are a project management technique covering the organization, management, and control of projects. A project has an apparent beginning, middle and end, a understandable organizational structure and defined objectives. You can use a managing methodology like PRINCE to ensure that a project is successful, which means that it finishes on time, within budget and offers the customer with what they have asked for. PRINCE was first urbanized by the CCTA, which is now part of the Office of Government Commerce (OGC), in 1989 as a UK Government standard for IT project management. Because its introduction, PRINCE has become widely used in both the public and private sectors and is now the de facto standard for project management in the UK. Although PRINCE was originally developed for the needs of IT projects, the methodology has also been used on many non-IT projects. The latest version of the methodology, PRINCE2, is designed to include the requirements of existing users and to enhance the methodology towards a generic, best practice approach for the management of all types of projects.

PRINCE2 is a process-based approach for project management providing a simply tailored and scalable methodology for the management of all types of projects. Each process is described with its key inputs and outputs together with the specific objectives to be achieved and activities to be carried out. The methodology describes how a project is divided into manageable stages enabling efficient control of resources and usual progress monitoring throughout the project.

The various roles and responsibilities for managing a project are completely described and are adaptable to suit the size and complexity of the project, and the skills of the organization. PRINCE2 summarize eight processes that are required to effectively carry out a project. These are:

1. Starting up a Project: To be confident about the project has a very clear beginning, this process occurs even before the project has really started. All decision-making persons have to come together and will appoint a Project Manager. Together they will discuss the project and outline reasons for it and how decide how the project is to be carried out. All this information will be put together in a 'Project Brief'.
2. Initiating a Project: Before a project can be permitted during the 'Directing a Project' process it must be carefully planned to ensure that it meets its objectives. Detailed estimations of costs needed time and other resources have to be made and these are put together by the Project Manager into a so-called Project Initiation Document (PID) for approval by the Project Board (PB).
3. Directing a Project: After the Project Brief and the PID have been put together, the project has to be permitted by a group of senior managers, called the Project Board (PB). During the rest of the project this PB has the in general responsibility for the success of the project whereas the Project Manager has the day-to-day accountability. He will inform the PB about the project's progress with the help of regular reports.
4. Controlling a Stage: One of the advantages of PRINCE2 is that projects are separated into manageable stages to make sure the project remains manageable and controlled. How many stages are used, will depend on the size of the project and the level of risk. In PRINCE2 each project stage must be completed before the next stage can be started and each new stage is planned in the stage preceding it. Also, the stage plans will be approved by the PB to help ensure that the project remains within budget and delivers its objectives.
5. Managing Stage Boundaries: This process engages preparing for the next stage and Notes reviewing the current stage. The Project Manager makes suggestions to the PB about the likelihood of the project achieving its business objectives and any changes in the business case, project plan, risks, and issues. When a project has clear stage boundaries it can be simply controlled and managed by permitting the project to continue only once the PB is satisfied with the current stage end and next stage plan.
6. Planning: Each project plan, stage plan and team plan must believe key planning aspects. These include what products to produce, the activities required to produce these products, estimated resources (including costs and time), scheduling the activities, and analyzing risks. By following the PRINCE2 planning process all these points are conducted in a sensible, logical sequence. Ensuring consistency enables plans to be compared and streamlines the planning process.
7. Managing Product Delivery: The objective of a PRINCE2 project is to deliver products. A product can be a physical thing such as a poster or it could be an intangible deliverable such as a service or sales agreement. In fact, everything produced in PRINCE2 (even a document) is called a product. Often a Project Manager does not create the product. A third-party supplier and/or their colleagues may do some or all of the work. It is the Project Manager's responsibility to ensure that the supplier produces the correct products at the right time by providing a description of the work to be done.
8. Closing a Project: At the end of the project, after its products have been delivered, the project is closed with approval of the PB. The Project Manager plans what will be done to assess the project's outcome, which is called the Post Project Review (PPR). A controlled close down is in effect the last provable PRINCE2 project action. Any lessons learned are recorded, resources are released, and the Post Project Review Plan (PPRP) is created.

Advantages

Besides the key idea of PRINCE2, there are some other advantages of the use of PRINCE2:

PRINCE2 is a structured methodology as long as organizations with a standard approach to the management of projects. The methodology embodies proven and established best practice in project management. It is widely recognized and unstated, and so provides a common language for all participants in the project, also PRINCE2 is very useful for educative use. PRINCE2 enables projects to have:

- A controlled and planned start, middle and end
- Usual reviews of progress against plan and against the Business Case
- Flexible decision points
- Automatic management control of any deviations from the plan
- The involvement of management and stakeholders at the right time and place during
- the project
- Good communication channels between the project, project management, and the rest of the organization.

eXtreme Programming (XP)

XP is a software engineering technique that has been formulated in 1996 by Kent Beck. XP has received fair media attention, and is most renowned for its practices that are sometimes regarded as contentious, such as pair programming and test-driven development.

Principles of XP

XP aims to decrease the risk involved in software development. In particular, it aims to reduce the cost of delaying design decisions. In XP, Beck gives a treatment of the cost and revenues of design decisions and aspect implements (which he calls 'options'), and he concludes that it is more beneficial to delay options of which it is uncertain whether they will generate revenue (that is. there is a certain amount of risk involved in implementing the option).

Usually, the cost of making decisions about (and therefore changes to) a software project would rise exponentially during development. It would therefore be costly to defer options, because implementing them later on might be too costly, and perhaps even cost more than the value of the option would be. XP decreases the cost of making modifications later on during development, and thereby allows decisions that entail high risk to be deferred until a sound judgment can be made on them.

Advantages

- An XP project is very impressionable. A usable product can be released very quickly, at which point the business can already take advantage of the product, and the product can and will be improved continually after that, with feedback that stems from live use.
- Especially when the project is exploratory for the customer as well, having feedback from live use and adapting to changing minds, wishes and circumstances can be invaluable.
- Additionally, the process is very clear. Progress, position and direction of the project are very transparent, which will make management happy as well.

Application Area- XP is a frivolous methodology for small-to-medium-sized teams developing software in the face of vague or rapidly changing requirements. XP is a good choice when requirements are unclear (which might occur when because himself does not know precisely what he wants), or prone to change (because of changing business situations, or as a result of external conditions). Because in XP the development of a product is divided into many small cycles, and each cycle is planned separately, changes to the planning can be made constantly, rapidly and easily. Team size is an issue when implementing XP. XP is meant for small-to-medium sized teams. In practice, this means that teams should be maximum ten people. A few more is probably okay, but twenty is too many.

Scrum

Scrum is an agile technique for project management, in use since at least 1990. It has been called a "hyper-productivity tool" and has been documented to considerably improve productivity in teams previously paralyzed by heavier methodologies-quickly producing results where there had been little or none. Scrum uses the following concepts:

- Sprint: A period of 30 days or less where a set of work will be executed to create a deliverable.
- Backlog: All work to be performed in the predictable future, both well-defined and requiring further definition.
- Sprint backlog: The work that should be done through the current sprint.
- Product backlog: The work that should be done for the entire product as desired by the customer.
- Scrum: A daily meeting at which progress and obstruction to progress are reviewed. Scrum is an iterative, incremental process for developing a product. The dissimilar iterations are shown in Figure 4 .

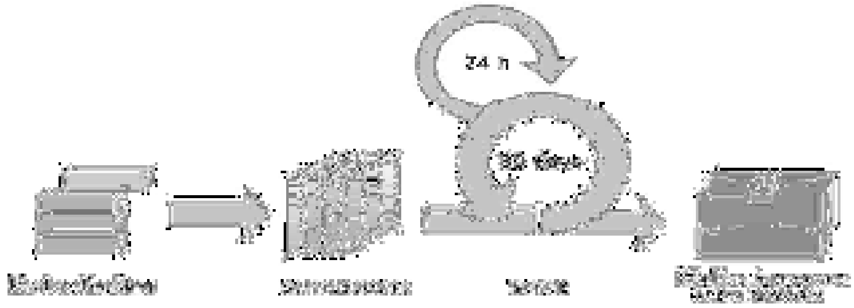


Figure 4: Scrum Work Flow

Advantages

- During a Scrum sprint there are no turbulence from the outside; this keeps the team focused and creative. Which is very good for the productivity?
- At the end of each sprint, what has been done and what should be done in the next sprint can be evaluated. This keeps the process very supple.

Application Area- Tentatively, Scrum can always be applied when a group of people should work together to archive a common goal. It has even been used as a project management approach, in a so called "Scrum of Scrums". Of course, to work correctly the teams should be small, but this can be solved by dividing projects into sub-teams. In the ideal situation all team members should be at the same location for optimal communications among the members. But when this is not the case the Scrum meetings is held as a teleconference.

Crystal Clear

Crystal Clear is a highly optimized way to use a small, collocated team, prioritizing for safety in delivering a satisfactory outcome, efficiency in development, and habitability of the working conventions." The Crystal Clear methodology is part of the Crystal family of methodologies, where every methodology is characterized by a color (Clear, Yellow, Orange, Red, Maroon, Blue, Violet). That color represents the number of people for which the methodology is suited; Crystal Clear is the lightest color and is meant for the smallest project groups, of two to eight people.

Crystal Clear has at its core seven properties that should be established for every project that wishes to adhere to the methodology. While all of these are desired, only the first three are mandatory; the other four will get the project further into the safety zone. The seven properties are:

1. Frequent Delivery: When delivering working, tested code to the actual software users once every few months (or more often, if possible), users will be able to deliver feedback on implemented requirements, sponsors will see progress and developers will get a morale boost.
2. Reflective Improvement*:* Taking time to let the team reflect on what works and what doesn't work for the project, and improving the things that don't work.

3. Osmotic Communication*:* Having the entire team so close together (if possible, in the same room, otherwise in adjacent rooms) that people don't have to go to a lot of trouble to raise or answer questions, but can do so instantly, will make people work together naturally, inspect each other's work and pick up relevant information as if by osmosis.
4. Personal Safety*:* If people feel safe to speak up without fear of reprisal, they can give constructive criticism on other people's work and admit their own mistakes, leading to honesty and ultimately to trust.
5. Focus*:* If everybody has time to focus on their primary objectives for two hours a day, for two consecutive days every week, without any distractions that can make them lose their train of thought (like meetings or other work), people will be more focused, and work will be finished quicker.
6. Easy Access to Expert Users*:* If expert users are available to the team, they can answer questions and deliver feedback on quality and design decisions.
7. Technical Environment with Automated Tests, Configuration Management & Frequent Integration*:* A proper technical environment where testing and configuration management/version control tasks (like making backups and merging changes) do not have to be done by hand will make life easier for developers.

Project Methods/ Techniques in SPM

This includes the procedures that can be employed as an aid to estimate, track, and evaluate different features of the project. We start with a discussion of PMBOK, which is not a technique in itself, but rather a collection of industry-standard techniques. After that, we discuss COCOMO, MTA, EV and Critical Path.

Project Management Body of Knowledge (PMBOK)

The Project Management Body of Knowledge is a broad term that explains the sum of knowledge within the profession of Project Management (PM). As with additional professions such as law, medicine, and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it. The full Project Management Body of Knowledge (PMBOK) comprise knowledge of proven traditional practices that are extensively applied, as well as knowledge of innovative and advanced practices that have seen more limited use. The PMBOK framework splits the project processes into five discrete process groups: initiating, planning, executing, controlling and closing.

Notes: These groups do not imply that the project has to go through each one in this order; they are only provided in order to be able to structure and categorize the different project processes.

PMBOK also recognize several project knowledge areas: integration management, scope management, time management, cost management, quality management, human resource management, communications management, risk management and procurement management. By using this twin categorization in process groups and knowledge areas, we can categorize project processes. The PMBOK Guide comprises summaries of generally accepted techniques and methodologies that can be used to implement these project processes.

Advantages

- PMBOK provides a general project management framework in the form of process groups and knowledge areas.
- PMBOK proposes a unified project management terminology.
- PMBOK gives a concise summary of and reference to generally accepted project management principles.

Application Area: PMBOK tries to imitate the growth of knowledge and practices in the field of project management by capturing those practices, tools, techniques and other relevant items that have become generally accepted. Usually accepted does not mean that the knowledge and practices described in the PMBOK framework are or should be applied uniformly on all projects; the project management team is always answerable for determining what is appropriate for any given project. A few well-known procedures included in the PMBOK framework are Earned Value (EV) management, Program Evaluation and Review Technique (PERT) [PMBOK-PERT] and Critical Path Method (CPM).

Constructive Cost Model (COCOMO)

COCOMO is an experiential, algorithmic model for estimating the effort, schedule, and costs of a software project. It was derived by collecting relevant data from many software projects, then analysing the data to discover the formulae that were the best-fit to the observations. The first version of the COCOMO model (now known as COCOMO 81) was a three-level model where the levels imitated the detail of the analysis of the cost estimate. The first level (basic) provided an initial, rough estimate; the second level modified this using several project and process multipliers and the most detailed level produced estimates for different phases of the project.

COCOMO 81 makes a variety of assumptions about the software development process to produce its estimates. The latter will only be somewhat accurate when the project uses the waterfall process model, and every line of code is produced from scratch. It also fails to consider that nowadays higher-level programming languages are employed, supported by various automated tools. We will not elaborate on this version, since it has been obsolete by COCOMO 2.

COCOMO 2 comprises support for various development methodologies such as component based development and prototyping, fourth generation programming languages and CASE support tools. COCOMO 2 still consists of three levels, but these have been given somewhat different interpretations:

1. The early prototyping level: Size estimates are based on object points. These object points are a simple way of quantifying the perceived complexity of requirements that need to be implemented. The required effort is then computed by applying a simple extrapolation from the object points and programmer productivity. Object points are based on the number of screens, reports, and modules in third generation programming languages, and can be weighed by the perceived complexity of the screen, report or module in question.
2. The post-architecture level: Once the system architecture has been designed a reasonably accurate estimate of the software size can be made. The estimate as this level uses a more extensive set of multipliers reflecting personnel capabilities, product, and project characteristics.
3. The early design level: This level corresponds to the completion of the system requirements with (perhaps) some initial design. Estimates are based on function points, which are obtained by working out the object points in detail. More specifically, the total number of points is computed by measuring or estimating the following program features: external inputs and outputs, user interactions, external interfaces and files used by the system. The function points are then converted to number of lines of source code using the tables provided by the COCOMO model.

Advantages

- Though it's hard to pinpoint the exact cost of any given project, one can still obtain usable data by calculating optimistic and pessimistic estimates.
- Implementation and execution of the model is very easy and proficient. As a result, it is supported by public as well as commercial tools.
- COCOMO is a well-known and well-documented method.

Application Area: COCOMO is a well-known experiential algorithmic cost estimation procedure. It is well documented, in the public domain and is supported by public domain and commercial tools. It has been extensively used and has a long pedigree from its first instantiation in 1981. The application of the first instantiation of the model was limited due to the quite large constraints on the development process. This issue has been mitigated by continued improvements on, and extensions of the model, resulting in COCOMO 2.

Milestone Trend Analysis (MTA)

MTA is a software engineering method for evaluating the actual progress of a project in relation to its planning. This comparatively simple technique consists of recording the dates of the milestone deadlines at the times they are changed, that is, when they are delayed or advanced. This way one gets a matrix of data: the columns of the matrix delimit the project milestones, the rows the dates on which the deadlines were re-evaluated, as an actual cell contains the new deadline estimate for the milestone in question. Of course, one can really enhance insight in these data by using some simple visualization techniques. This can be done by plotting the estimated deadlines against the dates on which they were evaluated. The latter are generally placed on the X-axis, the former on the Y-axis. The evolution of a project milestone deadline is thus observable as a curve on the graph: downward movement of the curve signifies that the deadline in question was advanced, while upward movement means postponement. One can also easily spot milestone completion: this is the case when the curve intersects the line y = x. The general shape of the graph is often approximately triangular: this is the result of the fact that we stop plotting a curve when the milestone in question has reached completion, that is, when it intersects with the angular bisector of the first quadrant.

Advantages

- MTA is a simple, elegant and effectual technique.
- MTA is extensively used and supported.
- MTA has a big application area.

Application Area: MTA can be applied to each project that utilizes milestones as the major indicators of progress. It is in essence a very simple and graceful technique that can easily be applied to assess progress. Of course, MTA is an evaluation technique that is to be used during the execution of a project. Its main uses are avoiding and correcting schedule slippage, and post-mortem schedule evaluation.

Critical Path

The critical path method operates on a directed acyclic graph that successively orders all tasks that need to be completed in the project. We term this graph the project network. An instance of a project network can be seen in Figure 5. The tasks connected in a project network are classically the terminal elements of a Work Breakdown Structure. The graph states the order in which the different tasks need to be completed, and the dependencies between them. Each task has an associated cost in time. The critical path is the longest path from the start of the project to the finish, and its cost is the shortest period in which the project can be completed. Any delay on tasks on the critical path will delay the entire project. In our example, the critical path is (s; b; d; t), with a cost of 60 days. A related concept is slack; this is the time that a single activity can be delayed, without delaying the project. By description, the slack of all activities on the critical path is 0.

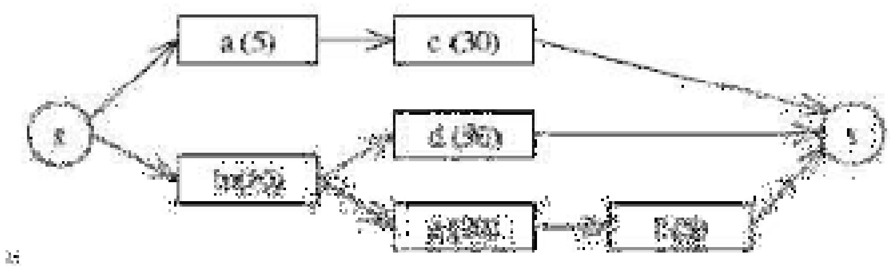


Figure 5: An Example of a Project Network

Advantages

Critical Path analysis is obvious and unambiguous. It can be used to identify the most important activities, and make sure additional care is given to them. In addition, for activities that are not on the critical path, the slack can be calculated and considered.

Application Area: Critical Path can be employed for task scheduling in just about any project management scheme. Though, the grade of dependencies between the tasks must be high enough to make critical path calculation useful.

Calculating the critical path for all the deliverables in a (linear) waterfall methodology just won't be all that amazing.

1.10 Problems with Software Project

The below list of software project failure reasons is not prioritized. Some of the reasons are claims that were measured by researchers.

The maturity of the software engineering field

- The software engineering field is much younger than the other engineering fields and that, in time, will get more established.
- The field is young and thus most of the field engineers and managers are also young.
- Young people have less experience and therefore tend to fail more. Young people are more optimistic and tend to estimate roughly.

Shortage of Knowledge Base

As a comparatively young engineering field, software engineering is short of accumulative knowledge bases. "Software engineering has evolved progressively from its founding days in the 1940s", but it is still short of accumulative knowledge base as opposed to other engineering fields. Another example is OOP (Object Oriented Paradigm). OOP is more effectual than the previous procedural paradigm. OOP was only embraced by the Software industry in the 1990s. "Even though it originated in the 1960s, OOP was not generally used in mainstream software application development until the 1990s."

Software is not Tangible

As contrasting to other engineering fields like civil engineering, the software engineering building blocks are much less tangible and therefore hard to measure and estimate. "Software is conceptual".

Competition: Harsh Deadlines

The competition in the software industry is cruel. The Time-To-Market (TTM) is vital and the drive to meet harsh deadlines is massive. This characteristic, along with other methodologic al anomalies like "Code first; think later" and "Plan to throw one away; you will, anyhow," makes competition cruel. The hard competition in the software industry causes not only the need to deliver ASAP, but also the requirement to catch as many probable customer eyes as possible. Firing in every direction causes disorganization, fast coding and projects that are not well planned.

Technology Changes Rapidly

"Software development skill change faster than other construction technologies." Until lately, Microsoft was regularly bombarding the industry with new technologies. Rapid technology changes introduce liability for software manufactures. Example: New Operating Systems obligate a company like Ahead to release a new adaptable version.

Change is Tempting

A building architect will not choose to add extra floors during the building construction. The result would be dreadful, as the building foundations were not constructed for it. The software architect's hand, though, will be much looser on the trigger. Irresponsible changes like adding new features and redefining existed ones may cause deadline disobedience and/or bad planning and coding (patch). Given the harsh competition, it looks like changes are expected.

Bad Time Management

Estimating the development time should associate to the employees ("resources") on hand. In some cases, managers estimate and then impose a timetable as if they were the ones who were going to do the developing. This type of enforcement yields pressure on growth and may harm it. Moreover, violating deadlines in this condition is common.

Bad or no Managing Skills

It is ordinary that software managers are used to being excellent, successful and professional software engineers. Regrettably, the skills are not the same when it comes to successful managing. Great engineering skills do not guarantee great managing. Newborn software managers do not obtain the right, or any, guidance.

Wrong or no Software Development Life Cycle (SDLC) Methodology

Growing life cycle methodology must be part of software project management. Nevertheless, it should not be forced into the R&D environment. The software engineering field is comparatively young, but still there are already well-known developing life cycle methodologists (Agile, Crystal, Spiral, Waterfall, etc.), successful stories and case studies. Software project managers may adopt one of the existing methodologies, but usually there is also a need to adapt the methodology to the company on hand. The adaptation includes company culture, employees, marker, managers, etc.

Bad or no Documentation

Documentation should be measured as a "must have" and not "nice to have". Documentation is an integral part of developing the life cycle process. It should not be caught as a nagging tedious task, done for the sake of some strict QA manager. There are a variety of types of software project documentation, each related to a certain stage in the development life cycle of the project.

Bad or no Software Requirements

As much as it sounds strange, in some software projects SRSs (Software Requirement Specifications) do not exist or are badly written. There are many types of SRS formats and even if it was only one common template, the content would vary from company to company. It is a question of how well-defined the requirements are. We have never heard about a well-defined SRS that caused projects to fail, but I am familiar with the opposite. A terse requirements document affects the ability to break the software complexity, generate tasks and estimate time. Furthermore, inadequate definitions cause misunderstandings and wrong implementation. Changes to the project during the development become inevitable and, in time, project deadlines will be missed.

Did you Know?

Badly written or no MRD or SRS document can cause project failure.

Lack of Testing

Those who develop the software should not test it. The developer should run unit testing, but it is not a replacement to an objective QA test. Testing only at the end of a long milestone raise harms due to the load of testing and inherent problems that should have been caught at earlier stages. Furthermore, managers tend to rush the testing period at the end of the milestone in order to release on time. QA that does not bite and has no real power does not have the right effect on the R&D department and is there for the project itself. QA should be started as soon as the software project starts. Hence, even in the planning stage. QA participation in early stages is important for its preparation for the software. For example, QA should also check the SRS document and make sure that the software was implemented according to it.

Human Resources Management

It is given information that lots of software project manager's start working without the basic guidance of how to motivate people to succeed. Software managers tend to manage their software engineers only in the professional engineering aspects. Though, software engineers are people too. Learning what motivates them requires time and will from the manager side. No two men are alike, both in terms of management and motivation.

No Version / Source Control

Astonishing as it may sound, some software projects are not backed up in source control. Sources get lost; versions cannot be regained; products on customer's side cannot be reconstructed.

No or Bad Risk Management

"A project risk is an unsure event or condition that has consequences for the project? The purpose of risk management is to identify, analyse, and respond to project risks? ". Given the above items and the fact that software projects tend to fail, it would be absurd not to manage risks.

1.11 Software Project Managers

A project manager is a character who has the overall responsibility for the planning, design, execution, monitoring, controlling and closure of a project. A project manager represents an essential role in the achievement of the projects. A project manager is a character who is responsible for giving decisions, both large and small projects. The project manager is used to manage the risk and minimize uncertainty. Every decision the project manager makes must directly profit their project.

Role of a Project Managers

- Leader: A project manager must lead his team and should provide them direction to make them understand what is expected from all of them.
- Medium: The Project manager is a medium between his clients and his team. He must coordinate and transfer all the appropriate information from the clients to his team and report to the senior management.
- Mentor: He should be there to guide his team at each step and make sure that the team has an attachment. He provides a recommendation to his team and points them in the right direction.

Responsibilities of a Project Manager:

1. Managing risks and issues.
2. Create the project team and assigns tasks to several team members.
3. Activity planning and sequencing.
4. Monitoring and reporting progress.
5. Modifies the project plan to deal with the situation.

Lab Exercise: Analyse the role of Software Project Management?

Summary

- A project includes several activities that must be completed in some order, or sequence.
- Projects have a specified completion date.
- The customer, or the recipient of the project's deliverables, expects a certain level of functionality and quality from the project.
- Software projects are disreputably hard to define. The aim of these processes is to make sure that various project tasks are well coordinated, and they meet the various project goals including timely completion of the project.
- The thick methodologies we consider are RUP, SSADM and PRINCE2. XP, SCRUM and Crystal Clear are measured as thin methodologies.
- The Project Management Body of Knowledge is a broad term that explains the sum of knowledge within the profession of Project Management (PM).
- A project manager is a character who has the overall responsibility for the planning, design, execution, monitoring, controlling and closure of a project.

Keywords

Project*:* A project is a sequence of unique, complex, and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification.

Software Project*:* Software Project is the complete procedure of software development from requirement gathering to testing and maintenance, carried out according to the execution methodologies, in a specified period to achieve intended software product.

Deliverables*:* Upon satisfactory completion of the work authorization, the engineer shall submit the deliverables as specified in the executed work authorization to the state for review and acceptance. While developing software, the purpose is to develop software to satisfy the needs of some users or clients.

Estimation*:* Estimation is the process of determining how long a project will take to complete and how much it will cost.

Software Project Management*:* SPM is a process of managing, allocating and timing resources to develop computer software that meets necessities. SPM is the art and discipline of planning and supervising software projects. Software projects are planned, implemented, monitored, and controlled.

Risk Management*:* Risk management is the analysis and identification of risks that is followed by synchronized and economical implementation of resources to minimize, operate, and control the possibility or effect of unfortunate events or to maximize the realization of opportunities.

Project Manager*:* A project manager is a character who has the overall responsibility for the planning, design, execution, monitoring, controlling and closure of a project.

Self Assessment

1. A __________ is a sequence of unique, complex, and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification.

A. project

B. process

C. product

D. procedure

2. Which of the following statement(s) is/are TRUE for a project?

A. Projects can vary from simple to difficult.

B. Projects can be operated by one person or a hundred.

C. Projects are usually described and approved by a project manager or team executive.

D. All the above.

3. Any project aims to produce some deliverable(s) which can be a product, service, or another result.

A. True

B. False

4. ____________ is the complete procedure of software development carried out according to the execution methodologies, in a specified period to achieve intended software product.

A. Software testing

B. Software maintenance

C. Software programming

D. Software project

5. Which of the following is NOT a characteristic of project?
A. Temporary
B. Unique Deliverables
C. Progressive Elaboration
D. Generic process for all projects

6. ___________ is a process of managing, allocating and timing resources to develop computer software that meets necessities.
A. APM
B. SPM
C. FPM
D. RPM

7. Which of the following is/are objective(s) of Software Project Management?
A. Understanding software requirements and converting that to project requirements.
B. Preparing plans to accomplish the work that needs to be done to meet those requirements.
C. Estimating cost, effort, duration, resources required for the project.
D. All the above.

8. _________ is one of the elements of the triple constraints for software projects.
A. Risk
B. Quality
C. Quantity
D. Association

9. ______________ is a document that outlines the expectations of those working on the project.
A. Working plan
B. Software Project Management Plan
C. Experience plan
D. Outlier

10. SPMP contains sections regarding the assumptions and constraints, the project deliverables, the summary of the schedule, and the plan for change in the SPMP.
A. True
B. False

11. The statement, "Anyone who has an interest in the project and who may be affected by the outcomes of the project" refers to whom in the project management.
A. Placeholder
B. Project holder
C. Stakeholder
D. Process holder

12. PMBOK stands for
A. Project Management Body of Knowledge
B. Procedure Maintenance Body of Knowledge
C. Procedure Maintenance Book of Knowledge
D. Project Management Book of Known

13. Methodology is a body of methods, rules, and postulates employed by a discipline or a particular procedure or set of procedures.
A. True
B. False

14. ___________ methodology is designed and documented utilizing Unified Modelling Language (UML).
A. Structured Systems Analysis and Design Methodology
B. Rational Unified Process
C. Projects in Controlled Environments
D. Sprint

15. The statement reflecting the role of project manager is
A. A character who has the overall responsibility for the planning, design, execution, monitoring, controlling and closure of a project.
B. Manages the risks and minimizes uncertainty.
C. Every decision the project manager makes must directly profit their project.
D. All the above.

Answers for Self Assessment

1.	A	2.	D	3.	A	4.	D	5.	D
6.	B	7.	D	8.	B	9.	B	10.	A
11.	C	12.	A	13.	A	14.	B	15.	D

Review Questions

1. Discuss the role of the software project manager?
2. What is SPM? Which different methods or techniques are utilised in SPM?
3. Elaborate on the software project failure reasons?
4. List and explain the different problems with software project management?
5. How are the different methodologies used in SPM?
6. What are the key characteristics of project?
7. Differentiate- Software Projects vs Other Types of Projects.
8. Explain Constructive Cost Model (COCOMO) with advantages.
9. Indicate the problems with Software Project Management.
10. Write a short note on:
    a. Rational Unified Process (RUP)
    b. Scrum

Further Readings

- Robert K. Wyzocki, Rudd McGary, Effective Project Management, WILEYDreamtech India Pvt. 8th edition, 2019.
- Roger S. Pressman, Software Engineering a Practitioner's Approach, Fourth Edition, McGraw Hill International, 2005.
- Bob Hughes, Mike Cotterell, Software and Project Management, Tata McGraw-Hill Publishing Company Limited, Fifth Edition, 2009

Web Links

- https://www.geeksforgeeks.org/software-engineering-software-project-management-plan-spmp/
- Software Project Management Phases & Best Practices – BMC Software | Blogs
- Software Project Management - javatpoint
- Software Project Management Plan: Steps and Tips - Designveloper
- Software Project Management Plan: Structure & Examples | Study.com

Unit 02: Introduction to Project

CONTENTS

Objectives

After studying this unit, you will be able to:

- explore the project scope and its aspects.
- learn the project objectives and understand the project characteristics.
- know about the project infrastructure.
- understand Work Breakdown Structure (WBS) and effort estimation.

Introduction

A project is a sequence of unique, complex, and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification. A project is well-defined task, which is a collection of several operations done in order to achieve a goal (for example, software development and delivery).

Project Planning

Planning is the trickiest process in project management. There are some basic steps in project planning. A main step in project planning is to plan in outline first and then in more detail. The key to an effectual project is in the planning.

Generating a project plan is the first thing you should do when undertaking any kind of project. Often project planning is ignored in favour of getting on with the work. Though, many people fail to realize the value of a project plan in saving time, money, and many problems.

2.1 Project Scope

Project scope is the total amount of work done to attain a project management team's project. It is the sum of all the products, necessities, and outcome as one project. In terms of project management, scope is the process preferred to make sure that the project is done.

In the planning process, the scope of the project is examined. A project's requirements, products, and results are defined. The definition of scope is the most essential part of project management. It assists the team in knowing what needs to be done and what achieving the project will entail.

Specially, the project management team discusses the needs, risks, strategies, effort and cost. Then the project management team splits the project scope into short-term objective to be accomplished. The project managers then allocate different people to accomplish the goals.

After the scope is done, it is checked and approved to make sure the project meets the product requirements, services, and results. It is the final step where project objectives are analyzed critically to make sure that the project meets the quality outcome.

When people talk about scope, they instantly think about time and cost. Time and cost are outputs of scope. Determining scope is a different exercise. When we talk about identifying the scope, we are talking about developing an ordinary understanding as to what is included in, or excluded from, a project. We are not talking about deciding how long it will take, or how much it will cost. That comes after the scope is described.

The scope is bound to change, and this is to be expected. As the details become clearer, more complications creep in. These are not foreseeable at the start and hopefully we build a contingency for what we cannot see. The scope changes that usually cause problems are those where the perception of what was in and out of scope was different between various parties. Example: If we were looking for an economical car, we would first define the scope. For example, we want a 4-cylinder front wheel drive with seating for 2 adults and 2 children, and less than 2 years old. Maybe you also want it to be a red convertible. Having defined the scope, you can calculate cost and time. How much you will have to spend and how long you will take to buy it. If you get the scope wrong, the time and cost will be wrong.

This sort of organization contains the processes required to guarantee that the project includes all the work required, and only the work required, to complete the project effectively. It is essentially concerned with the defining and controlling of what is or is not included in the project.

The processes, tools, and procedure used to administer product's scope differ by application area and are often described as part of the project life cycle. The project's output is a single product, but that product may comprise subsidiary components, each with its own separate but interdependent product scopes.

Notes: The significant thing to remember is that "Completion of the project scope is calculated against the project plan, but completion of the product scope is measured against the product requirements". We are also aware of the fact that if project is multifaceted and larger in size, the different team & different components are required to complete concurrently. There exists tradeoffs among the competing objects and alternatives are there to meet the needs of stakeholders.

The project scope contains the following aspects to be managed:

1. Scope Planning

2. Scope Definition

3. Create WBS

4. Scope Verification

Scope Planning

Scope planning refers to a project management process that describes boundaries and deliverables. A deliverable is an input/output term that refers specially to the unique and individual products, elements, results, or items that are produced for delivery at the conclusion of a specific project component, or at the conclusion of the project.

Deliverables can come in a number of different variations. Deliverables can be in the form of a written report, which can be extremely lengthy and can encompass extensive amounts of information and data. Deliverables can also be much shorter. In some cases, the end deliverable may be a short report, a slide presentation, a poster, a short blurb, or even a slogan. In these cases, the deliverable may actually be very short, and rather than containing all information gathered over the course of a project, may contain a succinct message that is meant to represent the sum total of the information without actually presenting it directly.

Deliverables towards the end of a project life are typically referred to as external deliverables, and these typically require the review and/or approval of the customer or financially responsible party. The basic matrix of a scope planning analysis consists of three main categories: Initiation, planning, and definition, with two control categories: Verification and change control mix together between the three main categories. The beginning inputs contain program deliverable description, strategic planning, program selection criteria, and historical information. The tools and techniques comprise program selection methods and expert judgment. The output of the initiation phase will contain a program charter, the identification and assignment of a program director, and the identification of known constraints and assumptions.

The planning category covers descriptions on deliverables, the program charter, constraints, and assumptions. The tools and techniques involved in this group contain deliverable analysis, a benefit/cost analysis, the identification of alternatives.

The final main category contains a statement of scope, a definition of assumptions and constraints, and other planning outputs and historical information. The tools and techniques involved contain work breakdown structure templates and decomposition. The output of definition is work breakdown structure, and the defined scope section of the project management plan.

Two control devises, verification and change control are mix between the main categories of scope planning.

Verification's inputs are work results, and deliverable documentation. Inspection is its sole tools and technique. The formal acceptance is verification's output and is necessary to advance the project management plan to the next level. Change control is positioned between planning and definition. Its inputs are comprised of work breakdown structure, performance reports, change requests, and the scope management plan. The tools and techniques contain the scope change control system, performance measurements and additional planning when indicated. The outputs of change control are changes in scope, corrective actions, and lessons learned entered in the information base for other project management considerations.

Scope Definition

Scope explanation often accounts for a paragraph or two in a Business Case or Project Charter. Regularly, they are qualitative and/or focus on general statements. "We will develop service by providing an information system to answer to customer inquiries." Is it a real time system? Is it all screen-based? What reports can be produced? Where does the knowledge come from? What management is required for the data? Is all the data compatible? Do you want to generate standard letters? How many letters? How customizable are the letters? Do you want to store the questions? Do you want to store the answers?

To define the scope, there will be supposition that need to be made. There is no point in waiting until everything is clear to define scope. By that time, the project will possibly be finished. Each of these assumptions should be documented and followed up later to validate the scope. If the supposition is false, it may have an impact on the scope.

There are plentiful ways to define the scope. They are:

- Define Deliverables
- Define Functionality and Data
- Define Technical Structure

Define Deliverables

One method to focus people on the scope is to describe the internal and external deliverables:

External deliverables are things the project delivers to the users, e.g., screens and reports. The users usually think of a system in these terms. It also comprises any hardware or software required by the users or the project team (Table 1).

Table 1: Example for External Deliverables

Name	Description
License Detail Screen	Screen to enter and view license details
Company Summary Screen	Screen to view all licenses issued by a particular company. Facility to drill down to License Detail Screen.
License Due Report	Report listing all licenses due in the next period. Facility to select a period e.g. 1 week, 4 weeks, quarter
5 Reports	Allow for 5 unspecified reports
Server	Server to run the application
Etc.	

Internal deliverables are things the project makes internally, e.g., Project Charter, Business Requirement Specification, etc.

Notes: Once the external deliverables are described, the project manager can define the internal deliverables

Define Functionality and Data

Another method is to define the functionality. This should not be either a lengthy or detailed process. A good system is to use a functional decomposition. If using a spreadsheet and a projector, a scribe can make the scope as it is discussed. Remember to start all functionality with a verb. It is valuable to do the functional decomposition in conjunction with a data definition. If this is unfeasible, once the scope is discussed, it will become reasonably clear what data is required. The project manager can conclude if there are any situations that need to be clarified with the users and finalize the scope definition. If for example, in defining the functionality it becomes apparent that considerable information will need to be moved from a legacy system, which is known to be inaccurate, data cleansing can be factored into the scope.

Examples of functional decomposition

- Capture License details
- Set up companies.
- Set up products.
- Create licenses.
- Modify licenses.
- Delete licenses.
- Generate payments.
- Create payment report.
- Authorize payments.
- Notify accounts etc.

It can also be defined as a diagram (Figure 1):

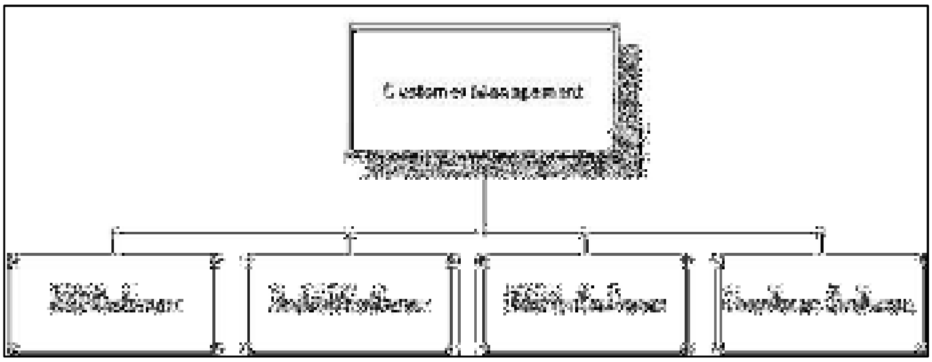


Figure 1: Functional Decomposition Example

Also, defining the data is comparable to functionality and should be employed in conjunction with functionality. The process is probable to capture what users expect to see in a system. The purpose is to get the business users to verbalize their requirements for information in a structured manner. Ask the users what the people, places and things are they want to keep track of.

Data Definition Example

Name	Description
Companies	Details of the company including address, overseas offices, and up to ten contacts
Licenses	Licenses for all software and hardware used in the organisation. Include contracts, correspondence, quotes and any other related documents. Does not include manuals
Renewal dates	Dates the license is due for renewal and the cost of the renewal.
Etc.	

This way will not capture data that may be required to technically make the system work. For example, it will not capture things like transaction log files, archive files, SQL script files, etc. Post workshop, the Project manager will need to sit with a data modeler to sort out what else is required. The hardest part is to stop doing a data model. Keep the focus on where the data is to come from, and recognize what is new, where the interfaces are likely to be, is existing data suitable, is the data currently captured, etc.

Define Technical Structure

This procedure of scope definition can be useful for describing scope where the project is focused on infrastructure. It can also be valuable in a situation where an existing system is being modified. The output can be either a table, or a diagram. A table might just list the components to be customized and the modification. The structure diagram might recognize the whole system and highlight which components are being modified and how they are being modified. It may also be appropriate to indicate the purpose of each component.

Example Technical Structure Table

Component	Description
Subsystem1	Handles all customer processing and interfaces to CMS (Customer Management System).
Subsystem2	Carries out inquiries on billing systems (2) and combines data into common format. Sorts data by date of payment.
Etc.	

Create Work Breakdown Structure (WBS)

Work Breakdown Structure (WBS) is a hierarchical description of the work that must be done to complete the project as defined in the Project Overview Statement (POS).

To understand WBS, we must know about activity. An activity is nothing but simply a chunk of work. The activities turn to tasks at some level in the hierarchy. A task is a smaller chunk of work. The terms activity and task have been used interchangeably among project managers and project management software packages.

- Work Package- A work package is a complete description of how the tasks that make up an activity will actually be done. It includes a description of the what, who, when, and how of the work.
- Decomposition- Breaking down work into a hierarchy of activities, tasks, and work packages is called decomposition. For example, look at the top of the WBS in Figure 2 below.

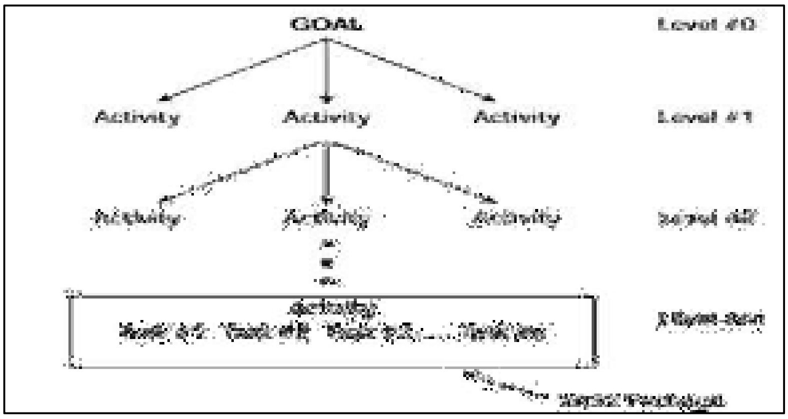


Figure 2: Hierarchical Visualization of the Work Breakdown Structure

Figure depicts (Figure 2):

- The goal statement from the POS is defined as a Level 0 activity in the WBS.
- The next level, Level 1, is a decomposition of the Level 0 activity into a set of activities defined as Level 1 activities. These Level 1 activities are major chunks of work. When the work associated with each Level 1 activity is complete, the Level 0 activity is complete. For this example, that means that the project is complete. As a general rule, when an activity at Level n is decomposed into a set of activities at Level n+1 and the work associated with those activities is complete, the activity at Level n, from which they were defined, is complete.

Scope Verification

Verification is a quality guarantying procedure or technique applied by Project Management whereby a valuation of a component, product or service is finished at the end of a phase or project to verify or confirm that it assures all of the regulations or specification requirements. The verification can take place during production or development; and is usually an internal process.

In contrast, validation is the process by which the project management sets up that the component; product or service meets the needs of the intended end-user or customer. It can be said that validation assures that the correct component, product or service was created, and verification guarantees that it was built or produced correctly. Building the correct component speaks to end-users' needs, while doing it correctly checks that the actual development process was followed suitably. In some applications, requirements are such that it is necessary to have written requirements for verification and validation, as well as formal protocols for determining compliance.

The project management efficiently implementing a verification/validation process can save the producer from the financial burden of expensive recall campaigns, costly product rework, and unexpected delays in product releases. With software project management, once the scope of the project has been defined, it is significant to get the endorsement of stakeholders before proceeding further.

If the project is small, it might only require a single signature from the main sponsor or client for scope verification however with larger projects there may be several stakeholders involved. With key stakeholders it is essential to get explicit scope verification which could be a formal signature on paper or via an email that specially states project approval. Whichever the method, a record of the scope verification should be retained. With other, less concerned stakeholders, it is acceptable to get implicit approval or scope verification.

In other words, the project manager presents the project plan to them for inspection with an ending date for voicing any questions or concerns. After that date if the project management team has not heard from the stakeholder it is assumed that approval has been granted.

2.2 Project Objectives

The successful objectives in project management are specific. A specific objective increases the chances of leading to a specific outcome. Consequently, the objectives shouldn't be vague, such as "to improve customer relations," because they are not measurable. The objectives should show how effective a project has been, for instance "to reduce customer complaints by 50%" would be a good objective. The measure can be, in some cases, a simple yes or no answer, for example, "did we reduce the number of customer complaints by 50%?"

The objectives can often be set under three headings:

- Performance and Quality**:** The end consequence of a project must fit the principle for which it was intended. At one time, quality was seen as the blame of the quality control department. In more recent years, the concept of total quality management has come to the fore, with the responsibility for quality shared by all staff from top management downwards.
- Budget: The project must be completed without more than the authorized expenditure. The financial sources are not always infinite, and a project might be abandoned altogether if funds run out before completion. If that was to happen, the money and effort invested in the project would be forfeited and written off. In tremendous cases the project contractor could face ruin. There are many projects where there is no direct profit motive, however, it is still important to pay proper attention to the cost budgets, and financial management remains essential.
- Time to Completion**:** Definite progress must match or beat planned progress. All significant stages of the project must take place no later than their specified dates, to result in total completion on or before the planned finish date. The timescale purpose is very significant because late completion of a project is not very likely to please the project purchaser or the sponsor.

In the project objectives, the people require details to help know where they are in the process, and data helps them make conversant decisions. It is recommended to use "DISCO" when forming objectives. "DISCO" offers a proper direction for creating project objectives and tracking their progress (Figure 3). For example,

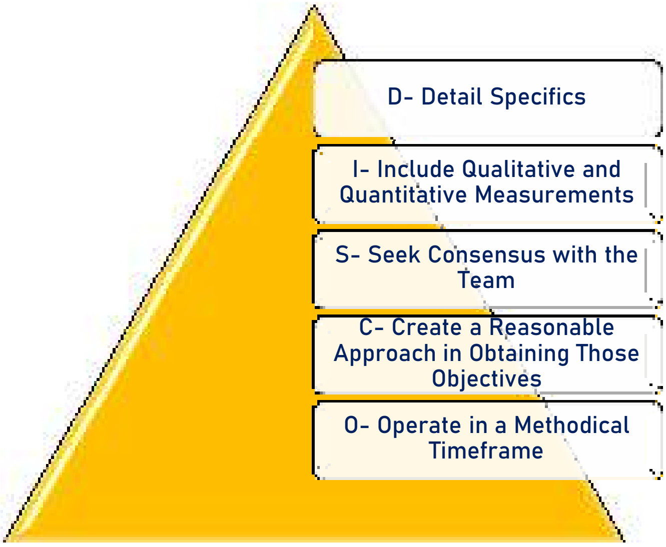


Figure 3: DISCO for creating Project Objectives

D- Detail Specifics

Give as much knowledge as possible and make these objectives very specific. Far too many objectives have been set, which are very grey in nature and lack data to help team members understand all specifics.

I- Include Qualitative and Quantitative Measurements

In this scenario, the objectives must be deliberate. When you look at an objective, you must ask, "Can we measure this?" If not, it needs to be rewritten so that it can be measured and tracked for successful completion. The only way to do this is to make sure qualitative and quantitative components are set.

Qualitative measurements calculate a project based on quality standards, quality indicators, or quality characteristics. Defect ratio, break down ratio, and improvement needs are all to be measured. Each of these can be prioritized and broken down into a specific tracking mechanism to follow and monitor.

Quantitative measurements calculate the project based on numerical indicators. Some of the most ordinary quantitative measurements are time, budget, production, work hours, process time, and development progress. Quantitative measurements normally include the need to set a series of benchmarks as a starting point to begin tracking.

S- Seek Consensus with the Team

Making sure the team agrees with the measurement is very significant. Sometimes objectives are set at the commencement of the project, and they are very loose. When the team sets a standard of measurement, it will usually be detailed and explicable. It is important because the team needs to be on the same page during planning. They must agree that these standards are the best possible measurements considering the project.

C- Create a Reasonable Approach in Obtaining Those Objectives

The approach for reaching objectives is tremendously significant. Unless the approach is understood by the entire team and supported, there will be conflict in the team's processes. The conflict means you will have people going in different directions and using various methods.

O- Operate in a Methodical Timeframe

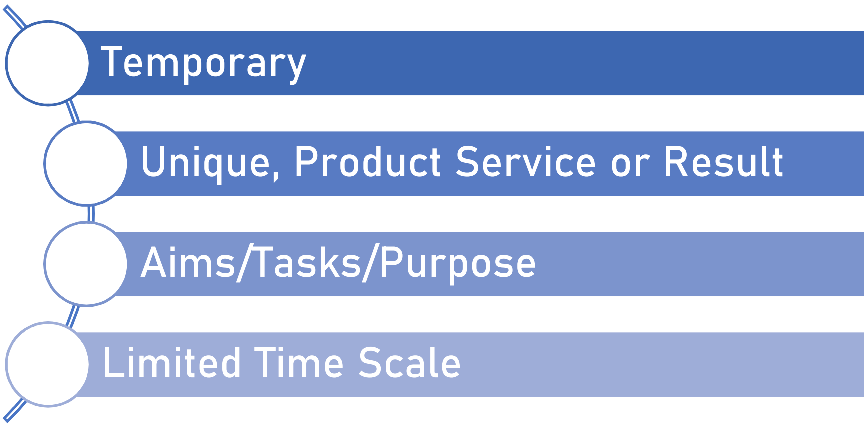
Setting up a timeline and follow it. This timeline must make sense and be exposed to the entire team. You must constantly focus on maintaining the clarity.

Example: An example of a great DISCO objective is, "We will design 15 training courses that meet organizational development guidelines by June 30 with a budget of $483,000. We will include courses on supervision, communication, performance appraisals, and creating an optimistic workplace." DISCO objectives can be very successful in pushing the project forward and bridging the gap for communication. However, good objectives will never write themselves, nor will they track themselves.

2.3 Project Characteristics

The project has certain characteristics that include:

Temporary: Temporary means that every project has a exact beginning and a definite end. The end is reached when the project's objectives have been attained, or it becomes clear that the project objectives will not or cannot be met, or the need for the project no longer exists and the project is terminated. Temporary does not essentially mean short in duration; many projects last for several years. In every case, however, the duration of a project is finite; projects are not ongoing efforts.



Unique, Product Service or Result*:* Projects engage creating something that has not been done in the same way before and which is, therefore, unique and distinct. The projects create:

- A product or artifact that is produced is experimental and can be either an end item in itself or a component item.
- A capability to perform a service, such as business functions supporting production or distribution.
- A result, such as new knowledge. For instance, a research and development project develop the knowledge that can be used to determine whether or not a trend is present, or a new process will benefit society.

Aims/Tasks/Purpose*:* The projects are designed to achieve exact targets defined in terms of aims, tasks or a purpose. The nature and size of the project depends upon complexity of the task, realization of the aims and scope of the purpose any organization wants to achieve. In short, a project has to be aimed for achieving certain tasks in a given time frame.

Limited Time Scale: The projects are always planned considering time constraints. Extension to the project completion deadlines are always discouraged as time overrun, costs extra and in some cases opportunity cost for not completing a project is too high.

2.4 Project Infrastructure

Project Infrastructure refers to the organizational structure, processes, tools, techniques, and training an organization puts in place to make projects more successful (Figure 4).

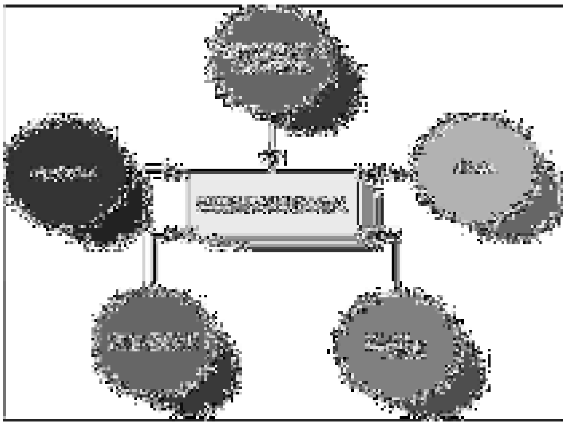


Figure 4; Project Infrastructure

- Organizational Structure– Organizational structure including such support mechanisms as project management office, project recruiting function, financial monitoring area, etc. It also covers lines of communication and escalation.
- Processes– Typically methodologies, checklists, and guidelines.
- Tools– Software and templates
- Techniques– Repeatable processes such as kick off meetings, PIRs, analysis techniques, etc.
- Training– Formal and informal training and reference documentation.

The project infrastructure is about analysis of the whole environment and finding out how to put in place an environment that will work in an integrated manner to support projects.

Detailed Project Infrastructure

- Organizational Structure: Structure refers to how a team is organized to be most effectual. Understanding what a team is best left to do is a good starting point. For example, is it a successful use of time and effort for a project manager to update resources requirement projections and recruit resources? Maybe it is more effective for a project coordinator working across several projects to undertake this task. Maybe a recruitment area could shortlist project resources. Another area might be project financials. Is there an explanation for a central project financial area? One quick test is to say what would be the cost of all the project managers tracking financials and what would be the cost of having a particular project financial analyst function.
- Processes: A project management process is not a collection of guides or templates. Templates are the output of processes. If you are doing a risk evaluation, you should not start off with a template and fill it out. You start off by understanding what is involved in carrying out a risk evaluation. You understand the techniques to generate a list of risks. You recognize who should be involved. You understand rating risks for impact and probability. After you put all this together into a process, you end up with information that finds its way into a template.
- Tools: We have seen organizations with several tools to do the same job. Almost surely this will result in problems. Having a steady set of tools is fundamental to the creation of a project infrastructure. The tools may include:
- Scheduling tools
  - Risk and issue management tools
  - Financial management tools
  - Document management tools
  - Action Item management tools
  - Databases for recording anything from benefits to progress reporting, to resources.

- Techniques: Techniques are the general, reusable process that an organization expands, or that an organization subscribes to. The people should be trained to apply the techniques, and participants will become familiar with the techniques. It makes life much easier if people can quickly slot into an environment because they have undertaken a similar activity previously. One exacting area where techniques are important is in the development of requirements. It should not be up to the project manager or business analyst as to what method they use to gather requirements. The organization should make a decision as to the technique they will use, and every project uses the same techniques. There are many associations that use a range of techniques such as UML, Data Flow diagrams, Functional Definition etc. to document system requirements. Each new project required a learning curve for participants where they had to become familiar with a new technique.
- Training: Communication does not take place by osmosis. There needs to be a training program in place to communicate the way in which projects should be assumed. Training will likely range from classroom to CBT (Computer-Based Training) to "one on one" training for new project managers. The training should not end for project managers. It is significant that project participants also receive training so they can understand how the project will be managed and what they are expected to contribute.

Building a Project Infrastructure

If you are building a project infrastructure, you will almost surely have some things in place. There may be templates, processes, techniques and documentation already in existence – if not in use. The starting point should be to carry out an audit of what previously exists.

- Define the scope
- Project Process Modeling
- Standing Infrastructure
- Gap Analysis
- Implementing the Infrastructure
- Working Teams
- Look at Individual Motivations
- Recognize Contributions
- Ownership

Define the Scope: Just like any project, we need to describe the scope. The limits of a project infrastructure can be blurred unless they are defined. For example, where does the project infrastructure take you in terms of financial management? Where do the usual company financial management start in relation to projects? Does the project infrastructure comprise skills register, or is that part of the HR function? Who allocates PCs to project teams? Is this part of a project infrastructure or is it part of your normal facilities management? Is space allocation for teams' part of your infrastructure?

Project Process Modelling: Once you have the scope recognized, it comes down to a business process modeling exercise. Take a new project and navigate it through the organization to completion. It is likely there will be multiple paths. For example, you may decide that there is a different path for a small project than for a large project. There may be different steps for projects requiring capital approvals. The purpose of this will be to understand what the optimal infrastructure. The project process model will emphasize where project infrastructure is required. When taking a project infrastructure view this may mean you need one or more of the following:

- Guidelines for running a scoping workshop.
- A template to record scope.
- Examples of previous scope documents.
- Training on how to create a scope statement.

- Guidelines to identify the various components of scope (Outcome, internal and external deliverables, objectives etc.).
- Checklist of common deliverables (Training Materials, Product Documents, Operations Manuals, etc.).

Standing Infrastructure: To undertake projects, there is also a standing infrastructure. The standing infrastructure will include things like:

- Knowledge management
- Skills optimization
- Resource Management
- Training
- QA
- Reporting

The projects will draw on the standing infrastructure to complete their work.

Gap Analysis: Given we now have a much clearer view of what is required, we can compare this with what already exists. It will include analysis of:

- Existing materials that fit the proposed project infrastructure
- Existing material that does not fit but could be reworked to fit
- Existing material that does not fit, and will never fit
- Gaps
- Duplication of materials (e.g. In one organization I found 4 templates to request seed funding for a project. They were all in use).

Implementing the Infrastructure: It is likely there will be well-established positions when it comes to giving up the old. Some people will use approach A and see no reason to use approach B. Some will use B and see no reason to use A. If there are valid reasons for only using one approach, then it will need to be enforced.

Working Teams: Form working teams to expand parts of the project infrastructure. For example, you might have a "Project Initiation Team" who put together the entire infrastructure to establish a project. They will need to work closely with other teams to ensure integration.

Look at Individual Motivations: Think what might inspire individuals and find benefits that will appeal to each person. For example: A "tidy" person will see appeal in having a clear concise path to follow with a consistent look and feel to the entire infrastructure. A "busy" person will focus on the efficiency of a clear process. A "less experienced" person will be motivated by having training and a clear path to follow.

Recognize Contributions: If you use a template someone has developed, identify them for the effort. In the version control section make sure the person who developed the template is identified. Recognition will encourage ownership.

Ownership: Make sure it is clear who owns the infrastructure, and who is in charge for authorizing changes. If the ground rules are set prior to the infrastructure being built, it will make it a lot easier to reach decisions.

Project Infrastructure and Governance

AS8000 defines Corporate Governance as "The system by which Entities are directed and controlled".

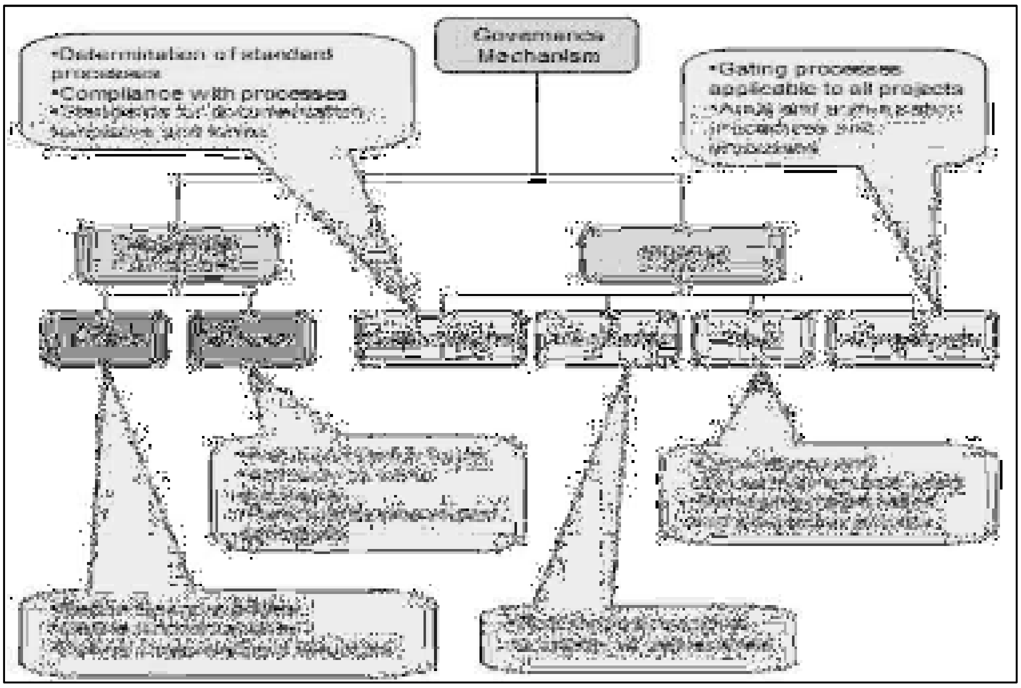


Figure 5: Project Infrastructure and Governance

From the Figure 5, a project infrastructure fits contentedly as a mechanism for managing project governance. The infrastructure covers both "People and Structure" and "Process". The good governance is both a driver of the project infrastructure and an outcome of having a proper project infrastructure.

Task: Perform an Analysis of the relationship between project infrastructure and governance

2.5 Work Breakdown Structure

A work breakdown structure (WBS) is a useful and widely used project management tool. It is a hierarchical description of the work that must be done to complete the project. Several processes can be used to create this hierarchy. One can organize each element in the WBS into scheduled activities that will make up the performance measurement baseline (PMB) to help define the deliverables for your project. WBS is a visual project breakdown. Beginning with the scope of work, the WBS shows the deliverables and how they connect back to the overarching project.

A WBS visually organizes project deliverables into different levels based on dependencies. It's essentially your project plan in a visual form, with your project objective at the top, then dependencies and sub-dependencies below. Since a work breakdown structure is displayed visually, it can be created using a combination of workflow management software and project management frameworks. Some of these methods include timelines, Kanban boards, and calendars.

WBS is a tool that helps to organize a project by hierarchy. With a WBS, one can break down deliverables into sub-deliverables to visualize projects and outline key dependencies. Every work breakdown structure is made up of a few parts:

A project baseline or scope statement, which includes a project plan, description, and name.

Project stakeholders.

An organized project schedule.

Project deliverables and supporting subtasks.

The project managers use work breakdown structures to help teams to break down complex project scopes, visualize projects and dependency-related deliverables, and give team members a visual project overview as opposed to a list of to-dos.

Task: Identify the role of project manager in WBS.

Types of WBS

- Deliverable-based WBS: This is a deliverable-oriented hierarchical decomposition of the work. This basically means that one will look at the overarching project scope and break your work down into deliverables that support it. This approach is best for shorter projects with a clear outcome. For example, developing a annual revenue report.
- Phase-based WBS: Here, one can use project phases to create work packages that house groups of tasks. These task groups are then completed in stages. One wants to use a phase based WBS for longer projects with less defined outcomes. For example, one wants to boost retention by 20% over the next three years.

Did You Know?

WBS and the Project Manager: It is the project manager who decides on the architecture of the WBS and the level of detail required. This detail is important because the project manager is accountable for the success of the project. WBS must be defined so that the project manager can manage the project. Apart from any senior management requirements for reporting or organizational requirements for documentation or process, the project manager is free to develop the WBS according to his or her needs and those of management

Uses of WBS

The WBS has four uses:

1. Thought process tool: The manager and the project team use WBS as a thought process tool that helps them to visualize exactly how the work of the project can be defined and managed effectively.

2. Architectural design tool: WBS can be used as a design tool as it is a picture of the work of the project that shows how the items of work are related to one another.

3. Planning tool: In the planning phase, the WBS gives the project team a detailed representation of the project as a collection of activities that must be completed for the project to be completed. It is at the lowest activity level of WBS that we estimate effort, elapsed time, and resource requirements; build a schedule of when the work will be completed; and estimate deliverable dates and project completion.

4. Project status reporting tool: The WBS is used as a structure for reporting project status. The project activities are consolidated (that is, rolled up) from the bottom as lower-level activities are completed. As work is completed, activities will be completed. The completion of lower-level activities causes higher-level activities to be partially complete. Some of these higher-level activities may represent significant progress whose completion will be milestone events during the project.

Generating the WBS

The best way to generate the WBS is as part of the Joint Project Planning (JPP) session. One of two simple decomposition processes is used to identify the activities that must be performed from the beginning to the completion of the project. These activities are the lowest level of managed work for the project manager. At this point in the planning process, one should have completed the Project Overview Statement (POS). One may have to go back and reconsider the POS as a result of further planning activities, but for now let’s assume the POS is complete. The technique for generating the WBS will reduce even the most complex project to a set of clearly defined activities. WBS will be the document that guides the remainder of the planning activities.

The two approaches can be used to identify the project activities:

Top **-** down approach **-** The top-down approach begins at the goal level and successively partitions work down to lower levels of definition until the participants are satisfied that the work has been sufficiently defined. Once the project activities have been defined using the top-down approach, they will be defined at a sufficient level of detail to allow you to estimate time, cost, and resource requirements first at the activity level and then aggregate to the project level.

Once the activities are described, one can sequence the project work so that as many activities as possible are performed in parallel, rather than in sequence. There are two variations of the top-down approach:

- Team approach- In this approach the entire team works on all parts of the WBS. For each Level 1 activity, appoint the most knowledgeable member of the planning team to facilitate the further decomposition of that part of the WBS. Continue with similar appointments until the WBS is complete. This approach allows all members of the planning team to pay particular attention to the WBS as it is developed, noting discrepancies, and commenting on them in real time. The team approach is better than the sub-team approach but it requires more time to complete.
- Sub-team approach- When time is at a premium, the planning facilitator will prefer the sub-team approach. The first step is to divide the planning team into as many sub-teams as there are activities at Level 1 of the WBS. Then follow these steps:
  - The planning team agrees on the approach to building the first level of the WBS.
  - The planning team creates the Level 1 activities.
  - A subject matter expert leads the team in further decomposition of the WBS for his or her area of expertise.
  - The team suggests decomposition ideas for the expert until each activity within the Level 1 activities meets the WBS completion criteria.

Bottom-up approach **-** Bottom-up approach is more like an organized brainstorming session used to build the WBS. It works as follows. The first steps are the same as those for the top-down approach. Namely, the entire planning team agrees to the first-level breakdown. The planning team is then divided into as many groups as there are first-level activities.

Each group then makes a list of the activities that must be completed to complete the first-level activity. To do this, they proceed as follows:

1. Someone in the group identifies an activity and announces it to the group. If the group agrees, then the activity is written on a slip of paper and put in the middle of the table. The process repeats itself until no new ideas are forthcoming.
2. The group then sorts the slips into activities that seem to be related to one another. This grouping activity should help the planning team add missing activities or remove redundant ones.
3. Once the team is satisfied it has completed the activity list for the first-level breakdown, the members are finished. Each group then reports to the entire planning team the results of its work.
4. Final critiques are given, missing activities added, and redundant activities removed.

Levels of Work Breakdown Structure

The levels of a WBS help separate tasks by dependencies. Since projects can differ so significantly, the levels of the WBS will too. While most projects do have some form of dependencies, it’s possible one will come across projects that don’t require sub-dependencies. There are three main levels of dependencies, though the structure could require more or fewer than that. Each level is connected to a parent task, with the work needed to complete the parent task organized into dependencies. Let's take a look at the three highest level dependencies within a WBS.

Level 1: The parent task

The first level of a WBS is the most simplified form of the project since it contains the parent task. This is usually the same as the project objective. Let's say, for instance, that the project team is working on revamping the website design. The first level of the WBS might look something like this: • Launch new website design. Level one is the basic objective and the first step of many project management phases. The work needed to complete this objective will come later, in levels two and three.

Level 2: Dependencies and Tasks

From there, the breakdown structure will get a bit more complicated depending on the scope of the project. Level two of WBS will include subtasks, otherwise known as dependencies, of the parent task. For example, let's look at what tasks might be needed to launch a new website design.

- Host a creative brainstorming session.
- Revamp brand guidelines
- Create messaging framework.
- Redesign your logo.
- Add new photography.

Notes: While slightly more granular than level one, level two is still a high-level overview of the dependencies needed to complete the project objective.

Level 3: Subtasks

In the third level of the WBS, break these dependencies down even further into more manageable components called sub-dependencies. At this stage—the lowest level of the project lifecycle—you're defining the most detailed tasks. These actionable tasks will simplify the path to completing all the required deliverables. In continuation of the above example, the level three tasks possibly for a new site design could include:

- Choose brand colors.
- Build a brand mood board.
- Assign UX designers.
- Build a mockup design.
- Review and approve mockups.
- Schedule a brand photoshoot
- Resize and edit pictures.

Work Breakdown Structure (WBS) Inclusions

WBS is essentially a condensed project plan organized in a visual hierarchy. That means it contains everything that a successful project charter has, which includes WBS elements such as objectives, deliverables, timelines, and key stakeholders. To create own breakdown structure, one needs to know what to put in one. Some of the key pieces to include in WBS can include:

WBS Dictionary **-** WBS dictionary is good to start when building a new project structure. Because the visual nature of a good WBS doesn't allow room for detailed explanations, the WBS dictionary describes each task in more detail. Creating a dictionary is an instrumental part of helping project team members more easily find necessary details of your tasks. While created by you, it may be beneficial to enlist the help of team members from various departments. This will ensure the dictionary is as useful as possible and all items are explained correctly.

Some fields that should be included in dictionary are:

- Task names: Keep this clear and simple, a few words at most.
- Descriptions: Go into a little more detail but no more than a sentence or two.
- Deliverables: Again, specificity is your friend here. Be clear about what, exactly, you're expecting the team to complete.
- Budget: your projected expenses, including how much you'll spend, for what, and by when.
- Milestones: Significant moments on the project timeline where a batch of tasks are completed.
- Approvals: What tasks—if any—need approvals.- While there are multiple fields you can include, the main thing to consider is creating a resource where project team members can find information on the project work needed to complete various tasks.

Task Description **-** The task descriptions include both a task name and a brief description of the objectives. Since your WBS won't have space for a full description, you can include additional details in your WBS dictionary. The objective of the task description is for team members to easily recognize what the task is in the shortest way possible.

Task Owner **-** The assigned task owner is an important piece to include both for accountability reasons and for communication. The easier it is to find answers, the quicker the tasks will be finished. While project managers are often task owners, department heads, and managers may also be owners depending on the type of task. Assigning task owners can improve team productivity as project stakeholders will be able to quickly direct questions to the appropriate person.

Task Budget**-** While not always needed, projects that require large budgets should be tracked carefully. It's helpful to assign specific task budget caps in order to easily track how close you are to your allocated budget. Not tracking the budget could result in spending more than anticipated, which can dig into profit margin. So be sure to not only track the total budget but individual task costs as well.

Completion Date- Tracking a target completion date is a rather important detail. It is important to be prepared for changes to your completion date. While it can be difficult to manage multiple projects that go over their allotted timeline, sometimes it's inevitable. To properly track progress, one should break down each task in a timeline or other project management tool. This way one can catch timeline delays in real time and work to prevent deadline issues from stacking up and causing miss in the original completion date.

Task Status- Along with timeline tracking, documenting task status is important for quick progress checks. This can be logged in a few different ways, but many teams use terms such as open, in progress, and complete. This will not only help track progress but give a high-level overview of team productivity. For example, if there's a pattern of select teams unable to complete tasks there may be an underlying issue. That way one can work to solve team workload or communication issues before they become huge problems.

Work Breakdown Structure (WBS) Creation

Using a Joint Project Planning Session to Build the WBS- The best way to build a WBS is as a group activity. To create the WBS, assemble a facilitator, the project manager, the core members of the project team, and all other managers who might be affected by the project or who will affect the project. The important thing is to have the expertise and the decision makers present in this part of the planning session who can give input into the WBS. This exercise should be continuous. The steps to build WBS are as follows:

The first step is for the whole planning team to decide on the first-level decomposition of the goal statement. One obvious approach would be to use the objective statements from the POS as the first-level decomposition.

Once the first-level decomposition is developed, the team has two choices on how to proceed: Without a doubt, the best way (from a WBS completion point of view) is to have the entire planning team remain intact and complete the WBS together. The second choice is to divide the planning team into groups and let each group take one or more of the first-level activities and complete the WBS for that part only. Whichever approach is used, it is essential that the entire group can review the final WBS and offer critiques of it. It is important that these efforts be made, because the WBS must be complete, and all the members of the team will see the result of the JPP.

There are three general approaches to building the WBS:

Noun-type Approaches: Noun-type approaches define the deliverable of the project work in terms of the components (physical or functional) that make up the deliverable. There are two noun-type approaches:

a. Physical Decomposition: In projects that involve building products, it is tempting to follow the physical decomposition approach. Take a mountain bike, for example. Its physical components include a frame, wheels, suspension, gears, and brakes. If each component is to be manufactured, this approach might produce a simple WBS.
b. Functional Decomposition: Using the bicycle example, one can build the WBS using the functional components of the bicycle. The functional components include the steering system,

gear-shifting system, braking system, and pedaling system. The same cautions that apply to the physical decomposition approach apply here as well.

Verb-type Approaches: Verb-type approaches define the deliverable of the project work in terms of the actions that must be done to produce the deliverable. The verb-type approaches include the design-build-test-implement and project objectives approaches. There are two verb-type approaches:

a. Design-build-test-implement: The design-build-test-implement approach is commonly used in those projects that involve a methodology. Application systems development is an obvious situation. Using our bicycle example again, a variation on the classic waterfall categories could be used. The categories are design, build, test, and implement.
b. Objectives: The objectives approach is like the design-build-test-implement approach and is used when progress reports at various stages of project completion are prepared for senior management. Reporting project completion by objectives gives a good indication of the deliverables that have been produced by the project team.

Organizational Approaches: Organizational approaches define the deliverable of the project work in terms of the organizational units that will work on the project. This type of approach includes the department, process, and geographic location approaches. The deployment of project work across geographic or organizational boundaries often suggests a WBS that parallels the organization. The project manager would not choose to use this approach but would rather use it out of necessity. In other words, the project manager had no other reasonable choice.

a. Geographic: If project work is geographically dispersed (our space program, for example), it may make sense from a coordination and communications perspective to partition the project work first by geographic location and then by some other approach at each location.
b. Departmental: On the other hand, departmental boundaries and politics being what they are, we may benefit from partitioning the project first by department and then within department by whatever approach makes sense. We benefit from this structure in that a major portion of the project work is under the organizational control of a single manager. Resource allocation is simplified this way. On the other hand, there is an added increased need for communication and coordination across organizational boundaries in this approach.
c. Business Process: The final approach involves breaking the project down first by business process, then by some other method for each process may make sense. This has the same advantages and disadvantages as the departmental approach but the added complication that integration of the deliverables from each process can be more difficult than in the former case.

Representing the WBS

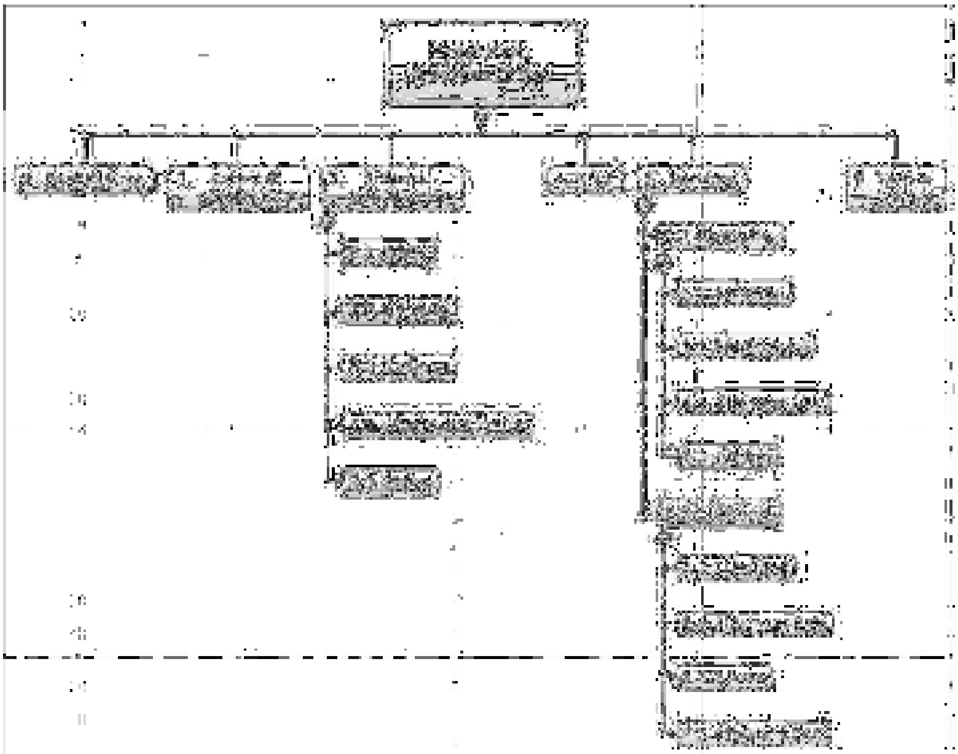


Figure 6: WBS for a House

The Figure 6 represents the WBS for a house as an example. The level 1 partitioning into some number of activities (also known as chunks of work) is a necessary and sufficient set of activities. That is, when all of these first-level activities are complete, the project is complete. For any activity that does not possess the six characteristics, we partition it into a set of necessary and sufficient activities at Level 2. The process continues until all activities have met the six criteria. The lowest level of decomposition in the WBS defines a set of activities that will each have an activity manager, someone who is responsible for completing the activity. The lowest-level activities are defined by a work package. A work package is simply the list of things to do to complete the activity. The work package may be very simple, such as getting management to sign off on a deliverable.

Summary

- A project includes several activities that must be completed in some particular order, or sequence.
- Scope planning refers to a project management process that describes boundaries and deliverables.
- A deliverable is an input/output term that refers specially to the unique and individual products, elements, results, or items that are produced for delivery at the conclusion of a specific project component, or at the conclusion of the project.
- In the planning process, the scope of the project is examined. A project's requirements, products, and results are defined.
- The definition of scope is the most essential part of project management. It assists the team know what needs to be done and what achieving the project will entail.
- External deliverables are things the project delivers to the users, for example, screens and reports. The users usually think of a system in these terms. It also comprises any hardware or software required by the users or the project team.
- Internal deliverables are things the project makes internally, e.g., Project Charter, Business Requirement Specification, etc.

- WBS is essentially a condensed project plan organized in a visual hierarchy. That means it contains everything that a successful project charter has, which includes WBS elements such as objectives, deliverables, timelines, and key stakeholders.
- Organizational approaches define the deliverable of the project work in terms of the organizational units that will work on the project.

Keywords

Project: A project is a sequence of unique, complex, and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification.

Scope planning: Scope planning refers to a project management process that describes boundaries and deliverables.

Deliverables: A deliverable is an input/output term that refers specially to the unique and individual products, elements, results, or items that are produced for delivery at the conclusion of a specific project component, or at the conclusion of the project.

Top-down approach: The top-down approach begins at the goal level and successively partitions work down to lower levels of definition until the participants are satisfied that the work has been sufficiently defined.

Bottom-up approach: Bottom-up approach is more like an organized brainstorming session used to build the WBS.

Project infrastructure: Project Infrastructure refers to the organizational structure, processes, tools, techniques, and training an organization puts in place to make projects more successful.

WBS dictionary: WBS dictionary is good to start when building a new project structure. Because the visual nature of a good WBS doesn't allow room for detailed explanations, the WBS dictionary describes each task in more detail.

Self Assessment

1. Generating a project plan is the first thing you should do when undertaking any kind of project.

A. True
B. False

2. Which of the following is TRUE for project scope.

A. Project scope is the total amount of work done to attain a project management team’s project.
B. Project scope is the sum of all the products, necessities, and outcome as one project.
C. Project scope is the process preferred to make sure that the project is done.
D. All the above.

3. In the project scope, _____________ is an aspect that needs to managed,

A. scope variable decision
B. scope verification
C. variance decision
D. case study

4. _____________ deliverables are things the project delivers to the users, e.g., screens and reports and comprises of any hardware or software required by the users or the project team.

A. External

B. Internal
C. Intermittent
D. Regressive

5. Internal deliverables are things the project makes internally, for example, Project Charter, Business Requirement Specification, etc.
A. True
B. False

6. ___________ is a hierarchical description of the work that must be done to complete the project as defined in the Project Overview Statement (POS).
A. Work Broadening Structure
B. Work Breakdown Structure
C. Work Business Structure
D. Work Border Structure

7. Which of the following statement aptly defines Verification?
A. Verification is a quality guarantying procedure or technique.
B. Verification is applied by project management to verify or confirm that a product, component, or service assures all of the regulations or specification requirements.
C. The verification can take place during production or development; and is usually an internal process.
D. All the above.

8. In a _________________ WBS, the hierarchical decomposition of the work is done which basically means that one will look at the overarching project scope and break your work down into deliverables that support it.
A. phase-based
B. hierarchy-based
C. deliverable-based
D. approach-based

9. To undertake projects, there is also a standing infrastructure. The standing infrastructure can include thing(s) like
A. Knowledge management
B. Skills optimization
C. Resource Management
D. All the above

10. In WBS generation, the _____________ approach begins at the goal level and successively partitions work down to lower levels of definition until the participants are satisfied that the work has been sufficiently defined.
A. bottom-down
B. top-down
C. bottom-up
D. scale-down

11. Creating a dictionary is an instrumental part of helping project team members more easily find necessary details of your tasks. The dictionary used in WBS is called as

A. Corpus
B. WBS dictionary
C. Web dictionary
D. Planner

12. The approach that defines the deliverable of the project work in terms of the components (physical or functional) that make up the deliverable is called as

A. Noun-type
B. Adventure-type
C. Verb-type
D. Stay-type

13. The organizational approach defines the deliverable of the project work in terms of the organizational units that will work on the project. This approach further can include

A. Geographic
B. Departmental
C. Business Process
D. All the above.

14. ______________ approach in WBS generation is more like an organized brainstorming session used to build the WBS.

A. Top-down
B. Top-scale
C. Bottom-up
D. Bottom-scale

15. A ____________ is simply the list of things to do to complete the activity and may be very simple, such as getting management to sign off on a deliverable.

A. work package
B. word list
C. word type
D. work type

Answers for Self Assessment

1.	A	2.	D	3.	B	4.	A	5.	A
6.	B	7.	D	8.	C	9.	D	10.	B
11.	B	12.	A	13.	D	14.	C	15.	A

Review Questions

1. Discuss the role of project infrastructure and governance.

2. What is Work Breakdown Structure? How is WBS important?
3. Differentiate organizational approach with verb-type approach for WBS creation.
4. List and discuss the different project characteristics.
5. Elaborate the different aspects of the project scope in detail.
6. Discuss in detail about scope verification.
7. How "DISCO" is relevant to the project objectives.
8. Explain in detail about the project infrastructure.
9. Compare External vs Internal deliverables using example.
10. Write a short note on:
    (a) Noun-type Approaches
    (b) Verb-type Approaches

Further Readings

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- Bob Hughes, Mike Cotterell, Software and Project Management, Tata McGraw-Hill Publishing Company Limited, Fifth Edition, 2009.

Web Links

- Project Scope 101 - ProjectManager
- Project Scope Statement: How to Write One With Examples - ProjectManager
- Project scope — definition, best practices, examples, and more (adobe.com)
- Software Engineering | Software Project Management (SPM) - GeeksforGeeks
- Work Breakdown Structure (WBS): What Is It? [2023] • Asana
- What is a Work Breakdown Structure (WBS) | Project Management

Unit 03: Project Planning

CONTENTS

Objectives

After studying this unit, you will be able to:

- get an overview of project planning.
- learn the planning fundamentals and need of project planning.
- know about the steps in project planning.
- explore the project planning tools and software.

Introduction

The development process of a software project can be broadly divided into two distinct phases: the planning phase and the execution phase. In the planning phase, all of the necessary tasks are identified and scheduled. The development team then works on completing these tasks in the execution phase.

Project planning refers to the phase in project management in which you determine the actual steps to complete a project. This includes laying out timelines, establishing the budget, setting milestones, assessing risks, and solidifying tasks and assigning them to team members. Project planning is the second stage of the project management lifecycle. The full cycle includes initiation, planning, execution, monitoring and closing. The five phases of the project life cycle are depicted in Figure 1.

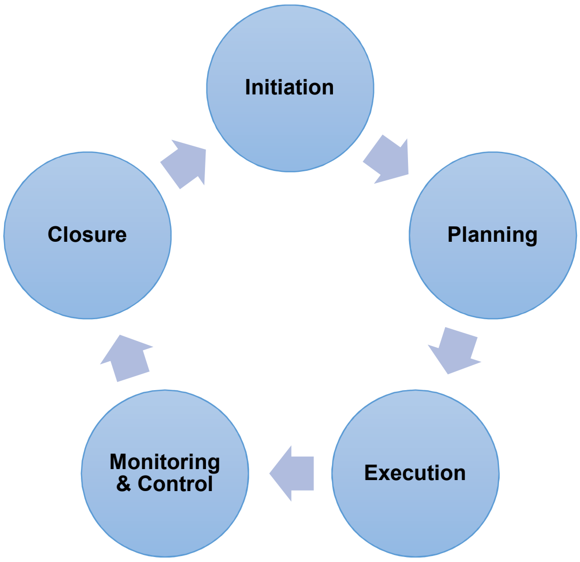

Figure 1: Phases of Project Life Cycle

Any project, whether big or small, has the potential to be very complex. It's much easier to break down all the necessary inclusions for a project plan by viewing your project in terms of phases. The Project Management Institute, within the Project Management Book of Knowledge (PMBOK), have identified the following 5 phases of a project:

- Initiation: The start of a project, in which goals and objectives are defined through a business case and the practicality of the project is determined by a feasibility study.
- Planning: During the project planning phase, the scope of the project is defined by a work breakdown structure (WBS) and the project methodology to manage the project is decided on. Costs, quality and resources are estimated, and a project schedule with milestones and task dependencies is identified. The main deliverable of this phase is the project plan.
- Execution: The project deliverables are completed during this phase. Usually, this phase begins with a kick-off meeting and is followed by regular team meetings and status reports while the project is being worked on.
- Monitoring & Controlling: This phase is performed in tandem with the project execution phase. Progress and performance metrics are measured to keep progress on the project aligned with the project plan.
- Closure: The project is completed when the stakeholder receives the final deliverable. Resources are released, contracts are signed off on and, ideally, there will be an evaluation of the successes and failures.

Planning is the trickiest process in project management. There are some basic steps in project planning. The main step in project planning is to plan in outline first and then in more detail. The key to an effectual project is in the planning. During the project planning stage, the project manager creates a project plan, which maps out project requirements. The project planning phase typically includes setting project goals, designating project resources, and mapping out the project schedule.

Generating a project plan is the first thing you should do when undertaking any kind of project. Often project planning is ignored in favor of getting on with the work. Though, many people fail to realize the value of a project plan in saving time, money, and many problems. It is important to track the progress of analysis phases of programming to ensure that the project is on track. Tracking allows managers to see where the project stands in progress and identify potential issues. There are a variety of tools that can be used for tracking, such as Gantt charts and project management software.

Benefits of Project Planning

Project planning is important because it helps form the steps needed to complete a project successfully. The planning helps teams avoid potential problems and roadblocks to ensure the project stays on track.

Project planning ensures project success and timely delivery, a crucially important function in any technical organization. The striving toward a perfect plan will help increase the probability of customer satisfaction and their trust in the organization for future investments. It's the most crucial step in the reduction of risk and project failures. After all, every project manager knows that no one gets points for a brilliant idea if the execution ultimately fails.

These are some benefits of a good project plan:

- Helps ensure projects are completed on time, within budget, and to the required standard.
- Facilitates effective communication between all members of a project team.
- Helps identify potential risks and issues at an early stage.
- Helps you communicate your vision and objectives to your team.
- Keeps everyone focused on the goal.

Project planning ensures monitoring of the budget and schedule at every step. The project plan includes a schedule that guides team members in completing their tasks and helps them in knowing which tool they will need and when. It also helps the team stay engaged for higher project performance. The project plan ensures there is the active participation of all the team members and allows them to have an opportunistic approach towards their work.

Project planning ensures timely testing of the output at every step. When successfully implemented, everyone on the project team can foresee problems before they happen. This creates efficiencies and ensures the successful execution of the plan. Additionally, project planning helps analyze, prioritize, and ensure an appropriate plan for all kinds of risks.

Proper planning ensures that if there is more than one risk, they can be prioritized and dealt with accordingly. This step ensures that nothing will fall apart, and the plan makes it easy for the project team to remember all the crucial details and deadlines.

Documents in Project Planning

Project planning consists of the following documents:

Project Charter: Provides a general overview of the project. It describes the project's reasons, goals, objectives, constraints, stakeholders, among other aspects.

Statement of Work: A statement of work (SOW) defines the project's scope, schedule, deliverables, milestones, and tasks.

Work Breakdown Structure: Breaks down the project scope into the project phases, subprojects, deliverables, and work packages that lead to your final deliverable.

Project Plan: The project plan document is divided in sections to cover the following: scope management, quality management, risk assessment, resource management, stakeholder management, schedule management and the change management plan.

3.1 Project Plan

A project plan—sometimes called a work plan—is a blueprint of the goals, objectives, and tasks your team needs to accomplish for a specific project. The project plan should include information about the project schedule, scope, due dates, and deliverables for all phases of the project lifecycle. But not all project planning processes are created equal—which leads some teams to underutilize them or skip over them completely. To write an effective project plan, one needs to be methodical (follow a series of steps), specific, and clear when it comes to the ideas and execution strategy.

A project plan is a series of formal documents that define the execution and control stages of a project. The plan includes considerations for risk management, resource management and communications, while also addressing scope, cost and schedule baselines.

Project planning software is used by project managers to ensure that their plans are thorough and robust. Project manager allows you to make detailed project plans with online Gantt charts that schedule task dependencies, resource hours, labor costs, milestones and more. The project plan, also called project management plan, answers the who, what, where, why, how, and when of the project—it's more than a Gantt chart with tasks and due dates. The purpose of a project plan is to guide the execution and control project phases.

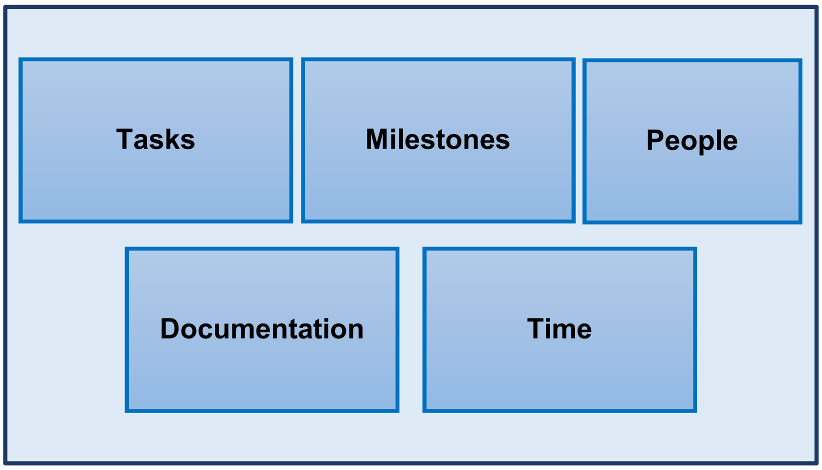

Figure 2: Components of a Project Plan

Components of a Project Plan

During the planning phase of the project management lifecycle, you'll determine the steps to achieve your project goals. This is the "how" of completing the project. The components of project planning are (Figure 2): tasks, milestones, people, documentation, and time. This step involves outlining your project scope, objectives, and timeline to make sure all stakeholders are on the same page.

- Tasks: Tasks are activities that need to be accomplished within a set period of time. These are assigned to different members of the team according to their role and skill set.
- Milestones: To go along with tasks, milestones are important points within the schedule that indicate progress. They tend to signify the completion of a deliverable or phase of the project.
- People: A project plan also includes the people working on your team and their roles. It's important that each team member understands their role and the tasks they're responsible for completing. Ensuring that everyone is clear on their assigned tasks frees you up to focus on managing the project, ultimately creating a sense of personal responsibility for team members.
- Documentation: During the project planning phase, it is a good idea to draft a project plan that links to relevant documentation. Besides your project plan, you can include documents like a RACI chart (Responsibility Assignment Matrix), which defines roles and responsibilities for individuals on your team. Another document is your charter which defines the project and outlines the details needed to reach your goals. You can include a budget and risk management plan, if relevant.
- Time: Project plans should include the estimated duration of the project. How much time will be spent on each part? The schedule will be the anchor of your project plan. It includes dates for starting and completing tasks, and dates (deadlines) for reaching specific milestones. Indicating the project's start and end dates will help situate this project among competing priorities and helps determine resources (including people) needed and when one will need them.

Project Plan vs Other Project Elements

- Project plan vs. work plan: A project plan and a work plan are the same thing. Different teams or departments might prefer one term or another—but they both ultimately describe the same thing: a list of big-picture action steps you need to take to hit the project objectives.
- Project plan vs. project charter: A project charter is an outline of the project. Mostly, one uses project charters to get signoff from key stakeholders before the start. Which means the project charter comes before the project plan. A project charter is an outline of a simple project plan—it should only include the project objectives, scope, and responsibilities. Then, once the charter has been approved, one can create a project plan to provide a more in-depth blueprint of the key elements of your project.

- Project plan vs. project scope: The project scope defines the size and boundaries of the project. As part of the project plan, one should outline and share the scope of the project with all project stakeholders. If one is ever worried about scope creep, one can refer back to the pre-defined scope within the project plan to get back on track.
- Project plan vs. agile project: Agile project management is a framework to help teams break work into iterative, collaborative components. Agile frameworks are often run in conjunction with scrum and sprint methodologies. Like any project, an Agile project team can benefit from having a project plan in place before getting started with their work.
- Project plan vs. Work Breakdown Structure: Like a project plan, the work breakdown structure (WBS) helps with project execution. While the project plan focuses on every aspect of the project, the WBS is focused on deliverables—breaking them down into sub-deliverables and project tasks. This helps to visualize the whole project in simple steps. Because it's a visual format, your WBS is best viewed as a Gantt chart (or timeline), Kanban board, or calendar—especially if one is using project management software.

How Do You Create a Project Plan?

The following steps will ensure that the project will be executed properly:

Define Stakeholders: Anyone with an interest in the project is a stakeholder. Thus, any person, organization, or party interested in a company or its actions' results is considered a stakeholder.

Define Roles: Stakeholders have a variety of responsibilities within the business. They may occasionally participate in making decisions, bringing in money, and performing other duties.

Introduce Stakeholders- It is essential to schedule formal or informal meetings with each team member at various points throughout the project. Before the project starts, issues like scope, budget, goals, schedule, and roles should be discussed.

Set Goals- Setting goals is essential to prepare for personal change and achieve project goals. It serves as a basis for managing performance and motivates and focuses attention.

Prioritize Tasks- One needs to set tasks in order of importance. Also, the more significant task can be simplified into smaller objectives and tasks.

Create a Schedule- Set up a system to make sure when deadlines are missed, corrective actions are taken. The timeline may need to be modified, considering the objectives.

Assess Risks- A risk is a potential issue with the project that may or may not materialize. To avoid being caught off guard later, it is crucial to identify risks in project management and mitigate them during the project planning phase.

Communicate- Setting up reliable communication lines and expectations for project communication is essential. Hold a meeting or solicit opinions from each team member regarding the risks you should consider.

Reassess- Reevaluate everything once one has reached the halfway point or other significant milestones. Doing so helps one assess which areas are doing well in and which require more effort. The original plan may need to be modified after revaluation.

Final Evaluation- One needs to reflect on the project once it is finished. Learn from the areas of weakness and focus more on improving the ones where one has performed better. The likelihood of project success goes up as a result.

3.2 Step Wise Project Planning

The project manager is responsible for planning and scheduling project development. They manage the work to ensure that it is completed to the required standard. They monitor the progress to check that the event is on time and within budget. The project planning must incorporate the major issues like size and the cost estimation scheduling, project monitoring, personnel selection evaluation & risk management. Figure 3 shows the stepwise project planning scenario.

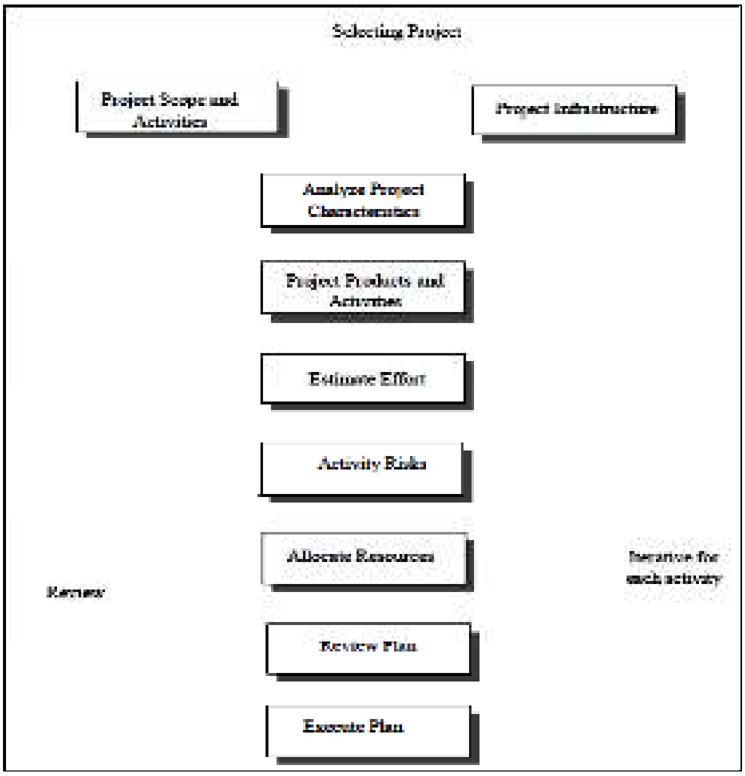

Figure 3: Stepwise Project Planning

Selecting project

This is the initial step which starts well outside the project planning process. The feasibility study of the project helps in choosing the appropriate one. The strategic planning process helps in evaluating the metrics of selecting the project. The different methodologies are inevitable, stemming directly from the questions of what constitutes a methodology and what are a methodology's underlying principles.

The projects differ according to size, composition, priorities, and criticality. The people on a project have different biases based on their experiences, principles, and fears. These issues combine so that what is optimal differs across projects. The projects are undertaken to produce a product or a service for various reasons. This includes factors like market share, financial benefits, return on investment, customer retention and loyalty, and public perceptions. The organizations might receive several projects at a time. They must select the best among the received projects requests. They can make decisions based on the best information they have about a particular project at a given point of time when selecting the project.

Project scope & objectives

Every stakeholder involved in the project must agree on the objectives defined in determining the success of the project. The scope statements may take many forms depending on the type of project being implemented and the nature of the organization. The scope statement details the project deliverables and describes the major objectives. The objectives should include measurable success criteria for the project. The scope statement should be written before the statement of work and it should capture, in very broad terms, the product of the project, for example, "developing a software-based system to capture and track orders for software".

The scope statement should also include the list of users using the product, as well as the features in the resulting product. As a baseline scope statement should contain:

- The project name
- The project charter
- The project owner, sponsors, and stakeholders
- The problem statement
- The project goals and objectives
- The project requirements
- The project deliverables
- The project non-goals
- Milestones
- Cost estimates

In more project-oriented organizations, the scope statement may also contain these and other sections: Project scope management plan; Approved change requests; Project assumptions and risks; Project acceptance criteria; The project objectives are identified, and practical measures are analyzed in achieving them; A project authority must be identified to have an overall authority over the project.

It must identify the different stakeholders involved in the development of the project. The changes in the objectives must be in a controlled manner. The interaction and communication among all parties must be straight forward.

Project infrastructure

Project Infrastructure refers to the organizational structure, processes, tools, techniques and training an organization puts in place to make projects more successful.

- Organizational Structure– Organizational structure including such support mechanisms as project management office, project recruiting function, financial monitoring area etc. It also covers lines of communication and escalation.
- Processes– Typically methodologies, checklists, and guidelines.
- Tools– Software and templates.
- Techniques– Repeatable processes such as kick off meetings, PIRs, analysis techniques, etc.
- Training– Formal and informal training and reference documentation.
- Organization must give priorities for multiple projects to be carried out.

In this phase, the strategic decisions must be documented within the strategic plan in identifying the relationship between multiple projects. Change control must be implemented without affecting the original objectives. Configuration and procedural standards are defined for quality checks at regular intervals of the SDLC process and documented in a separate manual. The measurement programme determines the control policy and monitors the progress of the project.

The project manager must have overall control of any project planning and control standards adopted. The project leader takes the responsibility of building the project team as an organized, well-built, and effective one yielding excellent result. The team members must work together as a team and resolve conflicts.

Analyze Project Characteristics

The project is categorized as either product-driven or objective-driven. A project has several characteristics:

- Projects are unique.

- Projects are temporary in nature and have a definite beginning and ending date.
- Projects are completed when the project goals are achieved, or it's determined the project is no longer viable.
- A successful project is one that meets or exceeds the expectations of the stakeholders.
- As the system is developed, the product is driven out of the defined objectives.
- The project must be analyzed based on its quality requirements.
- Projects are prone to higher risk which needs to be handled without affecting the product created.
- In implementing the product, user requirements are given due importance.
- Appropriate methodology and SDLC process must be chosen to suit the current product.
- Review the overall resource estimates.

Project Products and Activities

- Identify the project deliverables, that is, the product that has to been given over to the client.
- Some products are identified as intermediate products during the creation of deliverables.
- Project products can be system products, module products or management products.
- **Technical products** include training materials and operating instructions in managing the quality of the project.
- Describe the project products into components and sub-components related to individual modules in each step.
- Every activity must be carried out for each stage of the development process.

o **Management products** include progress of the project that is developed.

o Product descriptions contain the identity, purpose, derivation, composition, form, relevant standard and the quality criteria that apply (Figure 4).

Notes: Not all products are independent. Some products depend on other products for their creation.

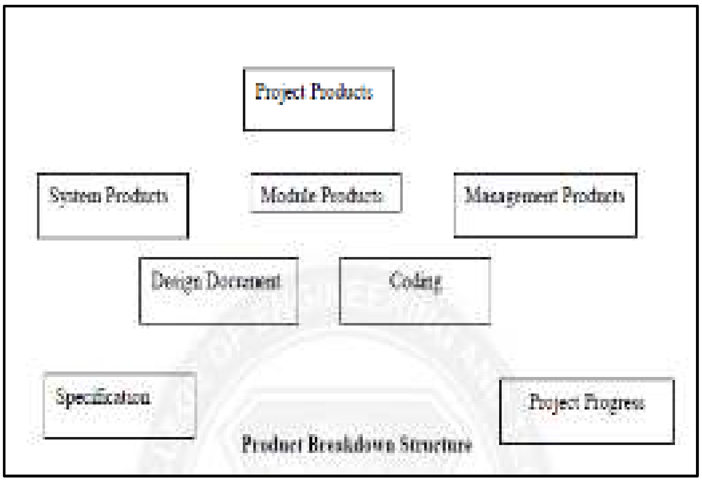

Figure 4: Product Breakdown Structure

Product flow diagram represents the flow of the product being developed.

Product instances must be recognized when a product is related to more than one product.

An activity network (Figure 5) is created for generating the product that depends on another product describing every task associated with it. The sequencing of activities minimizes the overall duration for the project. For a complex project, the entire project can be divided into stages and checkpoints can be formulated at each specific stage for compatibility. The milestones represent the completion of important stages of the project.

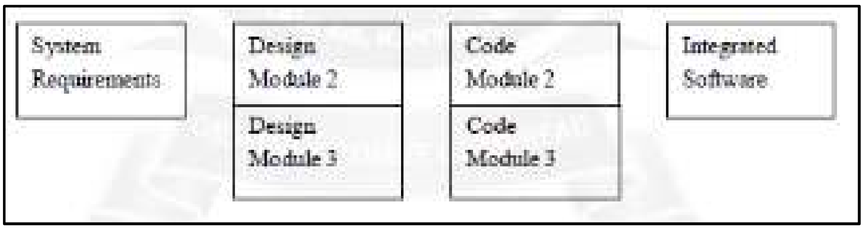

Figure 5: Sample Activity Network

Estimation Effort

The effort estimation for the staff required the probable duration and the non- staff resources needed for every activity is determined. These estimates depend on the type of activity. The effort is the amount of work that must be done. The software development efforts estimation is the process of predicting the most realistic use of effort required to develop or maintain software based on incomplete, uncertain and/or noisy input.

Effort estimates may be used as input to project plans, iteration plans, budgets, investment analyses, pricing processes and bidding rounds. The elapsed time is the time between the start and end of a task. With all the activities defined, the overall duration of the project can be calculated using the activity network. For longer activities, it will be difficult to control the project over estimating factors.

There are many ways of categorizing estimation approaches. The top-level categories are the following:

- Expert estimation: The quantification step, that is, the step where the estimate is produced based on judgmental processes.
- Formal estimation: The quantification step is based on mechanical processes, example, the use of a formula derived from historical data.
- Combination-based estimation: The quantification step is based on a judgmental or mechanical combination of estimates from different sources.

The uncertainty of an effort estimate can be described through a prediction interval (PI). An effort PI is based on a stated certainty level and contains a minimum and a maximum effort value. The most common measures of the average estimation accuracy is the MMRE (Mean Magnitude of Relative Error), where MRE is defined as:

$$\text{MRE} = |\text{actual effort} - \text{estimated effort}| \ / \ |\text{actual effort}|$$

Psychological factors potentially explain the strong tendency towards over-optimistic effort estimates that need to be dealt with to increase accuracy of effort estimates. These factors are essential even when using formal estimation models because much of the input to these models is judgment-based. The factors that have been demonstrated to be important are: Wishful thinking, anchoring, planning fallacy and cognitive dissonance. The psychological factors found in work by Jorgensen and Grimstad describes,

- It's easy to estimate what you know.
- It's hard to estimate what you know you don't know.
- It's very hard to estimate things that you don't know you don't know.

Activity Risks

The activity-based risks are identified for every activity based on a number of assumptions. Risk planning reduces the impact of identified risks. To realize the risk, contingency plans are specified. The new activities can reduce risks to a certain extent when there is a change in plans. The risks fall into three broad categories— controllable known, uncontrollable known and unknown. The former two are those risks that happen before they can determine how to manage them. This is done using root cause analysis. As the name implies, its goal is to look for the root cause on the problem and solve it at that point. The four ways of handling risk are:

- Avoidance- Take action to avoid the risk.
- Mitigation- Define actions to take when the risk occurs.
- Transfer- Have someone else handle the risk, that is, insurance.
- Acceptance- Identify the risk as acceptable and let it happen.

Determining which option to choose is primarily financial, but schedule and manpower may be involved. As a tool, several "checklist" opinions for looking at each of these options. The contingency planning is briefly discussed for scope, resource, and schedule.

Allocate Resources

Resource allocation is used to assign the available resources in an economic way. It is part of resource management. In project management, resource allocation is the scheduling of activities and the resources required by those activities while taking into consideration both the resource availability and the project time. The staff needed and available are identified for each activity and allocated their respective tasks. The staff priority list is generated based on the task allotted to them because some staff are used for more than one task.

A Gantt chart pictorially represents when activities must take place, and which one must be executed at the same time. The chart describes when staff will be carrying out the tasks each month. It also shows staff involved in more than one task. When allocating resources, the constraints associated is estimated and included in the overall cost.

Review Plan

When a task is completed, it leads to a quality review. These quality checks must be passed before the activity is completely signed-off. Every plan must be documented and all stakeholders must have agreed to all constraints and understand the project. There are some steps involved in project plan review:

- Define the problem.
- Determine the focus.
- Select the appropriate tools.
- Identify the participants.
- Document the review plan.

Define the problem**:** This activity provides the background for decisions about the scope and focus of the Project Review. Here are some simple questions the Project Review Team can ask themselves before creating a plan for the project. Use a planning tool to capture the background on the project.

- What, if any, review work has already been done?
- What is the problem we are trying to solve?
- What would success look like?
- Scope the Project. How big was it? How long did it take? How many people were involved?
- What is the investment the team would like to make?

Determine the focus: The focus of the Project Review is the question that the team will ask themselves as they investigate the events that occurred during the project. This is the fundamental question that will guide the decisions that the team will make while planning the Project Review. It is always stated as a question. A commonly used question that project teams ask is:

What are the root causes of events that determined or impacted resources, schedule, or quality?

Select the appropriate tools: Now that the scope, the goal, and the problem are known, the data set needed for the project review is identified along with the various activities that will used.

Identify the participants: The project review leadership team guides the Postmortem effort. As a group they determine the focus if the investigation, select the tools that will be used, review the output from each step, decide who should participate in each activity, and are responsible for reporting lessons learned and recommendations for action.

The Project Review Team usually consists of the movers and shakers that drove the project or event. They work together to manage the project review process. The team should consist of folks most intimate with the project including any of the following representatives: Project Managers; Product Managers; Development Leads; Quality Leads; Content Experts; Customer Support Leads; Management.

Document the review plan: The project review template can be used so that everyone responsible for implementation has a copy of the plan.

Execute Plan

Finally, the execution of the project is drawn with each specified activity as it is approached. The detailed planning of later stages is necessary because more information will be available than the start stage. The project planning and execution becomes an iterative process whereas each activity which is to be carried out approaches, they should be reviewed in detail.

3.3 Project Planning Tools

Project planning tools can be manual using tangible items like pen and paper. They can also be software tools that produce visual elements that can connect teams across departments and time zones. Project planning tools help everyone concerned keep track of project requirements and deadlines. Project planning tools has become an invaluable tool for project managers in recent years, as it provides them the ability to maintain and automate the components. Some of the most popular project planning tools include the following:

- Gantt chart
- Critical Path Method (CPM)
- PERT Chart
- Work Breakdown Structure (WBS)
- Project Documentation
- Risk register

Gantt chart

Figure 6: Sample Gantt Chart

A Gantt chart is the most essential tool for the project planning process. Gantt charts are an industry standard that helps in tracking both time and interdependencies between tasks.

Gantt charts are an essential tool to show different phases, jobs, and resources involved in project management. It helps to organize the tasks; add their duration and they automatically populate a project timeline. The supports setting the milestones to break the larger project into manageable phases, and link task dependencies to avoid bottlenecks later in the project.

Gantt charts typically show you the timeline and status—as well as who's responsible—for each task in the project (**Error! Reference source not found.**). Example details a Gantt chart enables to capture briefly can include:

- How a project breaks down into tasks?
- When will each task begin and end?
- How long each task will take?
- Who's assigned to each task?
- How tasks relate to and depend on each other
- When important meetings, approvals, or deadlines need to happen?
- How work is progressing in a project?
- The full project schedule from start to finish?

The 8 basic components in a Gantt chart are (Figure 7):

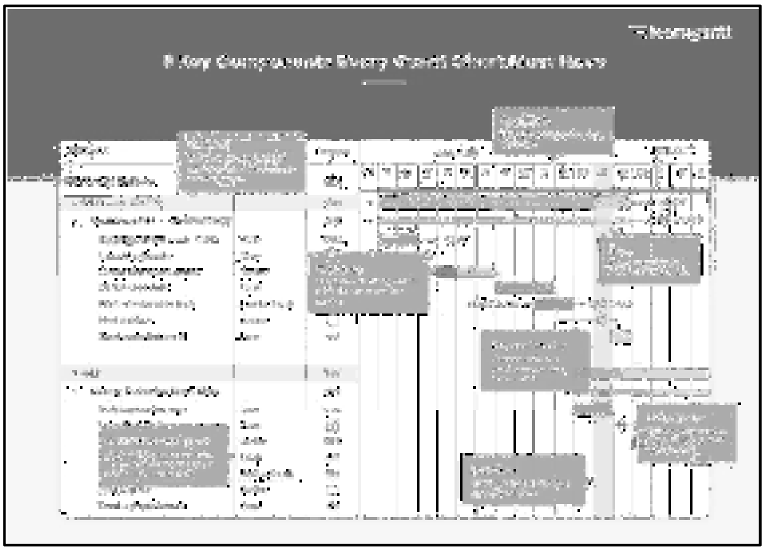

Figure 7: Basic Components in a Gantt Chart

1. Task list: Runs vertically down the left of the Gantt chart to describe project work and may be organized into groups and subgroups.
2. Timeline: Runs horizontally across the top of the Gantt chart and shows months, weeks, days, and years.
3. Dateline: A vertical line that highlights the current date on the Gantt chart.
4. Bars: Horizontal markers on the right side of the Gantt chart that represent tasks and show progress, duration, and start and end dates.
5. Milestones: Yellow diamonds that call out major events, dates, decisions, and deliverables.
6. Dependencies: Light gray lines that connect tasks that need to happen in a certain order.
7. Progress: Shows how far along work is and may be indicated by percent complete and/or bar shading.
8. Resource assigned: Indicates the person or team responsible for completing a task.

Critical Path Method (CPM)

Critical Path Method (CPM) is a crucial tool for determining the progress of the project to ensure that the project is on schedule. CPM helps in determining the essential or critical path by finding out the longest stretch of dependent tasks. In project management, the critical path is the longest sequence of tasks that must be completed to execute a project. The tasks on the critical path are called critical activities because if they're delayed, the whole project completion will be delayed. To find the critical path, project managers use the critical path method (CPM).

The critical path method (CPM) is a project management technique that's used by project managers to create an accurate project schedule. The CPM method, also known as critical path analysis (CPA), consists in using the CPM formula and a network diagram to visually represent the task sequences of a project. Once these task sequences or paths are defined, their duration is calculated to identify the critical path.

Finding the critical path is very helpful for project managers because it allows them to:

- Accurately estimate the total project duration.
- Estimate the time that's necessary to complete each project task.
- Identify critical activities which must be completed on time and require close supervision.
- Find out which project tasks can be delayed without affecting the project schedule by calculating slack for each task.
- Identify task dependencies, resource constraints and project risks.
- Prioritize tasks and create realistic project schedules.

PERT Chart

The Program Evaluation and Review Technique (PERT) helps in analyzing the tasks to complete the project and the time required to complete those tasks. PERT simplifies the planning and scheduling of large and complex projects. PERT is a procedure through which activities of a project are represented in its appropriate sequence and timing. It is a scheduling technique used to schedule, organize and integrate tasks within a project. PERT is basically a mechanism for management planning and control which provides blueprint for a particular project. All the primary elements or events of a project have been finally identified by the PERT.

Characteristics of PERT- The main characteristics of PERT are as following:

- It serves as a base for obtaining the important facts for implementing the decision-making.
- It forms the basis for all the planned activities.
- PERT helps management in deciding the best possible resource utilization method.
- PERT takes advantage by using time network analysis technique.
- PERT presents the structure for reporting information.
- It helps the management in identifying the essential elements for the completion of the project within time.

Advantages of PERT- It has the following advantages:

- Estimation of completion time of project is given by the PERT.
- It supports the identification of the activities with slack time.
- The start and dates of the activities of a specific project is determined.
- It helps project managers in identifying the critical path activities.
- PERT makes well organized diagram for the representation of large amount of data.

CPM vs. PERT

The critical path method (CPM) and program evaluation and review technique (PERT) are both project scheduling techniques. But they aren't interchangeable. PERT is used to get accurate time estimates for complicated projects. It uses an algorithm to calculate the estimated duration for unpredictable activities. It focuses on events and milestones on a PERT chart with nodes in the wireframe when developing projects.

However, while these are two different techniques, PERT and CPM can be used together for project planning and scheduling. The difference between them lies in that PERT is about time planning and time management, while CPM is about time and budgeting. PERT delivers a project quickly and CPM gets the project done on budget and on time.

PERT chart vs. Gantt chart

PERT and Gantt charts are both visual tools that help to plan projects. They help to keep the team organized and on track. PERT charts help to understand the task dependencies. The Gantt charts work best when tasks are clearly defined with a clear beginning and end date. Typically, one will use a PERT chart to help map out all of the tasks and milestones involved in a given project, then use it to create the Gantt chart. They are complementary tools.

Work Breakdown Structure (WBS)

Work Breakdown Structure (WBS) is a process of organizing the team's work into manageable sections. WBS is a hierarchical structure of the deliverables needed to complete the project. WBS is a visual project breakdown. Beginning with the scope of work, the WBS shows the deliverables and how they connect back to the overarching project. A WBS visually organizes project deliverables into different levels based on dependencies. It’s essentially a project plan in a visual form, with project objective at the top, then dependencies and sub-dependencies below.

Since a work breakdown structure is displayed visually, it can be created using a combination of workflow management software and project management frameworks. Some of these methods include timelines, Kanban boards, and calendars.

WBS is a tool that helps to organize a project by hierarchy. With a WBS, one can break down deliverables into sub-deliverables to visualize projects and outline key dependencies. Every work breakdown structure is made up of a few parts:

- A project baseline or scope statement, which includes a project plan, description, and name.
- Project stakeholders.
- An organized project schedule.
- Project deliverables and supporting subtasks.

The project managers use work breakdown structures to help teams to break down complex project scopes, visualize projects and dependency-related deliverables, and give team members a visual project overview as opposed to a list of to-dos.

Project Documentation

The project documentation is created during the project lifecycle, which involves project scope, its schedule, and the risk analysis. The project documents help in better understanding and risk analysis of the project.

Risk register

A chart that lists risks associated with the project, along with their probability, potential impact, risk level, and mitigation plans.

Notes: A Gantt chart and a risk register can be conceived manually or on software.

3.4 Project Planning Software

Project planning software is a great tool to facilitate project management processes such as schedule development, team management, cost estimation, resource allocation and risk monitoring. The planning software also allows managers to monitor and track their plan as it moves through the execution phase of the project. These features include dashboards, for a high-level view of the project’s progress and performance, and in-depth reports that can be used to communicate with stakeholders.

Project planning software comes in all different sizes and shapes. There are some that focus on a single aspect, and others that offer a suite of planning features that can be used in each one of the project planning steps.

Notes: What's right for the project depends on the specific needs, but in general terms, project planning software is a much more powerful tool than project planning templates.

Benefits of Online Project Planning Software

The online project planning software is highly flexible and adaptable to the team's style of work. It has features that are designed to assist throughout the project planning process. Before the rise of planning software, project managers would typically have to keep up with a disjointed collection of documents, excel spreadsheets and so on. The savvy managers, however, make use of the project management tools available to them to automate what they can, and streamline what they can't. Some of the benefits are:

- Organize, prioritize, and assign tasks.
- Plan and schedule milestones and task dependencies.
- Monitor progress, costs, and resources.
- Collaborate with team.
- Share project plans with team and stakeholders.
- Generate reports on plans.

Different Project Planning Software

Asana**:** This is a great option for small businesses, because it offers features like task management, time tracking, and file sharing. One can create projects and assign tasks to team members. It even has a built-in calendar so one can plan the upcoming workload.

Asana is a software-as-a-service platform designed for team collaboration and work management. The teams can create projects, assign tasks, set deadlines, and communicate directly within Asana. It also includes reporting tools, file attachments, calendars, and goal tracking. In 2022, Asana released features for team organization; this included My Goals, Automatic Progress Updates, and integrations for Google Workspace and Figma.

Features of Asana:

- Visualize the work the way one wants: Asana is built for everyone, not just spreadsheet users, so one can plan and structure work anyone wants.
- Involves boards, list, timelines, and calendar.
- Break work into manageable pieces for the team.
- Break up a task into smaller parts or show additional steps to complete an overall task.
- Helps to visualize significant checkpoints in a project to measure and share progress.
- Give tasks a clear owner, so everyone knows who's responsible.
- Use an embedded timer or manually track the time spent on tasks to support resourcing and view project progress.
- Add files from the computer, Dropbox, Box, or Google Drive to any task or conversation.
- Helps to sync tasks across projects: Keep the same task in multiple projects to see work in different contexts without duplicating efforts.

o Analyze the task dependencies: Task dependencies make it clear which tasks are ready to start, and which tasks are waiting on others.

o Offers portfolios, dashboards, calendar views etc.

ClickUp: ClickUp is a cloud-based software for managing projects, teams, and tasks. ClickUp is a popular project management tool suitable for all types of businesses and team sizes across various industries looking to collaborate on the cloud. One can create projects, organize tasks, assign tasks to team members, track progress, and much more. ClickUp also offers integrations with other popular apps, including Trello, Jira, Google Docs, and Slack.

ClickUp comes with hundreds of features that can be customized for any work need—with more added every week. And they're all free, forever. ClickUp's unique hierarchy helps to create the perfect structure that scales with the needs. Each level of ClickUp gives more flexibility and control to organize everything from small teams to enterprise companies. It offers effective communication and collaboration tools, alerts, assigning tasks and reporting statuses, and setting the view grid. ClickUp's free plan is limited to 100 uses of custom fields, the paid versions offer unlimited uses and more space. One can create marketing campaigns, manage development sprints and create the ideal workflow for the project.

Notes: ClickUp is a highly versatile and powerful project management tool that can be used by both teams and individuals. It combines important business application features and consolidates company project data into a single online solution.

Features of ClickUp

- Time Management: Identifying what needs to be done is the first step towards managing your time effectively. Thus, it is crucial to build a system for prioritizing your work. ClickUp is all about organizing tasks to help you meet your long-term objectives, as well as prioritizing tasks that must be completed first. The project managers and business owners can easily take advantage of ClickUp's time management features, which help optimize workflows by encouraging more seamless communication.
- Mobile Compatibility: Quick action is made easy with ClickUp mobile. Users can access ClickUp on any device, keeping them updated on projects wherever they are. The ClickUp mobile experience provides the same value to its users as desktop, without compromising on quality or user-friendliness. Through the app, users can organize tasks, edit them easily, interact with their team, view all of their to-dos at once and stay informed thanks to push notifications.
- Tagged Comments: When someone is tagged in a comment, their name will be highlighted in their notification feed. They also automatically become a "watcher," a user who gets notified whenever there are changes in the task. This helps team members prioritize the most important action items and increases oversight of critical project tasks. The users can group, filter and assign tasks in their preferred order using the tag functionality. Tags make it easy to share task information across your workspace, which improves overall workflow.
- Views & Collaboration: With ClickUp, users can choose from nine different view types, including list, board, table, box, calendar view, Gantt, activity, timeline and workload view. ClickUp encourages collaboration through team reporting, real-time editing, real-time syncing, comment editing, mentions and multiple assignees. The software also supports emojis, screenshot editing, comment assignment, discussions, setting comment reminders, sharing and quoting.
- Free Use: The most basic version of ClickUp is available for free and is surprisingly robust. When compared to its competitors, even advanced features and views, like Gantt Charts and automations, are included in ClickUp's free plan.

Freedcamp**:** Freedcamp is a web-based project management tool designed specifically for people who need help managing multiple projects at once. It features task lists, calendars, file sharing, and other features needed by teams who want to collaborate on a project simultaneously.

Hive**:** This is a very simple and easy-to-use project management tool that's great for teams of any size. It offers time tracking, progress reporting, and task management features. Hive is a project management platform that was designed with users in mind, providing a user-friendly interface. One can also integrate Hive with other tools like Slack, Google Drive, and Jira.

Features of Hive

- Hive Goals for keeping the team aligned on project objectives.
- Time tracking for recording task completion.
- Native messaging app for team collaboration and communication.
- Project summaries for providing a quick overview on project details and status.
- Automation capabilities for streamlining manual processes and workflows.

The outstanding versatility and scalability make Hive work for different types of users. For example, it offers excellent collaboration tools, such as a built-in messaging app, that would work for small or large teams. In addition, it has powerful reporting and analytics tools that work for enterprises or smaller organizations looking to gain insights from project data.

Scoro

This is another popular project management tool with many great features like Gantt charts, resource planning, and issue tracking. One can also add comments on tasks, assign tasks to specific users or teams, and collaborate with them through chat.

Trello

Trello is a popular free project management app for managing projects and collaborating with teams. With Trello, one can manage projects across teams or solo efforts using cards representing tasks or ideas for future projects. The tool offers flexible sharing options so team members can collaborate on specific cards from anywhere.

Features of Trello

- Views: View the team's projects from every angle.
- Automation: Automate tasks and workflows with Butler automation.
- Power-Ups: Power up the teams by linking their favorite tools with Trello plugins.
- Templates: Give the team a blueprint for success with easy-to-use templates from industry leaders and the Trello community.
- Integrations: Find the apps the team is already using or discover new ways to get work done in Trello.

Wrike

Wrike is a project management and collaboration tool that allows you to manage projects from start to finish (Figure 8). It has a clean, easy-to-use interface and features like time-tracking and resource management. Like other tools, Wrike can integrate with other tools like Slack and Gmail. It offers spreadsheet-based User Interface (UI) and best-in-class project tracking features.

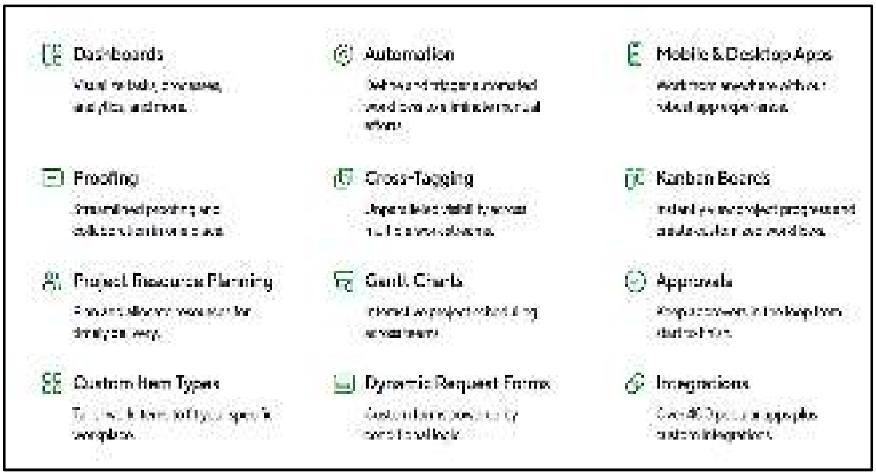

Figure 8: Features of Wrike

Summary

- Project planning refers to the phase in project management in which you determine the actual steps to complete a project.
- Planning is the trickiest process in project management. There are some basic steps in project planning. The main step in project planning is to plan in outline first and then in more detail.
- Project planning ensures project success and timely delivery, a crucially important function in any technical organization.
- Project planning ensures monitoring of the budget and schedule at every step. The project plan includes a schedule that guides team members in completing their tasks and helps them in knowing which tool they will need and when.
- The project manager is responsible for planning and scheduling project development. They manage the work to ensure that it is completed to the required standard. They monitor the progress to check that the event is on time and within budget.
- Project Infrastructure refers to the organizational structure, processes, tools, techniques and training an organization puts in place to make projects more successful.
- PERT simplifies the planning and scheduling of large and complex projects. PERT is a procedure through which activities of a project are represented in its appropriate sequence and timing.
- CPM helps in determining the essential or critical path by finding out the longest stretch of dependent tasks. In project management, the critical path is the longest sequence of tasks that must be completed to execute a project.
- WBS is a hierarchical structure of the deliverables needed to complete the project.
- A Gantt chart is the most essential tool for the project planning process. Gantt charts are an industry standard that helps in tracking both time and interdependencies between tasks.

Keywords

Project Plan: A project plan—sometimes called a work plan—is a blueprint of the goals, objectives, and tasks your team needs to accomplish for a specific project.

Project Scope: The project scope defines the size and boundaries of the project. As part of the project plan, one should outline and share the scope of the project with all project stakeholders.

PERT Chart: Program Evaluation and Review Technique (PERT) helps in analyzing the tasks to complete the project and the time required to complete those tasks.

Critical Path Method (CPM): CPM is a crucial tool for determining the progress of the project to ensure that the project is on schedule.

Work Breakdown Structure (WBS): Work Breakdown Structure (WBS) is a process of organizing the team's work into manageable sections.

Project Planning Software: Project planning software is a great tool to facilitate project management processes such as schedule development, team management, cost estimation, resource allocation and risk monitoring. The planning software also allows managers to monitor and track their plan as it moves through the execution phase of the project.

ClickUp: ClickUp is a cloud-based software for managing projects, teams, and tasks. ClickUp is a popular project management tool suitable for all types of businesses and team sizes across various industries looking to collaborate on the cloud.

Asana: Asana is a software-as-a-service platform designed for team collaboration and work management. The teams can create projects, assign tasks, set deadlines, and communicate directly within Asana.

Self Assessment

1. A project plan is also called as a _________.

A. Outlier

B. Illustrate plan

C. Demo plan

D. Work plan

2. Which of the following statement refers to project planning?

A. Project planning refers to the phase in project management in which you determine the actual steps to complete a project.

B. Project planning ensures project success and timely delivery, a crucially important function in any technical organization.

C. Project planning ensures monitoring of the budget and schedule at every step.

D. All of the above.

3. The ______________ includes a schedule that guides the team members in completing their tasks and helps them in knowing which tool they will need and when.

A. timer plan

B. timeline

C. project plan

D. worklist

4. PERT stands for

A. Program Effectiveness and Review Technique

B. Program Evaluation and Review Technique

C. Program Excessive Result Technique

D. Program Excessive Reset Technique

5. __________ refers to the organizational structure, processes, tools, techniques and training an organization puts in place to make projects more successful.

A. Project Infrastructure

B. Project objective

C. Project illustration

D. Project type

6. Which of the following statement is/are TRUE for Work Breakdown Structure (WBS)?

A. WBS is a hierarchical structure of the deliverables needed to complete the project.

B. WBS is a process of organizing the team's work into manageable sections.

C. WBS is best viewed as a Gantt chart (or timeline), Kanban board, or calendar—especially if one is using project management software

D. All the above.

7. CPM in project planning stands for

A. Critical Path Method

B. Critical Procedure Mode

C. Controlled Procedure Mode

D. Controlled Pathway Method

8. Asana is a _____________ cloud-based platform designed for team collaboration and work management in project planning.
A. database-as-a-service
B. software-as-a-service
C. monitor-as-a-service
D. metal-as-a-service

9. The project plan should include information about the different entities for all phases of the project lifecycle. The entity can be
A. project schedule
B. due dates
C. deliverables
D. All the above

10. The components in the project plan include:
A. Overload
B. Task buffer
C. Milestones
D. Shift timer

11. Which of the statement is relevant to the project plan?
A. A project plan is a blueprint of the goals, objectives, and tasks your team needs to accomplish for a specific project.
B. A project plan is a series of formal documents that define the execution and control stages of a project.
C. The plan includes considerations for risk management, resource management and communications, while also addressing scope, cost and schedule baselines.
D. All the above.

12. A __________ defines the project's scope, schedule, deliverables, milestones, and tasks.
A. project charter
B. project plan
C. statement of work
D. WBS

13. The __________ is created for generating the product that depends on another product describing every task associated with it.
A. product network
B. illustrator network
C. activity network
D. complex network

14. The statement TRUE for the estimation effort is
A. The effort estimation for the staff required the probable duration and the non- staff resources needed for every activity is determined.

B. The effort is the amount of work that must be done.

C. It is the process of predicting the most realistic use of effort required to develop or maintain software based on incomplete, uncertain and/or noisy input.

D. All the above.

15. There are many ways of categorizing estimation approaches. In the __________ approach, the estimate is produced based on judgmental processes.

A. Expert estimation

B. Formal estimation

C. Combination-based estimation

D. None of the above

Answers for Self Assessment

1.	D	2.	D	3.	C	4.	B	5.	A
6.	D	7.	A	8.	B	9.	D	10.	C
11.	D	12.	C	13.	C	14.	D	15.	A

Review Questions

1. What is project planning? How Do You Create a Project Plan?
2. What is a project plan? What are the benefits of project planning software?
3. What are the uses of project planning tools? List different project planning tools.
4. List the features of different project planning software.
5. Discuss the different phases of project life cycle in detail.
6. Which documents are obtained in the project planning.
7. Which steps are essential for project planning?
8. Compare the project plan with other project elements.
9. Indicate the components of a project plan.
10. Write a short note on:
    (a) Project Infrastructure
    (b) Work Breakdown Structure

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- 9-Step Guide for Effective Project Planning Software - Waydev

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Unit 04: Program Management & Project Evaluation

CONTENTS

Objectives

After studying this unit, you will be able to:

- understand the meaning of program management and its features.
- learn about project evaluation, individual projects, and technical assessment.
- know about the management of allocation of resources and how to follow creating the program.
- understand the concept of Cost Benefit Analysis (CBA).

- explore risk identification and evaluation.

Introduction

Program Management or Programme Management is the procedure of organizing numerous related projects, often with the meaning of improving an organization's performance. Project evaluation is an organized and objective measurement of an ongoing or completed project. The aim is to conclude the relevance and level of achievement of project objectives, development effectiveness, efficiency, impact, and sustainability. The evaluations also feed lessons learned into the decision-making process of the project stakeholders, including donors and national partners.

4.1 Programme Management

Programme Management is the procedure of managing numerous ongoing interdependent projects. An instance would be that of designing, manufacturing, and providing support infrastructure for an automobile manufacturer. This necessitates hundreds, or even thousands, of different projects. In an organization or enterprise, Program Management also reflects the emphasis on coordinating and prioritizing resources across projects, departments, and entities to make sure that resource contention is managed from a global focus. The five major features of Programme management are:

- Governance: Defining roles and responsibilities and providing oversight.
- Management: Planning and administering both projects and the overall program.
- Financial Management: Implementation of specific fiscal practices and controls.
- Infrastructure: The program office, technology, and other factors in the work environment supporting the program effort.
- Planning: Activities that take place at multiple levels, with different goals. The program plan is not a traditional plan.

1. Program Governance

Program governance is the feature of the discipline that creates both the structure and practices to guide the program and offer senior-level leadership, oversight, and control. Strategically, it encompasses the relationship between the oversight effort and the enterprise's overall business direction.

Notes: It also encompasses all the decision-making roles and responsibilities involved in executing the program effort.

Projects are usually governed by a simple management structure. The project manager is responsible for day-to-day direction, a senior IT executive integrates technology with business interests, and a business sponsor is accountable for ensuring that the deliverables align with business strategy. The programs require a more compound governing structure because they involve fundamental business change and expenditures with important bottom-line impact. In fact, in some instances their outcomes determine whether the enterprise will survive as a viable commercial/governmental entity.

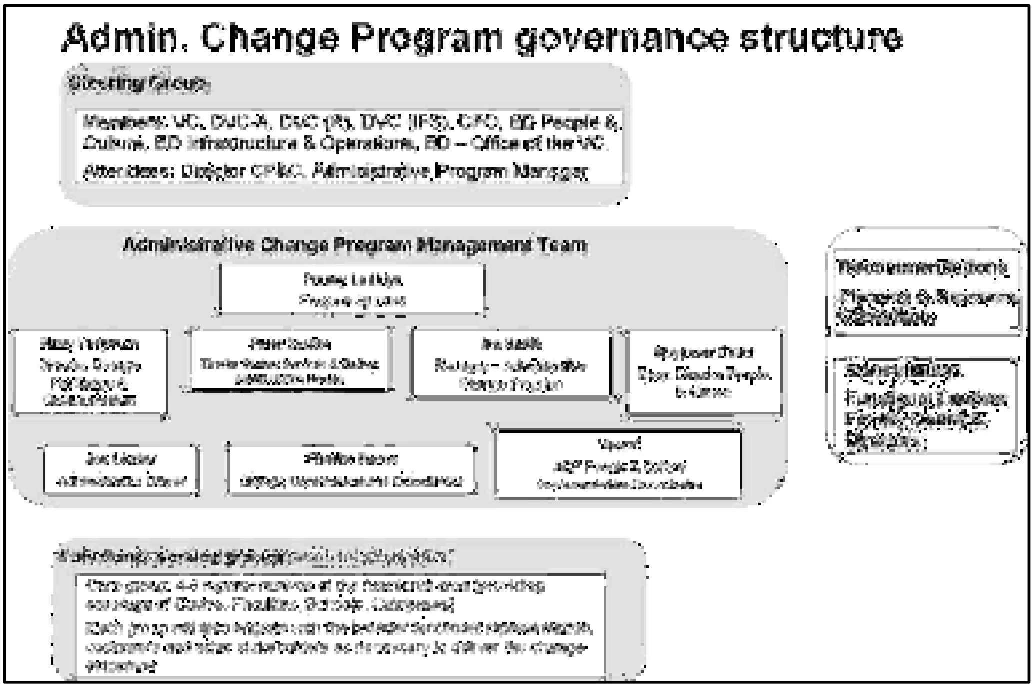


Figure 1: Sample Program Governance Structure

As depicted in the Figure 1 above, unlike most projects, programs generally have a steering committee or other group that represents different interests and provides executive level oversight. As the program evolves, this governing body ensures that it maintains to align with the enterprise's strategic direction and makes decisions that may eventually filter up to the board of directors. Defining the role and decision-making powers of the steering committee is a significant part of the program governance effort and should be done with an eye toward facilitating rapid decisions and promoting a clear, unified direction. The figure also shows a typical program management structure, which is more complex than that of a project. Creating this structure engage defining specific roles with specific decision-making authority and making clear to all who "owns" certain program functions.

Did You Know?

Good governance is dangerous to program success. A poorly articulated management structure, overlapping roles and decision-making authority, and roles filled by the wrong people (or not filled at all) can prevent a program from achieving persistent momentum or bog it down with endless attempts to achieve consensus on every decision.

2. Project management

Project management is the planning, organizing, directing, and controlling of corporation resources for a comparatively short-term purpose. Project management is concerned with the dynamic allocation, utilization, and direction of resources (both human and technical), with time— in relation to both individual efforts and product delivery schedule— and with costs, relating to both the acquisition and consumption of funding.

Notes: Without the direction project management give, work would have to go on via a series of negotiations, and/or it would not align with the goals, value proposition, or needs of the enterprise.

Within a program, these same errands (i.e., allocation, utilization, and direction) are allocated to people at three levels in the management hierarchy: the higher the level, the more common the responsibilities. For example, at the bottom of the management hierarchy, project managers are assigned to the different projects within the overall program. Each manager carries out the management responsibilities. At the core or middle of the hierarchy is the program manager/director, whose major responsibility is to ensure that the work effort attains the outcome specified in the business and IT strategies. This involves setting and reviewing objectives, coordinating activities across projects, and controlling the integration and reuse of interim work products and results. This person spends more time and effort on integration activities, negotiating changes in plans, and communicating than on the other project management activities we described (e.g., allocating resources, ensuring adherence to schedule, budget, etc.). At the top of the program management hierarchy are the program sponsor(s) and the program steering committee. Their main responsibility is to own and oversee the implementation of the program's underlying business and IT strategies, and to define the program's connection to the enterprise's overall business plan(s) and direction. Their management activities contain providing and interpreting policy, creating an environment that fosters sustainable momentum for the program (that is, removing the barriers both inside and outside the enterprise), and occasionally reviewing program progress and interim results to ensure alignment with the overall strategic vision. These individuals receive periodic summary reports and briefings on funding consumption, resources and their utilization, and delivery of interim work products and results. Typically, they will focus on these reports only if there is significant deviation from the plan.

3. Program Financial Management

The financial feature of a program comprises the need to conform to internal (and sometimes external) policies and/or regulations for significant expenditures. It also includes development and use of program-specific procedures for making and reporting expenditures. The overall costs for programs are usually considerably greater than those for projects.

For example, projects that consume one to five man-years of attempt might have an internal cost range of $250,000 to $1,000,000, assuming the resources are employees (not contractors) with an hourly charge-back rate of $100 to $150 per hour. A program to upgrade and rewrite the core software applications of a large financial services company might require between 750,000 and 1,000,000 work hours, a staff of 175 consultants and 225 employees, and expenses ranging very high.

The costs are bigger not only because the program is larger, but also as it entails more types of expenditures. In a project, the expenditures are for labor, from an accountancy viewpoint. The program costs would include labor (both internal chargeback and consulting fees, and travel and living expenses, including short-term apartment leases), hardware, packaged software applications (which may be capitalized and depreciated), workspace (perhaps construction, too), and furnishings/equipment, such as computers, servers, printers, desks, chairs, cubicles, and so on.

Enterprises have different ways to treat these expenditures, outlined in financial policies and procedures. The government agencies and regulated industries may also have laws or regulations regarding spending and expense reporting.

From an administrative point of view, the responsibilities associated with authorizing, recording, and reporting program expenditures go well beyond those typically exercised by an individual project manager. Typically, the office of the Chief Financial Officer (CFO) will be involved during the strategic definition and financial justification phases of a program. The financial analysts will construct and/or use complex financial models, see that the enterprise's financial policies are interpreted and applied correctly, and ensure that the program's financial impact is accurately represented to executives at key decision points.

The program office will typically include a role for a budget administrator who assists the program manager/director in ensuring conformance to financial policies and guidelines. One can plan and conduct a checkpoint review of the financial management apparatus and identify needs and requirements that are specific to the program. Implementing the program's financial practices may require nothing more than educating people about how to apply them.

Caution: To succeed, program financial management demands early and active engagement on the part of the CFO and his or her staff.

4. Program Infrastructure

Infrastructure is a useful term to describe collections of roles, tools, and practices that organizations assemble and integrate in order to provide services and support for software development. To understand the infrastructure required for a successful program, the management and administrative roles, tools, and practices that constitute the Program Management Office, or PMO can be explored. Then, the requirements for the technical environment and tools can be studied.

- Administrative Infrastructure:

The PMO provides administrative and management support to the program manager/director and all other program participants. It also provides specialized staff expertise for specific work areas. The PMO involves many roles covering numerous areas and activities. In addition to serving the program manager/director, the staff members, a group of senior specialists, fill essential program roles.

For large, complex programs, the PMO helps establish and maintain appropriate work processes, controls, and reporting functions to keep management apprised of the program's progress. It also defines, plans, and completes various work efforts. Example— The role of facilities administration — and how it contributes to program success. Whoever takes on this role must identify, plan, and deliver all necessary facilities for either a program-specific or permanent PMO.

To do this, the facilities administrator must:

- Work with the PMO manager and program manager to define what should be included in facilities and define and prioritize facility needs.
- Develop and gain approval for a facilities plan.
- Manage execution of the facilities plan and associated deliveries, construction, and installation.
- Collaborate closely with the infrastructure and technical environment coordinator.
- Technical Environment and Tools

A program infrastructure also includes both hardware— for desktop and network devices for storage and communication— and software, including desktop software and shared platforms with development tools, modelling software, planning tools, communication tools (email, Internet browser, virtual meeting/collaboration programs, telecommunications programs), and software for document retention and reproduction.

An individual project may introduce new tools or hardware partly in order to understand their capabilities and limitations. The project manager may become involved in technical support or infrastructure functions, to acquire, install, and/or "tune" the hardware and software. Typically, this will involve a small number of installations for a small number of IT staff. The periodic changes and/or additions to the development environment will affect larger numbers of IT staff, but these are typically defined and managed as separate projects.

Program technical activities, in contrast, usually include large numbers of staff from a variety of sources (internal and external) and various technology backgrounds. As managers identify and staff component projects in the program, they must also specify, acquire, and install technology environments and tools for each project, which collectively form the program's technical infrastructure. The infrastructure effort should be treated as an internal program project. The managers should plan a well-defined, rapid, and brief lifecycle for creating the technology environment. The effort should include defining needs and requirements, setting a scope, and installing, testing, and implementing all technologies. If some tools will be new to some portion of the program staff, it may also be necessary to define a rapid-delivery training effort.

Task: The PMO involves many roles covering numerous areas and activities. What are areas and activities they are talking about?

5. Program Planning

For program planning, most managers will typically use a bottom-up approach that identifies and executes planning iterations for the program's individual component projects. First, each project manager constructs a plan that estimates and allocates resources required to deliver the project's products or results, using the same techniques and practices they would employ in planning a standalone project. Then, in the next planning iteration, managers identify connections and dependencies among the program's projects, and refine and rework their project plans to integrate them with others.

Often this integration effort requires adjustments to the products planned for each project, the numbers and types of resources required, and— naturally— the schedule. The managers' ability to continuously manage and adjust to inter-project dependencies is a significant determinant of program success. This ability is also a major differentiator between the requirements of project planning and program planning.

Program Plan: Once the individual project plans are integrated, it is time to initiate the program planning effort. What exactly is a program plan? American Heritage Dictionary defines a plan as "A scheme, program, or method worked out beforehand for the accomplishment of an objective: a plan of attack". Typically, the program plan is a seismograph that seeks to detect and measure the potential impact of any trembling in the ground underneath the program effort. The project plans record completion percentages, expenditure of resources, and interim (or final) dates for work activities, the program plan integrates these measures and shows their collective impact. This enables managers to assess the program's progress against plan and detect potential problems.

4.2 Project Evaluation

Project evaluation is a step-by-step process of collecting, recording and organizing information about project results, including short-term outputs (immediate results of activities, or project deliverables), and immediate and longer-term project outcomes (changes in behavior, practice or policy resulting from the project).

Common rationales for conducting an evaluation are:

- response to demands for accountability.
- demonstration of effective, efficient and equitable use of financial and other resources.
- recognition of actual changes and progress made.
    - identification of success factors, need for improvement or where expected outcomes are unrealistic.
    - validation for project staff and partners that desired outcomes are being achieved.

Notes: The project planning stage is the best time to identify desired outcomes and how they will be measured. This will guide future planning, as well as ensure that the data required to measure success is available when the time comes to evaluate the project.

Why is Project Evaluation important?

Evaluating the project results is helpful in providing answers to key questions like:

- What progress has been made?
- Were the desired outcomes achieved? Why?
- Are there ways that project activities can be refined to achieve better outcomes?
- Do the project results justify the project inputs?

What are the Challenges in Monitoring and Evaluation?

- getting the commitment to do it.
- establishing base lines at the beginning of the project.
- identifying realistic quantitative and qualitative indicators.
- finding the time to do it and sticking to it.
- getting feedback from your stakeholders.
- reporting back to your stakeholders.

4.3 Managing Allocation of Resources

Powerful resource allocation is highly important and essential pertaining to any project management. The project managers can effectively monitor and balance resource workloads across multiple projects from one report.

Management of resource allocation supports:

- Assigning team members to projects by group, department or company.

- Mass assignment of team members to tasks by skill set.
- Swapping the resources on tasks with just a few mouse clicks.
- Viewing the resource allocation on work scheduled across all projects.
- Drilling down to see projects and tasks in resource allocation reports.
- Using drag and drop to balance workload of under and overburdened resources.
- Suggesting the most available resource by skill set.
- Forecasting and run 'what if' scenarios on projects in planning phase.
- Setting the default burden and bill rates at the system, project, or task level.

The project managers have the power over the management of resource allocation for software development, marketing, product development teams and more. It enables assigning the team members to business goals, projects and individual tasks in a simple and easy way using different software. There can be graphical displays that give the visibility over the entire organization to ensure that resources have the right amount of work now, and in the future. It can involve mass assigning the team members' tasks grouped by skill set, department or resource type, or handle resource allocation management for a single person.

Additionally, it is equally simple to change a resource on a set of project tasks as well. It allows resource allocation managers and project managers to use project level and/or cross project resource allocation to manage workloads in order to achieve their goals. The software applications can report and evenly divide the work (hours) among the workdays (duration) scheduled for the tasks to calculate the total work or effort assigned to a resource within a specified date range.

4.4 Efficient Resource Allocation and Workload Management

Case Study: Let us consider example for a project management software such as, "Project insight". Project Insight, a web project management software provides real-time resource allocation data based on the allocation of their assignments to project tasks system wide. In this software, the resource information may be accessed from the 'Resources' tab within a project to review the availability of resources. The project managers can also view all resources across all projects in Project Insight. This information is accessed in 'My Reports,' 'Cross Project Resource Allocation.'

The data may be hidden or displayed according to each person's preferences, supporting a wide variety of applications for these reports. Hundreds of permutations of resource allocation reports are available. Other project management software applications claim to have extensive resource allocation capabilities in their marketing materials; however, they often fall short.

Project Insight not only allows resource managers or project managers to see the total workload each resource has per day, week or other time period, it allows them to drill down on all of the projects and tasks that are causing the over allocation in one view. The tasks can easily be reassigned using Project Insight's simple drag and drop functionality. It's perfect for the management of all kinds of goals, tasks and projects including IT projects, interactive or marketing projects, product development projects, professional services and more.

Notes: All tasks are efficiently managed with proper resource allocation and tracking, down to the last detail.

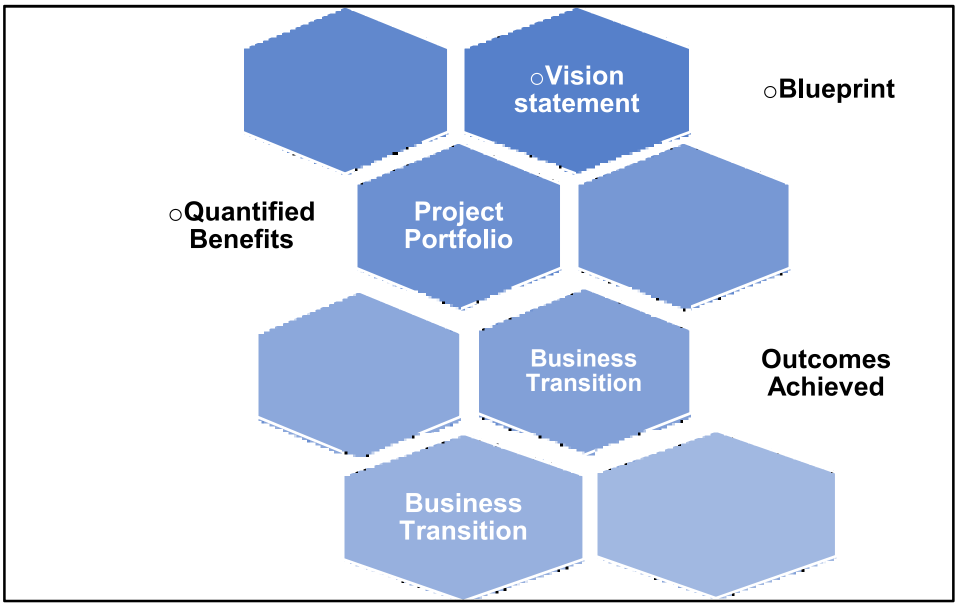
4.5 Creating Programme

Across India, there are hundreds of programmes being run, but how well are they being run and how does the sponsor know that his/her programme is in a healthy shape? There are several ways to find out, most of them costing money from consultants.

Most programmes are complex and are being run using a methodology that fits one of the following descriptions:

- Home-grown: The organisation has taught itself how to run large complex change initiatives based on its project experience.
- Proprietary methodologies from one of the big consultancies at a significant cost.
- OGC Managing Successful Programmes methodology available for public use and owned by the OGC. This is by far the dominant approach in the current marketplace.

It is noticeable there is a thread that runs through most proven methodologies and is often missing from the home-grown approach. It is called "The Golden Thread", as all the successful programmes we have come across use it, whilst less successful ones don't.



The Golden Thread

4.6 The Golden Thread

- Vision statement: The vision statement clearly sets out the direction and purpose of the programme.
- Blueprint: A detailed description and understanding of what the future state of the organisation will be like, an important step often missed. If you don't know where you are going, how will you know when you have arrived?
- Quantified Benefits: A detailed description of the benefits to be delivered, not a set of bullet points buried in a business case. This is the core of an effective Programme and can't effectively be done until you know where you are going.
- Project Portfolio: Project portfolio should be well structured to maximize the efficient use of resources, designed to deliver dividends early and effective control points to stop the programme running away with itself.
- Business Transition: Effective plans to minimize the instability caused to the business whilst remaining ambitious about the intended achievements.
- Outcomes Achieved: Focus remains, the new systems have been installed and moved to the new building, you have reached the new state, but you still will not have achieved the benefits.
- Benefits Realization: It's all too easy to declare victory before the benefits have been achieved. People still think that a miracle will occur that turns outcomes into benefits which is wrong-management intervention will still be required.

With this information, one can check and test the quality of their programme. If the key components of The Golden Thread are not in place one will undoubtedly run into trouble.

Task: Most programmes are complex and are being run using a methodology. Discuss.

4.7 Individual Projects

An individual project is an economically indivisible series of works fulfilling a precise technical function and with clearly identifiable aims. An individual project may include one or more sub-projects.

Example: The funding of individual R&D projects oriented to the market represents by far the core activity of the EUREKA network. Challenged now by the Eurostars programme for the small and medium sized enterprises also ran by EUREKA, it remains the main European funding tool for large companies and research Institutes willing to do business through technology.

Case Study: EUREKA ongoing projects in figures:

Project Participants

Large companies	476
SMEs	1174
Research Institutes	491
Universities	409
Government/National Administration	40
Total number of organisations involved in EUREKA projects	2640

Budget

Number of running projects	722
Total budget for these projects	€ 1.3 billion
Average budget per project	€ 1.8 million

4.8 Technical Assessment

Assessment (analysis and normative evaluation) of a particular technical device, system, or procedure regarding a defined set of criteria, goals and objectives. Assessment can "often be used as a synonym for evaluation." Assessment is "data collection with a purpose," and often addresses the "what questions about teaching and learning—what do students know and what can they do?". Assessment provides evidence that things are working or not (example, "Do students actually learn better?").

Evaluation may be defined as "the systematic investigation of the merit or worth of an object" and is often used in the context of "what value has been added through this project, and how do you know?"

Project evaluation is often used to demonstrate accountability (example, "have the project goals been met?").

Assessment of education and outreach programs may be done for many reasons, on many scales and the results may be utilized by different interested groups-including top-to-bottom project reviews, evaluation of the effectiveness of specific materials or methods, indicators of student learning, long-term impacts of a project, confirmation that the goals of a project have been met. The assessment activities may also lead to more expansive research on learning projects. The scholarship of teaching and learning provides many exciting (and much needed) opportunities to form partnerships with the cognitive and social sciences. There are a few basic principles that will help effectively develop own assessment plans to best meet the needs of a project:

- Clearly define project goals and expected outcomes at the start.
- What is the purpose of the assessment? Who will use the results and in what way?
- Identify the baseline data you will need to document change.
- There is an arsenal of assessment techniques that are available; pick the right tools and metrics that will provide the information required to meet your needs.

Assessment is done throughout the course of a project for varying reasons: formative assessment is done to provide feedback for ongoing activities, and to inform any needed mid-course corrections; summative assessment is done to measure a project's overall success; longitudinal assessment tracks impact beyond the duration or initial scope of the project. The assessment plans should be integral to the development and management of the project, not just added on as an afterthought. Develop partnerships with colleagues who have knowledge and expertise in assessment.

4.9 Cost Benefit Analysis

The most common way of carrying out an economic assessment of a proposed information system, or other development, is by comparing the expected costs of development and operation of the system with the benefits of having it in place. The assessment is based upon the question of whether the estimated costs are exceeded by the estimated income and other benefits. Additionally, it is usually necessary to ask whether the project under consideration is the best of a number of options. There might be more candidate projects than can be undertaken at any one time and, in any case, projects will need to be prioritized so that any scarce resources may be allocated effectively.

Cost-benefit Analysis (CBA) is a systematic process that businesses use to analyze which decisions to make and which to forgo. The cost-benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action. Some consultants or analysts also build models to assign a dollar value on intangible items, such as the benefits and costs associated with living in a certain town.

Key CBA Facts:

- CBA is the process used to measure the benefits of a decision or taking action minus the costs associated with taking that action.
- CBA involves measurable financial metrics such as revenue earned, or costs saved as a result of the decision to pursue a project.
- CBA can also include intangible benefits and costs or effects from a decision such as employees morale and customer satisfaction.
- More complex CBA may incorporate sensitivity analysis, discounting of cashflows, and what-if scenario analysis for multiple options.
- o All else being equal, an analysis that results in more benefits than costs will generally be a favourable project for the company to undertake.

4.10 Understanding Cost Benefit Analysis

Before building a new plant or taking on a new project, prudent managers conduct a CBA to evaluate all the potential costs and revenues that a company might generate from the project. The outcome of the analysis will determine whether the project is financially feasible or if the company should pursue another project. In many models, a CBA will also factor the opportunity cost into the decision-making process. Opportunity costs are alternative benefits that could have been realized when choosing one alternative over another. In other words, the opportunity cost is the forgone or missed opportunity because of a choice or decision.

Factoring in opportunity costs allows project managers to weigh the benefits from alternative courses of action and not merely the current path or choice being considered in the cost-benefit analysis. By considering all options and the potential missed opportunities, the CBA is more thorough and allows for better decision-making. Finally, the results of the aggregate costs and benefits should be compared quantitatively to determine if the benefits outweigh the costs. If so, then the rational decision is to go forward with the project. If not, the business should review the project to see if it can make adjustments to either increase benefits or decrease costs to make the project viable. Otherwise, the company should likely avoid the project.

History of Cost Benefit Analysis

The idea of this methodology originated with Jules Dupuit, a French engineer whose 1848 article is still worth reading. The British economist, Alfred Marshall, conceived some of the formal concepts that are at the foundation of CBA.

But the practical development of CBA came as a result of the impetus provided by the Federal Navigation Act of 1936. This act required that the U.S. Corps of Engineers carry out projects for the improvement of the waterway system when the total benefits of a project exceed the costs of that project. Thus, the Corps of Engineers had created systematic methods for measuring such benefits and costs.

The engineers of the Corps did this without much assistance from the economics profession. It wasn't until about twenty years later in the 1950s that economists tried to provide a rigorous, consistent set of methods for measuring benefits and costs and deciding whether a project is worthwhile.

4.11 Evaluating Cost Benefit Analysis

The standard way of evaluating the economic benefits of any project is to carry out a cost-benefit analysis, which consists of two steps:

Identifying and estimating all of the costs and benefits of carrying out the project**:** This includes development costs of the system, the operating costs and the benefits that are expected to accrue from the operation of the system. Where the proposed system is replacing an existing one, these estimates should reflect the costs and benefits due to the new system. A sales order processing system, for example, could not claim to benefit an organization by the total value of sales- only by the increase due to the use of the new system.

Expressing the costs and benefits in common units**:** We must evaluate the net benefit, which is the difference between the total benefit and the total cost. To do this, we must express each cost and each benefit in monetary terms.

Costs in Cost Benefit Analysis

Most costs are relatively easy to identify and quantify in approximate monetary terms. It is helpful to categorize costs according to where they originate in the life of the project.

Development costs **-** Include the salaries and other employment costs of the staff involved in the development project and all associated costs.

Setup costs **-** Include the costs of putting the system into place. These consist mainly of the costs of any new hardware and ancillary equipment but will also include costs of file conversion, recruitment and staff training.

Operational costs **-** Consist of the costs of operating the system once it has been installed.

4.12 Benefits of Cost Benefit Analysis

Benefits, on the other hand, are often quite difficult to quantify in monetary terms even once they have been identified. Benefits may be categorized as follows.

Direct benefits**:** These accrue directly from the operation of the proposed system. These could, for example, include the reduction in salary bills through the introduction of a new, computerized system.

Assessable indirect benefits**:** These are generally secondary benefits, such as increased accuracy through the introduction of a more user-friendly screen design where we might be able to estimate the reduction in errors, and hence costs, of the proposed system.

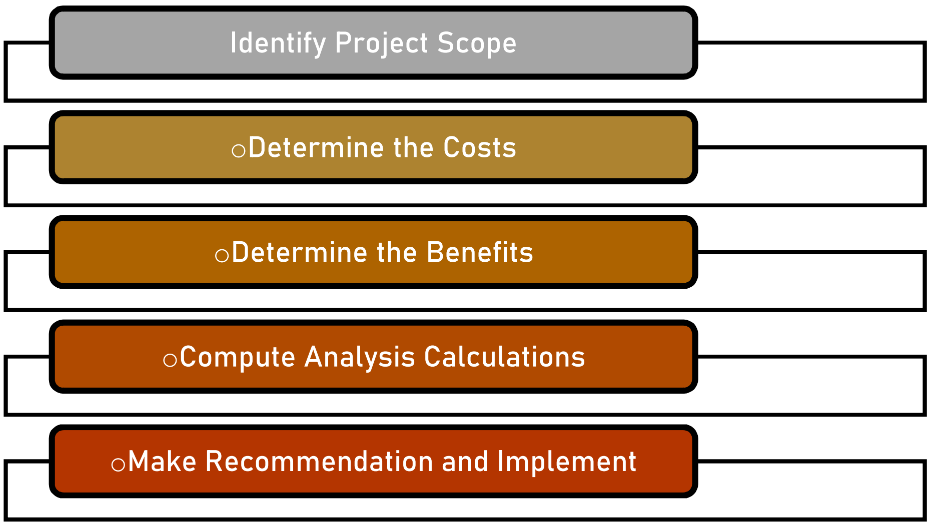
Intangible benefits**:** These are generally longer term or benefits that are considered very difficult to quantify. Enhanced job interest can lead to reduced staff turnover and, hence, lower recruitment costs.

Scenarios Utilizing Cost Benefit Analysis: CBA is the foundation of the decision-making process across a wide variety of disciplines. In business, government, finance, and even the nonprofit world, CBA offers unique and valuable insight when:

- Developing benchmarks for comparing projects
- Deciding whether to pursue a proposed project
- Evaluating new hires
- Weighing investment opportunities
- Measuring social benefits
- Appraising the desirability of suggested policies
- Assessing change initiatives
- Quantifying effects on stakeholders and participants

4.13 Cost-Benefit Analysis Process

There is no single universally accepted method of performing a cost-benefit analysis. However, every process usually has some variation of the following five steps:



Identify Project Scope**:** The first step of a CBA is to understand your situation, identify your goals, and create a framework to mold your scope. The project scope is kicked off by identifying the purpose of the CBA. An example of a CBA purpose could be "to determine whether to expand to increase market share" or "to decide whether to renovate a company's website".

This initial stage is where the project planning takes place, including the timeline, resources needed, constraints, personnel required, or evaluation techniques. It is at this point that a company should assess whether it is equipped to perform the analysis. For example, a company may realize it does not have the technical staff required to perform an adequate analysis.

During the project scope development phase, key stakeholders should be identified, notified, and given a chance to provide their input along the process. It may be wise to include those most impacted by the outcome of the analysis depending on the findings (that is, if the outcome is to renovate a company's website, IT may be required to hire multiple additional staff and should be consulted).

Determine the Costs: With the framework behind us, it's time to start looking at numbers. The second step of a CBA is to determine the project costs. The costs may include the following:

- Direct costs would be direct labor involved in manufacturing, inventory, raw materials, manufacturing expenses.
- Indirect costs might include electricity, overhead costs from management, rent, utilities.
  - Intangible costs of a decision, such as the impact on customers, employees, or delivery times.
  - Opportunity costs such as alternative investments or buying a plant versus building one.

The cost of potential risks such as regulatory risks, competition, and environmental impacts. When determining costs, it's important to consider whether the expenses are reoccurring or a one-time cost. It's also important to evaluate whether costs are variable or fixed; if they are fixed, consider what step costs and relevant range will impact those costs.

Notes: "Costs" can be financial (that is, expenses recorded on an income statement) or non-financial (that is, negative repercussions on the community).

Determine the Benefits: Every project will have different underlying principles; benefits might include the following:

- Higher revenue and sales from increased production or new product.
- Intangible benefits, such as improved employee safety and morale, as well as customer satisfaction due to enhanced product offerings or faster delivery.
- Competitive advantage or market share gained as a result of the decision.
- An analyst or project manager should apply a monetary measurement to all of the items on the cost-benefit list, taking special care not to underestimate costs or overestimate benefits.
- Analysts should also be aware of the challenges in determining both explicit and implicit benefits. Explicit benefits require future assumptions about market conditions, sales quantities, customer demands, and product expectations. Implicit costs, on the other hand, may be difficult to calculate as there may be no simple formula.

Compute Analysis Calculations**:** With the cost and benefit figures in hand, it's time to perform the analysis. Depending on the timeframe of the project, this may be as simple as subtracting one from another; if the benefits are higher than the cost, the project has a net benefit to the company. Some CBA require more in-depth critiquing. This may include:

- Applying discount rates to determine the net present value of cashflows.
- Utilizing various discount rates depending on various situations.
- Calculating CBA for multiple options. Each option may have a different cost and different benefit.
  - Level-setting different options by calculating the cost-benefit ratio.
  - Performing sensitivity analysis to understand how slight changes in estimates may impact outcomes.

Make Recommendation and Implement**:** The analyst that performs the CBA must often then synthesize findings to present to management. This includes concisely summarizes the costs, benefits, net impact, and how the finding ultimately support the original purpose of the analysis.

4.14 Cost-benefit Evaluation Techniques

CBA techniques are a common business activity owners and managers use to assess various projects. These techniques essentially compare the total capital investment for the project against its potential returns.

Several techniques are available, with the most common being the payback period, net present value, and rate of return. The companies can use one or all of the CBA techniques. The assessment occurs after the company has all necessary information and prior to investing capital into one or more of the projects.

Payback Period**:** The payback period is generally the simplest of all CBA techniques. The method uses all the same information as the other techniques, except the calculation process is quite different. First, a company must compute all costs associated with a project. This includes investment in fixed assets, costs for employees, and lost production time for training or implementation. Second, the company divides the total for all these costs by the potential financial returns, resulting in the time it will take for the project to pay for itself.

Net Present Value (NPV**):** The net present value technique is a bit more technical than the payback period. The cost accumulation process is the same as the payback period. The company then uses the cost of capital associated with outside funds to pay for starting the new project. The estimation of future financial returns is also the same as the other analysis techniques. A financial manager will discount the total future financial returns using the company cost of capital to determine if the current value of the return is higher than the investment's cost.

Rate of Return**:** The rate of return is a common method a company can use for single or small investments. The basic formula for this process is the total gains from the investment less its total associated costs. Dividing the difference between these two items by the investment's cost produces a percentage return. Owners and managers use this percentage to determine if the investment is a worthwhile use of capital. Rate of return may be a hybrid method among different cost-benefit analysis techniques as companies can compare the return percentage to the cost of capital.

Mistakes and Problems with Cost-benefit Analysis

A frequently made mistake in the CBA method is to use non-discounted amounts for calculating the costs and benefits. A method like NPV (Net Present Value) or Economic Value Added or CFROI is strongly recommended, because all of these account for the time value of money. A frequent problem with CBA is that typically the costs are tangible, hard and financial, while the benefits are hard and tangible, but also soft and intangible. Caution should be taken here against people who claim that "if you can't measure it does not exist/it has no value". Especially, in more strategic investments, frequently the intangible benefits clearly outweigh the financial benefits.

4.15 Cost Benefit Analysis Examples

Cost-benefit analysis (CBA) is the weighing-scale approach for decision-making. All the positive elements (cash-flows and other intangible benefits) are put on one side of the balance and all the negative elements (the costs and disadvantages) are put on the other. Whichever weighs the heavier wins. One may have been intensely creative in generating solutions to a problem, and rigorous in the selection of the best one available. This solution may still not be worth implementing, as one may invest a lot of time and money in solving a problem that is not worthy of this effort.

Cost Benefit Analysis or CBA is a relatively simple and widely used technique for deciding whether to make a change. As its name suggests, to use the technique simply add up the value of the benefits of a course of action, and subtract the costs associated with it.

Costs are either one-off or may be ongoing. The benefits are most often received over time. We build this effect of time into our analysis by calculating a payback period. This is the time it takes for the benefits of a change to repay its costs. Many companies look for payback over a specified period of time- example, three years. In its simple form, cost-benefit analysis is carried out using only financial costs and financial benefits.

Case Study: Example: A simple cost/benefit analysis of a road scheme would measure the cost of building the road, and subtract this from the economic benefit of improving transport links. It would not measure either the cost of environmental damage or the benefit of quicker and easier travel to work.

Example 1: A sales director is deciding whether to implement a new computer-based contact management and sales processing system. His department has only a few computers, and his salespeople are not computer literate. He is aware that computerized sales forces are able to contact more customers and give a higher quality of reliability and service to those customers. They are more able to meet commitments and can work more efficiently with fulfillment and delivery staff. His financial cost/benefit analysis is shown below:

Costs: New computer equipment-

- 10 network-ready PCs with supporting software @ $2,450 each
- 1 server @ $3,500
- 3 printers @ $1,200 each
- Cabling & Installation @ $4,600
- Sales Support Software @ $15,000

Training costs:

- Computer introduction – 8 people @ $400 each
- Keyboard skills – 8 people @ $400 each
- Sales Support System – 12 people @ $700 each

Other costs:

- Lost time: 40 man days @ $200/day
- Lost sales through disruption: estimate: $20,000
- Lost sales through inefficiency during first months: estimate: $20,000
- Total cost: $114,000

4.16 Risk Management

A risk can be defined as a problem that could cause some loss or threaten the success of project. The potential risk factors may have an adverse impact on the cost, schedule, or technical success of the project. The risk management is the process of identifying, determine and solve the potential problems before they can damage the project. The projects can be risky endeavors, and if not managed properly, they can quickly go off the rails. Without proper risk management, projects can have time or cost overruns, resulting in missed deadlines, unbudgeted expenses, and ultimately failure.

If someone is a project manager, the best way to deal with risks is to prepare for them beforehand and implement risk management strategies to mitigate them. That's why today, the "ability to manage project risks" is an essential skill employers look for when hiring project managers.

Project risk is any potential issue that could negatively impact the successful completion of your projects. Risks could be due to internal or external factors. For instance, a key supplier going out of business and a key team member leaving your organization—both qualify as project risks.

Project risk management is the process of identifying, assessing, and responding to unexpected risks that might affect your project's goals and progress. The project risk management is a process that aims to reduce project risks that have already occurred, are occurring, or are likely to occur in the future. It focuses on risk reduction by identifying the root causes of risks and minimizing their impact, if not eliminating them.

Why do you need project risk management?

As a project manager, identifying and assessing risks is an essential part of your job. It helps prioritize your project management efforts. If a risk assessment indicates that the impact of a particular threat will be severe, you should take necessary steps to avoid or mitigate that threat in advance.

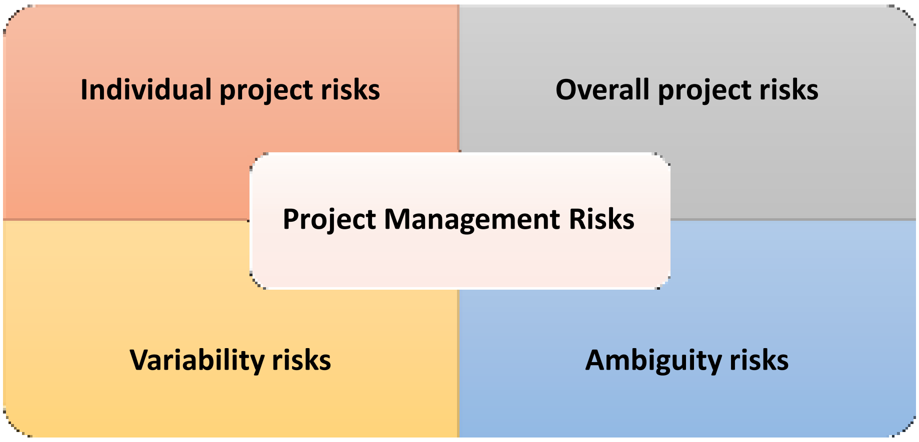
For any project, there are many risks to consider, but the most influential ones are related to project schedule, cost, quality, technology, and resources.

Schedule risk	Possibility that the project will not complete on time.
Cost risk	Possibility that the total project cost will exceed the budget.
Quality risk	Possibility that the project quality will not meet the defined standards.
Technology risk	Possibility that the selected project technology will not perform as required.
Resource risk	Possibility that team members won't have sufficient time or skills to complete the project.

4.17 Common Types of Project Management Risks

Individual project risks: These are individual risk events that, if they occur, can affect the quality, cost, time, and/or scope of a project. Examples include not having enough resources for a job and having to deal with sick leaves or employee time-off during peak season.

Overall project risks: These risks refer to the impact of uncertainty on the overall project. Overall project risk comprises an aggregate of individual risks plus all other sources of project uncertainty. Examples of such uncertainties include natural calamities, wars, and changes in government policies.



Variability risks: These risks are associated with fluctuations or inaccuracies in demand, supply, quality, price, etc., that can impact the project outcome. Examples include varying raw material prices and changing the supplier of a crucial product component.

Ambiguity risks: These risks stem from the lack of clarity in project requirements that can lead to misinterpretations or mistakes. Examples include inaccurate requirements gathered from clients and different interpretations of the project scope among team members.

Steps to Manage Project Risks

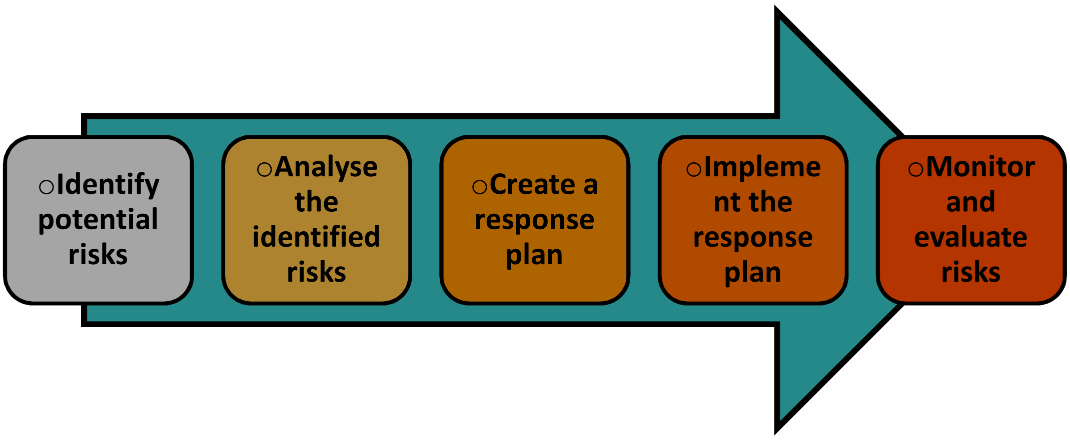
Risks are an inherent part of any project. While it's impossible to eliminate all risks, it's indeed possible to limit their impact by managing them. The following steps will help you competently reduce and control all potential project risks:

Identify Potential Risks: The first step is identifying all potential risks that could affect the project's timeline or goals. It includes closely analyzing the overall project plan and determining any potential issues that could arise. One way to ace this step is by scheduling brainstorming sessions with the project team and stakeholders. Once you identify the risks, put them into a risk register.

This will help to track all the risks along with their details such as duration, impact, priority, and status.

Analyze the identified risks: Once you identify the risks, start analyzing them to understand how and to what extent they can impact your project. Focus on quantitative and qualitative risk analysis. Quantitative risk analysis assigns a numerical value to risk probability, while qualitative risk analysis is used to identify and assess risks that can't be quantified. Both help identify risks that need your immediate attention. When assessing risks, consider three key factors: risk probability (likelihood of a risk event occurring), risk impact (consequences of a risk event occurring), and risk vulnerability (extent to which a risk event can be controlled). These will help you understand the overall project risk level and plan mitigation measures accordingly.

Create a response plan: Now that one has a better understanding of potential project risks, it's time to develop a response plan. The response plan should include how one will address each of the identified high-priority risks. The plan should also be achievable, practical, and tailored to fit the project's specific needs. The transfer, mitigation, avoidance, and acceptance are four different ways to respond to risks. Based on the risk tolerance, create a response plan to either transfer, mitigate, avoid, or accept potential project risks.



Implement the response plan: After developing a response plan, it's time to implement it. This will require close coordination between team members and stakeholders. Make sure everyone involved in the project is aware of the risks and knows what they need to do to mitigate them. To execute the plan effectively, designate someone to be in charge of each step so there is continuity and no confusion. As the project progresses, keep a close eye on the risks and make changes to the response plan as needed.

Monitor and evaluate risks: Risk management is not a one-time activity; it's an ongoing process that should be revisited regularly. And that's why one should never stop monitoring and evaluating project risks. Continuous monitoring will allow to track the progress of mitigation measures, ensure they are effective, and make necessary adjustments when required.

4.18 Risk Identification

The project organizer needs to anticipate the risk in the project as early as possible so that the impact of risk can be reduced by making effective risk management planning. A project can be of use by a large variety of risk. To identify the significant risk, this might affect a project.

Risk identification requires knowledge of the organization, the market in which it operates, the legal, social, economic, political, and climatic environment in which it does its business, its financial strengths and weaknesses, its vulnerability to unplanned losses, the manufacturing processes, and the management systems and the business mechanism by which it operates. Any failure at this stage to identify risk may cause a major loss for the organization. The risk identification provides the foundation of risk management. The identification methods are formed by templates or the development of templates for identifying sources, problems, or events. You may face some barriers that could prevent you from identifying risks. There are ten common barriers outlined:

Identification quality: How precise, accurate, applicable, or relevant is the risk one has identified?

Imagination: What limits the project team's ability to think of all plausible risks?

Inadequate planning approach: If the planning approach is not well or fully developed, one may not be able to identify the proper risk areas.

Lack of knowledge: If the manager and the project team lack or can't access sufficient project, technical, or subject matter expertise, such as applying risk identification tools and techniques, one is likely to struggle with identifying risks.

Lack of management support: Is risk identification activity supported from the top down? Any resistance or lack of support can impede identifying risks.

Level of detail: It can be challenging to determine how detailed risk exploration and documentation should be. Too little detail may cause overlooking some critical risks.

One observation: Limiting to a single risk identification activity severely limits the potential risks you can identify for your project.

Risk attitude: The project team being too reckless or too risk-averse can affect the quality of the risk identification activities.

Time and cost constraints: In case there is limitation on the time or budget, one may not be able to conduct sufficient risk identification activities.

Too many assumptions: One may make project decisions based on assumptions. Making too many assumptions complicates the risk analysis and identification activities.

4.19 Methods for Risk Identification

- Checklist Analysis– Checklist Analysis is type of technique generally used to identify or find risks and manage it. The checklist is basically developed by listing items, steps, or even tasks and is then further analyzed against criteria to just identify and determine if procedure is completed correctly or not. It is list of risk that is just found to occur regularly in development of software project.
- Brainstorming– This technique provides and gives free and open approach that usually encourages each and every one on project team to participate. It also results in greater sense of ownership of project risk, and team generally committed to managing risk for given time period of project. It is creative and unique technique to gather risks spontaneously by team members. The team members identify and determine risks in 'no wrong answer' environment. This technique also provides opportunity for team members to always develop on each other's ideas.
- Casual Mapping– Causal mapping is method that builds or develops on reflection and review of failure factors in cause and effect of the diagrams. It is very useful for facilitating learning with an organization or system simply as method of project-post evaluation. It is also key tool for risk assessment.
- SWOT Analysis– Strengths-Weaknesses-Opportunities-Threat (SWOT) is very technique and helpful for identifying risks within greater organization context. It is generally used as planning tool for analyzing business, its resources, and also its environment simply by looking at internal strengths and weaknesses and opportunities and threats in external environment. It is technique often used in formulation of strategy.
- Flowchart Method– This method allows for dynamic process to be diagrammatically represented in paper. This method is generally used to represent activities of process graphically and sequentially to simply identify the risk.

4.20 Risk Evaluation

The offshore program and project management involves four critical activities:

Transition Management**:** The process of managing assets during a period of restructuring is defined as transition management. The role of the transition manager is to minimize the costs and risks thus ensuring that the process runs smoothly. The real process starts when the contract is signed. Smooth transition management is the next issue to manage. Transition management is a critical success factor of offshore activities. Transition management is defined as the detailed knowledge of transfer and documentation of all relevant tasks, technologies, and workflows The transition period is perhaps the most difficult stage of an offshore endeavor, taking anywhere from three months to a year to complete. The transition management involves the following:

- Develop an initial transition plan (involving activities such as milestones, assets and benchmarks).
- Initiation of projects.
- Internal procedures and processes.
- Manage employees.
- Document lessons learned to improve vendor management.

Analyze in group of four why transition management is considered to be a critical success factor of offshore activities?

Governance**:** After managing the issue of transition put the skills into practice by governing the offshore relationship- client management, third party contract. The approach focuses on the evolution of services provided, ongoing communication processes, and overall project management. The governance activities pertaining to areas of off shoring can make or break a project. The ongoing governance involves the following:

- Project management
- Relationship building and management
- Risk management describes the processes concerned with identifying, managing, and correction of outsourcing partnership risks.

Performance Management**:** As offshore outsourcing has become an important aspect for multiple business processes, the types and complexity of contracts and sourcing alliances are bound to explode. With organizations outsourcing almost every aspect of their operations, multiple vendors participating in sourcing deals, and activities occurring 24x7, it's a nonstop challenge to coordinate interactions, manage performance, monitor contract terms, track financial metrics, and maintain alignment. The ongoing governance involves the following:

- Measures outsourcing effectiveness using appropriate metrics.
- Implementing improvements and adjustments.
- Evaluating feasibility of additional outsourcing.

Quality Management**:** Quality is a huge concern with offshore outsourcing. The errors are more costly to fix, and debugging becomes essential. A strict quality assurance and control program forms an integral part of every offshore delivery project. The performance management aims at reviewing and continuous improvement of software development and business processes, validation and verification of work products and customized status reports.

Summary

- Programme Management is the procedure of managing numerous ongoing interdependent projects. An instance would be that of designing, manufacturing, and providing support infrastructure for an automobile manufacturer.
- Project evaluation is an organized and objective measurement of an ongoing or completed project.

- Program governance is the feature of the discipline that creates both the structure and practices to guide the program and offer senior-level leadership, oversight, and control.
- The project manager is responsible for day-to-day direction, a senior IT executive integrates technology with business interests, and a business sponsor is accountable for ensuring that the deliverables align with business strategy.
- Infrastructure is a useful term to describe collections of roles, tools, and practices that organizations assemble and integrate in order to provide services and support for software development.
- The project managers have the power over the management of resource allocation for software development, marketing, product development teams and more.
- Assessment (analysis and normative evaluation) of a particular technical device, system, or procedure regarding a defined set of criteria, goals and objectives.
- Assessment can "often be used as a synonym for evaluation.
- The cost-benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action.

Keywords

Programme management*:* Program Management or Programme Management is the procedure of organizing numerous related projects, often with the meaning of improving an organization's performance.

Project evaluation*:* Project evaluation is a step-by-step process of collecting, recording and organizing information about project results, including short-term outputs (immediate results of activities, or project deliverables), and immediate and longer-term project outcomes (changes in behavior, practice or policy resulting from the project).

Program Infrastructure*:* A program infrastructure also includes both hardware— for desktop and network devices for storage and communication— and software, including desktop software and shared platforms with development tools, modelling software, planning tools, communication tools (email, Internet browser, virtual meeting/collaboration programs, telecommunications programs), and software for document retention and reproduction.

Program plan*:* A program plan refers to a scheme, program, or method worked out beforehand for the accomplishment of an objective: a plan of attack.

Individual project*:* An individual project is an economically indivisible series of works fulfilling a precise technical function and with clearly identifiable aims. An individual project may include one or more sub-projects.

Technical assessment*:* Assessment (analysis and normative evaluation) of a particular technical device, system, or procedure regarding a defined set of criteria, goals and objectives.

Cost-benefit Analysis (CBA*):* Cost-benefit Analysis (CBA) is a systematic process that businesses use to analyze which decisions to make and which to forgo.

Self Assessment

1. Which of the following is a method for risk identification?

A. Checklist Analysis

B. Brainstorming

C. Flowchart Method

D. All the above

2. ________ is the process of managing assets during a period of restructuring in risk evaluation.
A. Transition Management
B. Operation Management
C. Deliverance
D. Governance

3. _____________risks stem from the lack of clarity in project requirements that can lead to misinterpretations or mistakes. Examples include inaccurate requirements gathered from clients and different interpretations of the project scope among team members.
A. Ambiguity risks
B. Transformation risks
C. Overall project risks
D. Variability risks
4. The statement(s) that aptly describes project management includes:
A. Project management is the planning, organizing, directing, and controlling of corporation resources for a comparatively short-term purpose.
B. Project management is concerned with the dynamic allocation, utilization, and direction of resources (both human and technical), with time— in relation to both individual efforts and product delivery schedule— and with costs.
C. Project management relates to both the acquisition and consumption of funding.
D. All the above.

5. Risk identification requires knowledge of the organization, the market in which it operates, the legal, social, economic, political, and climatic environment in which it does its business, its financial strengths and weaknesses etc.
A. True
B. False

6. Which of the following statement(s) is/are TRUE for Cost-benefit analysis?
A. It is a weighing-scale approach for decision-making.
B. All the positive elements (cash-flows and other intangible benefits) are put on one side of the balance and all the negative elements (the costs and disadvantages) are put on the other.
C. It simply adds up the value of the benefits of a course of action, and subtract the costs associated with it.
D. All the above.

7. The basic formula for Rate of Return is the total gains from the investment less its total associated costs. Dividing the difference between these two items by the investment's cost produces a percentage return.
A. True
B. False

8. SWOT in SWOT Analysis stands for,
A. Strengths-Wonder-Operations-Threat

B. Strengths-Weaknesses-Opportunities-Threat
C. Software-Wonder-Operating-Theory
D. System-Weaknesses-Operations-Theory

9. ____________ is a step-by-step process of collecting, recording and organizing information about project results, including short-term outputs (immediate results of activities, or project deliverables), and immediate and longer-term project outcomes (changes in behavior, practice or policy resulting from the project).
A. Project state
B. Project status
C. Project evaluation
D. Project result

10. A program infrastructure also includes both hardware— for desktop and network devices for storage and communication— and software, including desktop software and shared platforms with development tools, modelling software, planning tools, communication tools etc.
A. True
B. False

11. A ____________ refers to a scheme, program, or method worked out beforehand for the accomplishment of an objective: a plan of attack.
A. program status
B. program plan
C. program risk
D. program attack

12. Risk Management is the procedure of managing numerous ongoing interdependent projects.
A. True
B. False

13. The cost(s) involved in CBA include:
A. Development costs.
B. Setup costs
C. Operational costs
D. All the above.

14. A __________ can be defined as a problem that could cause some loss or threaten the success of project. The potential such factors may have an adverse impact on the cost, schedule, or technical success of the project.
A. attacker
B. hacking
C. risk
D. surplus

15. ______________ is method that builds or develops on reflection and review of failure factors in cause and effect of the diagrams.
    A. SWOT analysis
    B. Causal mapping
    C. Cap mapping
    D. Infrastructure reloading

Answers for Self Assessment

1.	D	2.	A	3.	A	4.	D	5.	A
6.	D	7.	A	8.	B	9.	C	10.	A
11.	B	12.	B	13.	D	14.	C	15.	B

Review Questions

1. What is Cost-benefit Analysis (CBA)? Discuss the benefits associated with it.
2. List the costs involved in the Cost-benefit Analysis (CBA).
3. Discuss the significance of Programme management and project evaluation.
4. Write a brief note on Cost Benefit Analysis.
5. Evaluate and discuss the different features of Programme Management.
6. Investigate the process of Cost-Benefit Analysis.
7. Discuss the importance of Risk identification.
8. What are the common types of project management risks?
9. Explain the steps to manage project risks?
10. Write a short note on:
    (a) Technical assessment
    (b) Creating Programme

Further Readings

- Robert K. Wyzocki, Rudd McGary, Effective Project Management, WILEYDreamtech India Pvt. 8th edition, 2019.
- Roger S. Pressman, Software Engineering a Practitioner's Approach, Fourth Edition, McGraw Hill International, 2005.
- Bob Hughes, Mike Cotterell, Software and Project Management, Tata McGraw-Hill Publishing Company Limited, Fifth Edition, 2009.

Web Links

- A Framework for Programme Management | Project Smart
- What is Program Management? | Definition and Overview (productplan.com)
- Project Evaluation Process: Definition, Methods & Steps (projectmanager.com)
- Project Evaluation: What It Is and How To Do It | Indeed.com
- What is risk management? | IBM

- Risk Identification: Importance & Process | SafetyCulture
- How to Manage Project Risk: A 5-Step Guide | Coursera
- What Is Project Risk Management? Here's Everything You Need To Know | Capterra
- Methods for Identifying Risks - GeeksforGeeks

Unit 05: Project Approach

CONTENTS

Objectives

After studying this unit, you will be able to:

- learn about the project approach and its phases.
- know about technical plans and understand the software processes.
- explore the process models and their characteristics with an investigation into the choice of process models.
- understand the waterfall, v-process, RAD, agile, spiral, prototyping, and incremental delivery models.

Introduction

The purpose of the project approach is to identify the project management methodologies that will be used on the project. The approach should be based on the project management framework but should also contain reference to and iterative development, or prototyping methodologies that will be utilized. It is imperative to offer enough description of the approach, but the description should not be too detailed.

Notes: It Should also be noted here if no specific or a general approach will be used

The approaches vary from highly planned and controlled to fast, supple and adaptable. The traditional approaches focus on predictability whereas fresher approaches prioritize flexibility to changing environments and requirements, to maximize business benefits. The approaches vary according to the amount of overlap between phases and how often and rapidly they are carried out.

There is no one right approach. The best approach should be chosen according to the environment and the type of project being undertaken. The approaches should be chosen according to:

- How well understood the objectives are (by the client and the team).
- How stable the technology is (well proven or need testing and adaptation).
- How experienced the team is (in the technology, in development and in understanding the objectives set by the organizations management)
- How much control management want?

Generic project phases include:

- Initiation/Analysis
- Design
- Construction/Implementation/Execution/Coding
- Testing/Pilot/Debugging/Verification)
- Deployment
- Review & Maintenance

Popular Approaches

- Waterfall: Waterfall approach has extremely strict separate stages, with no overlap, and high levels of planning and process control. This is suitable for projects with a well understood scope that can be built using proven technology before they go out of date. For example, this is the favored approach in the construction industry.
- Iterative: In iterative approach, the team produces succeeding releases that eventually evolve into a complete product. This is a good approach when there are many unknowns, or when speed is of the essence. This might be a good approach to implementing a leading-edge product or developing for a user who is not sure what they want.
- Agile: Agile approach is the same as Iterative approach but with particularly small/fast releases in a high-performance environment with low levels of process control. Good for motivated experienced teams with strict deadlines and good understanding of the organisation's strategy.

The project approach should also list exact tools or techniques that are not part of the project management framework or not included in the approved information management technology list. The approach should be based on the decided information management project methodology.

5.1 Key Phases in a Project Management Approach

The project management approach should comprise the following key tasks or phases:

Business Case Analysis: The objective of the business case analysis phase is to determine the business case for investing in a data warehouse or business intelligence solution. It identifies the projected return on investment.

Planning and Analysis: The objectives of the planning and analysis phase are to:

- Recognize and secure approval for information management requirements; and
- Complete project planning in enough detail to commence technical architecture and design.

Architecture and Design: The objective of the architecture and design phase is to describe the technical architecture for the entire solution including:

- Database architecture and infrastructure.
- Database sizing and performance expectations.
- Identification of the extract, transform and load process.
- Recommendations for the sizing and configuration of hardware; and Access control, backup and recovery guidelines.

Build and Test: The objectives of the build and test stage is to deliver:

- Code required to extract data from the source systems and load it into a temporary staging area.
- An automated process that will extract data from source systems.
- Programs that will load the data warehouse with the source data from the staging area including all database scripts for views, indexes, synonyms and aggregations.
- Processes to clean the data in the staging area and ensure that it is fully consistent with business rules.
- Programs and scripts that ensure backup/recovery, access control and archiving.
- System processes to handle the data warehouse manager.
- A query manager to support business intelligence requirements.
- Pre-developed queries and reports and user access tools to access information.
- A set of repeatable system integration, volume, and aggregation tests; and
- A set of repeatable manual reconciliation tasks.

User Acceptance Test (UAT): The objective of the UAT stage is to ensure that the information management solution meets the agreed requirements.

Release to Production: The objective of this stage is to migrate the information management solution into a production environment. The initial data should be pre-loaded, and the Data Warehouse should be tuned for performance, if necessary.

5.2 Technical Plans

The project technical plan can have two meanings, depending on the management:

Non-schematic representation of the WBS: Yes, the project technical plan is more or less the WBS, it is a non-graphical non-schematic representation of the WBS. All the information that is incorporated in the WBS can still be known by reading the project technical plan, including the dependencies. The project technical plan and also have sub-technical plans, which are further breakdowns to activities in the main project technical plan (sub-project technical plans exist only in very large projects).

A part of the project plan listing the technical issues/challenges pertaining to the project and how to address them: For instance, the project technical plan of a web project will state that the web application will receive a lot of visitors, which will drain the server's resources, so the best way to address this problem is by adding more web and database servers to the infrastructure to handle the potential load and to ensure that the written code is efficient.

The project technical plan illustrates a detailed breakdown of the relationships between the major activities required by the project. Succeeding sub-project technical plans are based on it and any later amendments should be highlighted. Prepared at the same time as the project resource plan; these two plans together show a high-level view of the project's products, activities and resources. Once approved by the project owner the project technical plan becomes the top-level production schedule for the major products required throughout the project.

The technical plan will differ greatly depending on the industry or business sector. A technical plan should be created as part of the business plan, this allows more accurate budgeting for things such as capital equipment, land, energy costs, etc. It would contain items such as initial building plan, ground requirement, machinery or equipment, Energy usage, waste treatment, in fact anything that clarifies the technical part of the project together with a Gantt (timing) chart and possibly some sketches of the product, building and possibly a flow chart of the process.

An environmental impact report should also be completed for any manufacturing processes you may be involved in. This is usually a specialized document showing how "Green" your company is. In today's business climate it is very important.

Technical Documentation

In many situations, the input of technical information will not be required, in particular for smaller projects, none manufacturing projects or internet projects. If the project involves land, building or substantial capital equipment then it is better to include information that is more technical. This is mainly due to the need for accurate figures for land, buildings and capital equipment, which cannot be estimated precisely. These are required for the Financial Reports. This process needs some initial design work consequently for a project including buildings and work areas and one would need some form of initial plan showing the land area required and any construction etc.

Other items referring to the capital costs should be additional to the Technical Plan, such as a listing of capital equipment, a timing chart to show cash flow and, if the project relates to a manufactured item, process flow diagrams such as below. It is also valuable, including initial product costing, product specifications and any other information that will clarify the profitability of the project. If the suggested technical information is incorporated, then the plan becomes a more valuable document containing the information needed to complete the project.

5.3 Software Process

Software is the set of instructions in the form of programs to govern the computer system and to process the hardware components. To produce a software product the set of activities is used. This set is called a software process. The software processes are the activities for designing, implementing, and testing a software system. The software development process is complicated and involves a lot more than technical knowledge. A software process model is an abstract representation of the development process. A software process includes the set of activities and associated outcome that produces a software product. Software engineers mostly carry out these activities.

There are four key process activities (Figure 1), which are common to all software processes. These activities are:

Figure 1: Software Process Activities

There are four key process activities, which are common to all software processes. These activities are:

Software specifications: In this process, detailed description of a software system to be developed with its functional and non-functional requirements. The functionality of the software and constraints on its operation must be defined.

Software development: In this process, designing, programming, documenting, testing, and bug fixing is done. The software to meet the requirement must be produced.

Software validation: In this process, evaluation of the software product is done to ensure that the software meets the business requirements as well as the end user's needs. The software must be validated to ensure that it does what the customer wants.

Software evolution: It is a process of developing software initially, then timely updating it for various reasons. The software must evolve to meet the changing client needs.

Basic Software Process Approaches

The software processes in software engineering refer to the methods and techniques used to develop and maintain software. Some examples of software process approaches include:

Waterfall: A linear, sequential approach to software development, with distinct phases such as requirements gathering, design, implementation, testing, and maintenance.

Agile: A flexible, iterative approach to software development, with an emphasis on rapid prototyping and continuous delivery.

Scrum: A popular Agile methodology that emphasizes teamwork, iterative development, and a flexible, adaptive approach to planning and management.

DevOps: A set of practices that aims to improve collaboration and communication between development and operations teams, with an emphasis on automating the software delivery process.

Notes: Each process has its own set of advantages, and the choice of which one to use depends on the specific project and organization

5.4 Software Process Models

A software process model is an abstraction of the software development process. The models specify the stages and order of a process. It is a representation of the order of activities of the process and the sequence in which they are performed (Figure 2). A model defines the following:

- The tasks to be performed.
- The input and output of each task.
- The pre- and post-conditions for each task.
- The flow and sequence of each task.

The goal of a software process model is to provide guidance for controlling and coordinating the tasks to achieve the product and objectives as effectively as possible. The basic software process models on which different type of software process models can be implemented:

Workflow model: It is the sequential series of tasks and decisions that make up a business process.

Waterfall model: It is a sequential design process in which progress is seen as flowing steadily downwards. The phases in waterfall model are:

- Requirements Specification
- Software Design
- Implementation
- Testing

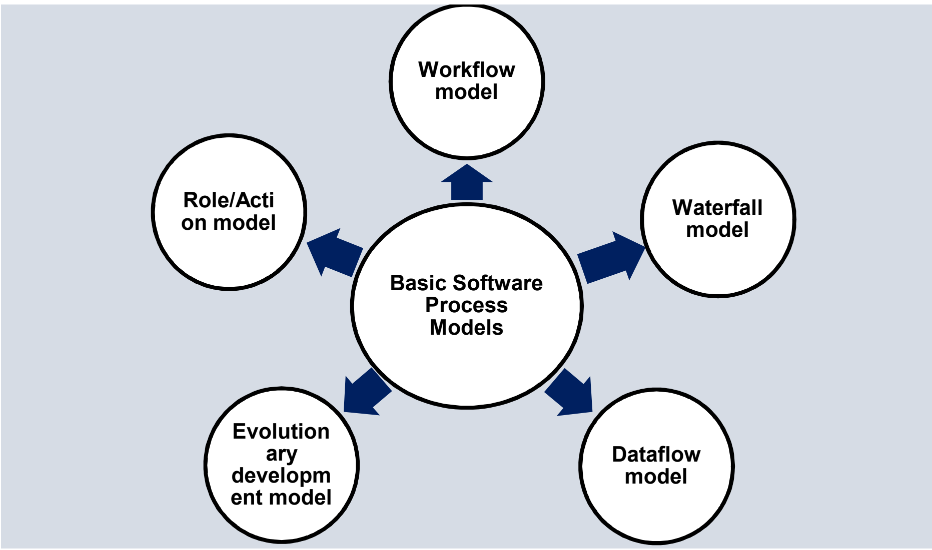


Figure 2: Software Process Models

Dataflow model: It is diagrammatic representation of the flow and exchange of information within a system.

Evolutionary development model: Following activities are considered in this method:

1. Specification
2. Development
3. Validation

Role/Action model: Roles of the people involved in the software process and the activities.

5.5 Need of Software Process Models

The software development team must decide the process model that is to be used for software product development and then the entire team must adhere to it. This is necessary because the software product development can then be done systematically. Each team member will understand what the next activity is and how to do it. Thus, a process model will bring the definiteness and discipline in overall development process.

Every process model consists of definite entry and exit criteria for each phase. Hence the transition of the product through various phases is definite. If the process model is not followed for software development, then any team member can perform any software development activity, this will ultimately cause a chaos and software project will definitely fail without using process model, it is difficult to monitor the progress of software product. Thus, a process model plays an important rule in software engineering.

5.6 Factors in Choosing a Software Process Model

Choosing the right software process model for your project can be difficult. If you know your requirements well, it will be easier to select a model that best matches your needs. You need to keep the following factors in mind when selecting your software process model:

Project requirements: Before you choose a model, take some time to go through the project requirements and clarify them alongside your organization or team's expectations. Will the user need to specify requirements in detail after each iterative session? Will the requirements change during the development process?

Project size: Consider the size of the project you will be working on. The larger projects mean bigger teams, so you'll need more extensive and elaborate project management plans.

Project complexity: The complex projects may not have clear requirements. The requirements may change often, and the cost of delay is high. Ask yourself if the project requires constant monitoring or feedback from the client.

Familiarity with technology: This involves the developers' knowledge and experience with the project domain, software tools, language, and methods needed for development.

Customer involvement: Do you need to consult the customers during the process? Does the user need to participate in all phases?

Cost of delay: Is the project highly time-bound with a huge cost of delay, or are the timelines flexible?

Project resources: This involves the amount and availability of funds, staff, and other resources.

5.7 Different Types of Software Process Models

There are many kinds of process models for meeting different requirements. These are referred to as SDLC models (Software Development Life Cycle models). The most popular and important SDLC models are as follows:

Waterfall model

Waterfall model represents a breakdown of software project activities in a linear sequential phase. Each phase of this model relies on the deliverables of the previous phase, and it corresponds to the aspects of the tasks. Waterfall model is the first software process model that was introduced. This model is extremely easy to understand by the developers. The waterfall model is the earliest SDLC approach that was used for software development. Waterfall model is also referred to as a linear-sequential life cycle model.

In a waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phases. It illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete.

In this waterfall model (Figure 3), the phases do not overlap, that is, each phase of this model is completed before the next phase to avoid the overlapping among the multiple phases. It goes from requirements > design > development > testing > deployment > maintenance. The waterfall model derives its name due to the cascading effect from one phase to the other. In this model each phase is well defined, has a starting and ending point, with identifiable deliveries to the next phase.

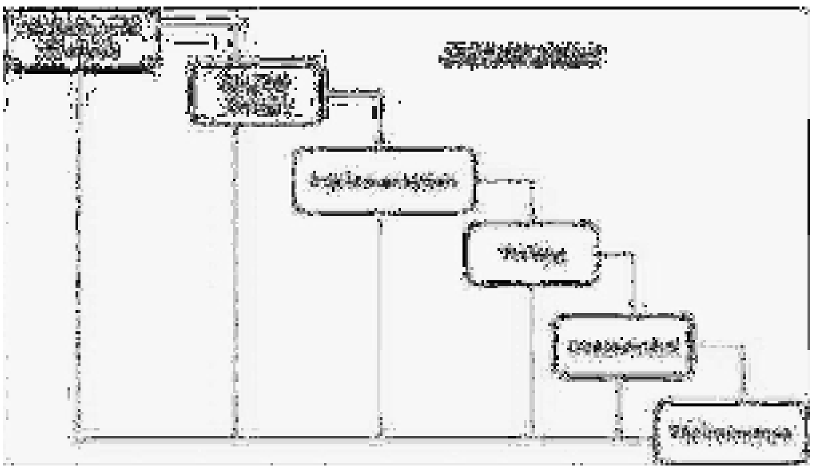


Figure 3: Waterfall Model

The sequential phases in waterfall model are−

1. Requirement Gathering and analysis− All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document.

2. System Design− The requirement specifications from first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture.
3. Implementation− With inputs from the system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.
4. Integration and Testing− All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
5. Deployment of system− Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.
6. Maintenance− There are some issues which come up in the client environment. To fix those issues, patches are released. Also, to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment.

Applications of Waterfall Model: Every software developed is different and requires a suitable SDLC approach to be followed based on the internal and external factors.

- Some situations where the use of waterfall model is most appropriate are:
- Requirements are very well documented, clear and fixed.
- Product definition is stable.
- Technology is understood and is not dynamic.
- There are no ambiguous requirements.
- Ample resources with required expertise are available to support the product.
- The project is short.

Advantages: The advantages of waterfall development are that it allows for departmentalization and control. A schedule can be set with deadlines for each stage of development and a product can proceed through the development process model phases one by one. The development moves from concept, through design, implementation, testing, installation, troubleshooting, and ends up at operation and maintenance. Each phase of development proceeds in strict order. Some of the major advantages of the Waterfall Model are as follows:

- Simple and easy to understand and use
- Easy to manage due to the rigidity of the model. Each phase has specific deliverables and a review process.
- Phases are processed and completed one at a time.
- Works well for smaller projects where requirements are very well understood.
- Clearly defined stages.
- Well understood milestones.
- Easy to arrange tasks.
- Process and results are well documented.

Disadvantages: The disadvantage of waterfall development is that it does not allow much reflection or revision. Once an application is in the testing stage, it is very difficult to go back and change something that was not well-documented or thought upon in the concept stage. The major disadvantages of the waterfall model are as follows:

- No working software is produced until late during the life cycle.
- High amounts of risk and uncertainty.

- o Not a good model for complex and object-oriented projects.
- o Poor model for long and ongoing projects.
- o Not suitable for the projects where requirements are at a moderate to high risk of changing. So, risk and uncertainty is high with this process model.
- o It is difficult to measure progress within stages.
- o Cannot accommodate changing requirements.
- o Adjusting scope during the life cycle can end a project.
- o Integration is done as a "big-bang. at the very end, which doesn't allow identifying any technological or business bottleneck or challenges early.

Waterfall Model Software and Tools: Gantt charts are a common management tool for waterfall projects. These charts enable easy visualization of sequential phases, letting project managers map dependencies and subtasks to each phase of the process. They provide a clear view of timelines and deadlines for each phase. Some project management software products that feature Gantt charts include the following:

- o Asana
- o Jira
- o Microsoft Excel
- o Microsoft Project
- o Microsoft SharePoint
- o ProjectManager
- o Smartsheet and
- o Wrike

V Model

The V model for software process represents a development methodology that can be considered as an extension of the waterfall software model. In this process, instead of moving down in a unique and linear manner, the steps of the process are bent upwards soon after the coding phase, to develop a typical V shape. V-Model also referred to as the Verification and Validation Model. In this, each phase of SDLC must complete before the next phase starts. It follows a sequential design process same as the waterfall model. The testing of the device is planned in parallel with a corresponding stage of development.

- Verification: It involves a static analysis method (review) done without executing code. It is the process of evaluation of the product development process to find whether specified requirements meet.
- Validation: It involves dynamic analysis method (functional, non-functional), testing is done by executing code. Validation is the process to classify the software after the completion of the development process to determine whether the software meets the customer expectations and requirements.

So, V-Model (Figure 4) contains verification phases on one side of the Validation phases on the other side. Verification and Validation process is joined by coding phase in V-shape. Thus, it is known as V-model.

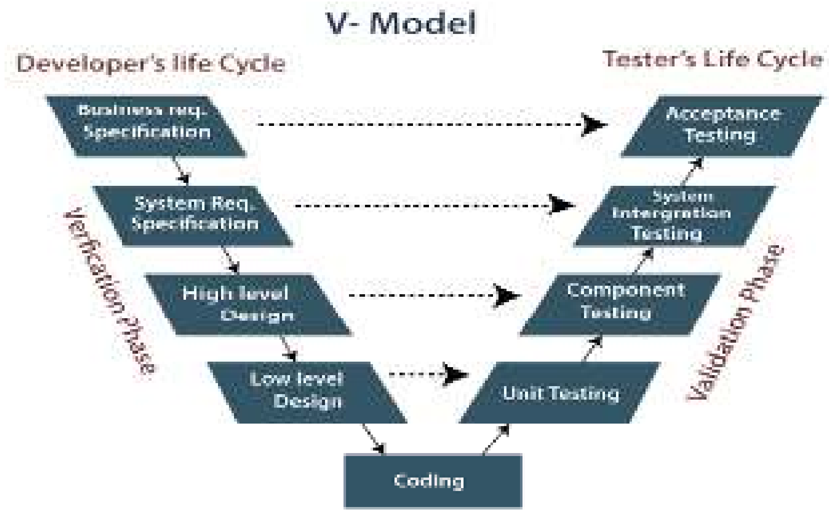


Figure 4: V-Model

This model represents the relationship between each phase of the software development life cycle, along with the associated phases of software testing. The horizontal and vertical axis of this model represent time/project completeness and level of abstraction, respectively.

There are the various phases of Verification Phase of V-model:

- Business requirement analysis: This is the first step where product requirements understood from the customer's side. This phase contains detailed communication to understand customer's expectations and exact requirements.
- System Design: In this stage system engineers analyze and interpret the business of the proposed system by studying the user requirements document.
- Architecture Design: The baseline in selecting the architecture is that it should understand all which typically consists of the list of modules, brief functionality of each module, their interface relationships, dependencies, database tables, architecture diagrams, technology detail, etc. The integration testing model is carried out in a particular phase.
- Module Design: In the module design phase, the system breaks down into small modules. The detailed design of the modules is specified, which is known as Low-Level Design.
- Coding Phase: After designing, the coding phase is started. Based on the requirements, a suitable programming language is decided. There are some guidelines and standards for coding. Before checking in the repository, the final build is optimized for better performance, and the code goes through many code reviews to check the performance.

There are the various phases of Validation Phase of V-model:

- Unit Testing: In the V-Model, Unit Test Plans (UTPs) are developed during the module design phase. These UTPs are executed to eliminate errors at code level or unit level. A unit is the smallest entity which can independently exist, e.g., a program module. Unit testing verifies that the smallest entity can function correctly when isolated from the rest of the codes/ units.
- Integration Testing: Integration Test Plans are developed during the Architectural Design Phase. These tests verify that groups created and tested independently can coexist and communicate among themselves.
- System Testing: System Tests Plans are developed during System Design Phase. Unlike Unit and Integration Test Plans, System Tests Plans are composed by the client's business team. System Test ensures that expectations from an application developer are met.

- Acceptance Testing: Acceptance testing is related to the business requirement analysis part. It includes testing the software product in user atmosphere. Acceptance tests reveal the compatibility problems with the different systems, which is available within the user atmosphere. It conjointly discovers the non-functional problems like load and performance defects within the real user atmosphere.

When to use V-Model?

- When the requirement is well defined and not ambiguous.
- The V-shaped model should be used for small to medium-sized projects where requirements are clearly defined and fixed.
- The V-shaped model should be chosen when sample technical resources are available with essential technical expertise.

Advantages of V-Model:

- Easy to Understand.
- Testing Methods like planning, test designing happens well before coding.
- This saves a lot of time. Hence a higher chance of success over the waterfall model.
- Avoids the downward flow of the defects.
- Works well for small plans where requirements are easily understood.

Disadvantages of V-Model:

- Very rigid and least flexible.
- Not a good for a complex project.
- Software is developed during the implementation stage, so no early prototypes of the software are produced.
- If any changes happen in the midway, then the test documents along with the required documents, has to be updated.

Incremental Model

Incremental Model is a process of software development where requirements are divided into multiple standalone modules of the software development cycle. In this model, each module goes through the requirements, design, implementation, and testing phases. Every subsequent release of the module adds function to the previous release. The process continues until the complete system is achieved (Figure 5).

The incremental model of the software development process is a method through which the software is carefully designed, implemented, and tested in an incremental manner until the final product is obtained. This process involves both the development and maintenance aspects. The final product is declared as complete when it can satisfy all of the requirements.

Each of the iterations passes through various requirements, designs, coding, and testing phases. Each subsequent release of the product adds functions to the formal release until the designed functions become fully implemented. The incremental model conducts the amalgamation of the elements of the waterfall model along with the iterative philosophy of prototyping.

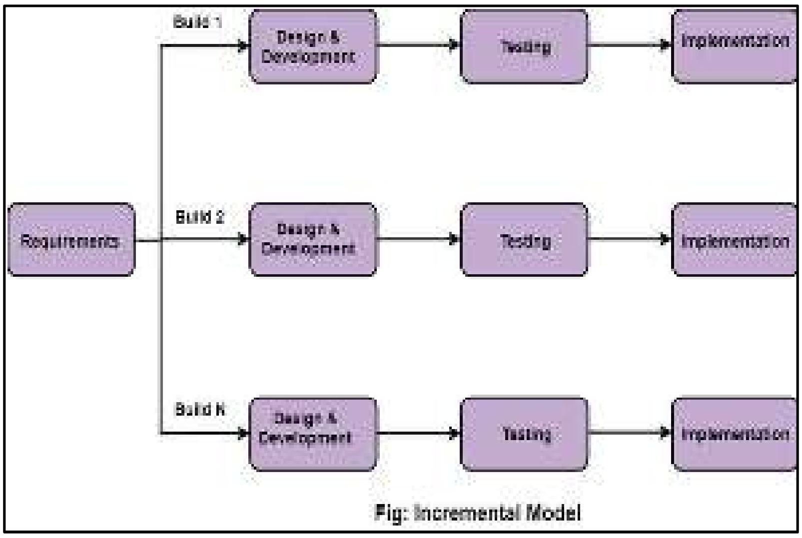


Figure 5: Incremental Model

The various phases of incremental model are as follows:

Requirement analysis: In the first phase of the incremental model, the product analysis expertise identifies the requirements. And the system functional requirements are understood by the requirement analysis team. To develop the software under the incremental model, this phase performs a crucial role.

Design & Development: In this phase of the Incremental model of SDLC, the design of the system functionality and the development method are finished with success. When software develops new practicality, the incremental model uses style and development phase.

Testing: In the incremental model, the testing phase checks the performance of each existing function as well as additional functionality. In the testing phase, the various methods are used to test the behavior of each task.

Implementation: Implementation phase enables the coding phase of the development system. It involves the final coding that design in the designing and development phase and tests the functionality in the testing phase. After completion of this phase, the number of the product working is enhanced and upgraded up to the final system product.

When to use the Incremental Model?

- When the requirements are superior.
- A project has a lengthy development schedule.
- When Software team are not very well skilled or trained.
- When the customer demands a quick release of the product.
- You can develop prioritized requirements first.

Advantages of Incremental Model

- Errors are easy to recognize.
- Easier to test and debug.
- More flexible.
- Simple to manage risk it handles during its iteration.
- The client gets important functionality early.

Disadvantages of Incremental Model

- Need for good planning.
- Total Cost is high.
- Well defined module interfaces are needed.

RAD model

The Rapid Application Development Model was first proposed by IBM in the 1980s. The RAD model is a type of incremental process model in which there is an extremely short development cycle. When the requirements are fully understood, and the component-based construction approach is adopted then the RAD model is used. The various phases in RAD are Requirements Gathering, Analysis and Planning, Design, Build or Construction, and finally Deployment.

The critical feature of this model is the use of powerful development tools and techniques. A software project can be implemented using this model if the project can be broken down into small modules wherein each module can be assigned independently to separate teams. These modules can finally be combined to form the final product.

Development of each module involves the various basic steps as in the waterfall model, that is, analyzing, designing, coding, and then testing, etc. Another striking feature of this model is a short time span, that is, the time frame for delivery(time-box) is generally 60-90 days.

RAD (Rapid Application Development) is a concept that products can be developed faster and of higher quality through (Figure 6):

- Gathering requirements using workshops or focus groups.
- Prototyping and early, reiterative user testing of designs.
- The re-use of software components.
- A rigidly paced schedule that refers design improvements to the next product version.
- Less formality in reviews and other team communication.

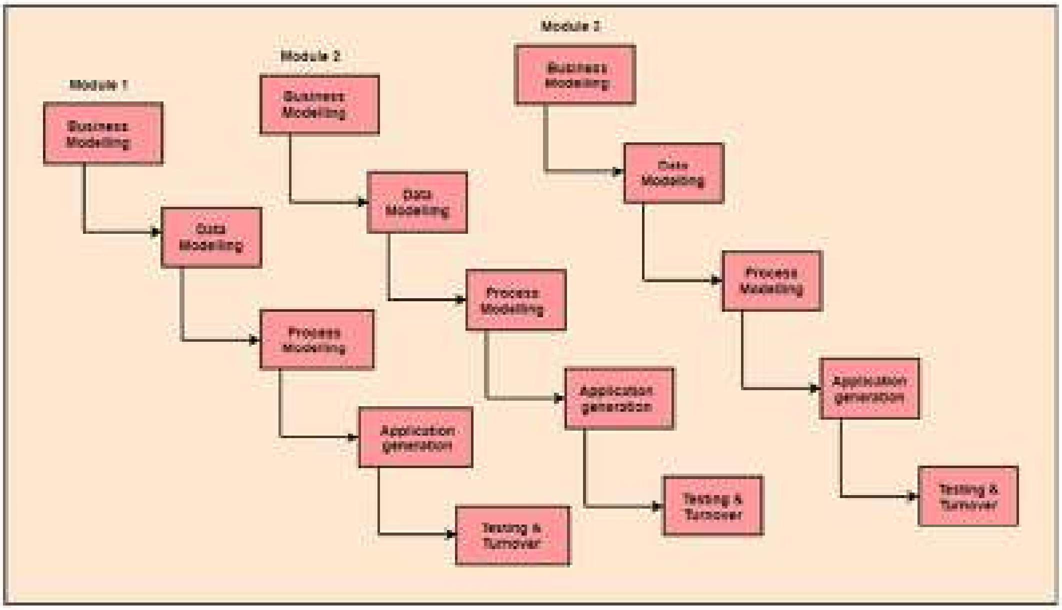


Figure 6: RAD Model

The various phases of RAD are as follows:

1. Business Modelling: The information flow among business functions is defined by answering questions like what data drives the business process, what data is generated, who generates it, where does the information go, who process it and so on.
2. Data Modelling: The data collected from business modeling is refined into a set of data objects (entities) that are needed to support the business. The attributes (character of each entity) are identified, and the relation between these data objects (entities) is defined.

3. Process Modelling: The information object defined in the data modeling phase are transformed to achieve the data flow necessary to implement a business function. Processing descriptions are created for adding, modifying, deleting, or retrieving a data object.
4. Application Generation: Automated tools are used to facilitate construction of the software; even they use the 4th GL techniques.
5. Testing & Turnover: Many of the programming components have already been tested since RAD emphasis reuse. This reduces the overall testing time. But the new part must be tested, and all interfaces must be fully exercised.

When to use RAD Model?

- When the system should need to create the project that modularizes in a short span time (2-3 months).
- When the requirements are well-known.
- When the technical risk is limited.
- When there's a necessity to make a system, which modularized in 2-3 months of period.
- It should be used only if the budget allows the use of automatic code generating tools.

Advantages of RAD Model

- This model is flexible for change.
- In this model, changes are adoptable.
- Each phase in RAD brings highest priority functionality to the customer.
- It reduced development time.
- It increases the reusability of features.

Disadvantages of RAD Model

- It requires highly skilled designers.
- All applications are not compatible with RAD.
- For smaller projects, we cannot use the RAD model.
- On the high technical risk, it's not suitable.
- Required user involvement.

Agile model

The meaning of Agile is swift or versatile. The "Agile process model" refers to a software development approach based on iterative development. The agile methods break tasks into smaller iterations, or parts do not directly involve long term planning. The project scope and requirements are laid down at the beginning of the development process. Plans regarding the number of iterations, the duration and the scope of each iteration are clearly defined in advance.

Each iteration is considered as a short time "frame" in the Agile process model, which typically lasts from one to four weeks. The division of the entire project into smaller parts helps to minimize the project risk and to reduce the overall project delivery time requirements. Each iteration involves a team working through a full software development life cycle including planning, requirements analysis, design, coding, and testing before a working product is demonstrated to the client.

Agile model (Figure 7) is typically used in the software development process for helping the businesses to respond proactively, referring to a group of software process methodologies. At this stage, the requirements and software solutions evolve alongside the collaboration between multiple self-organizing functional teams. The primary objective of this model is backed by the software development team's ability to develop and respond to a turbulent environment.

Figure 7: Agile Model

The Agile model refers to an umbrella term for a specific set of practices and methods based on the values expressed in the same manifesto. The agile manifesto represents a way of thinking that allows businesses and team members to quickly innovate and respond to the ever-changing demands of the industry while eliminating the risks. The organizations can use the Agile methodology with the help of various available frameworks such as Kanban, Lean, Scrum, etc.

Phases of Agile Model

1. Requirements gathering: In this phase, you must define the requirements. You should explain business opportunities and plan the time and effort needed to build the project. Based on this information, you can evaluate technical and economic feasibility.
2. Design the requirements: When you have identified the project, work with stakeholders to define requirements. You can use the user flow diagram or the high-level UML diagram to show the work of new features and show how it will apply to your existing system.
3. Construction/ iteration: When the team defines the requirements, the work begins. Designers and developers start working on their project, which aims to deploy a working product. The product will undergo various stages of improvement, so it includes simple, minimal functionality.
4. Testing: In this phase, the Quality Assurance team examines the product's performance and looks for the bug.
5. Deployment: In this phase, the team issues a product for the user's work environment.
6. Feedback: After releasing the product, the last step is feedback. In this, the team receives feedback about the product and works through the feedback.

Prototype Model

Prototyping is defined as the process of developing a working replication of a product or system that must be engineered. It offers a small-scale facsimile of the end product and is used for obtaining customer feedback. The prototyping model is one of the most popularly used Software Development Life Cycle Models (SDLC models). The prototype model requires that before carrying out the development of actual software, a working prototype of the system should be built. A prototype is a toy implementation of the system. A prototype usually turns out to be a very crude version of the actual system, possibly exhibiting limited functional capabilities, low reliability, and inefficient performance as compared to actual software. In many instances, the client only has a general view of what is expected from the software product. In such a scenario where there is an absence of detailed information regarding the input to the system, the processing needs, and the output requirement, the prototyping model may be employed.

This model is used when the customers do not know the exact project requirements beforehand. In this model, a prototype of the product is first developed, tested, and refined as per customer feedback repeatedly till a final acceptable prototype is achieved which forms the basis for developing the final product.

In this process model (Figure 8), the system is partially implemented before or during the analysis phase thereby giving the customers an opportunity to see the product early in the life cycle. The process starts by interviewing the customers and developing the incomplete high-level paper model. This document is used to build the initial prototype supporting only the basic functionality as desired by the customer. Once the customer figures out the problems, the prototype is further refined to eliminate them. The process continues until the user approves the prototype and finds the working model to be satisfactory.

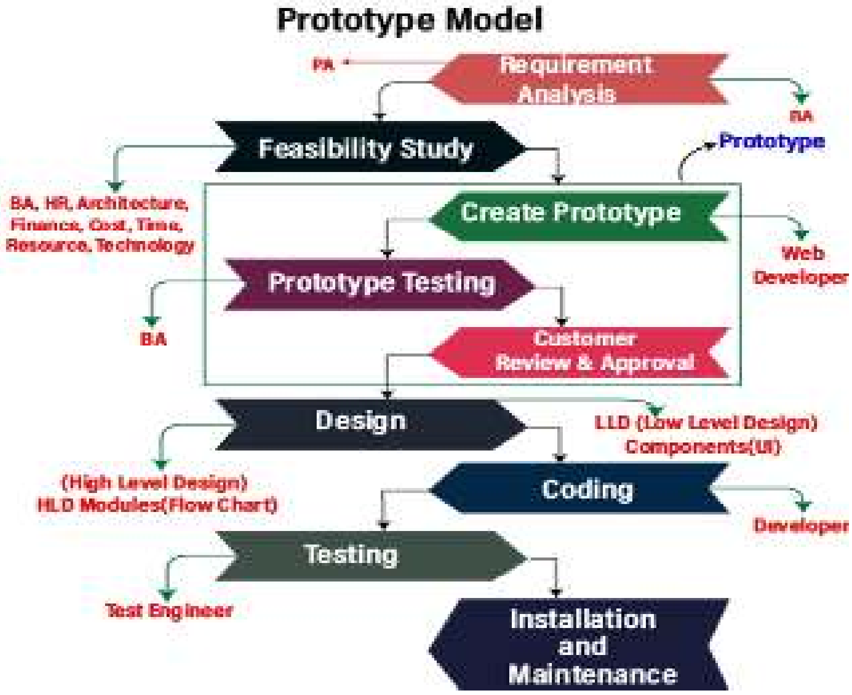


Figure 8: Prototype Model

Steps of Prototype Model

1. Requirement analysis: This model starts with collecting the requirements from the customers. And these requirements of the project should be in detail. These details are received by the Business Analyst and Product Analyst. Where Business analyst is assigned for service-based software companies, and the Product analyst is assigned for product-based software companies.
2. Feasibility study: In the next stage, the BA, HR, Architecture, and finance teams head will sit together and talk about the cost of the product, which resource is going to be needed, which technology is used to develop the product and how much time is required to complete the product and deliver.
3. Create a prototype: After we complete the feasibility study, we will move to our next stage, where we will be creating the prototype (sample or dummy) based on the data collected from

the client, and the web developer will design the prototype. Here, we have the following types of prototypes:

- o Static prototype: In the static prototype, we kept the entire prototype of the requirements in a word document with having all the guidelines, screenshot, and the description of how to build the software, how the completed product will look like and how it will work and so on.
- o Dynamic prototype: The dynamic prototype is parallel to the browser, but here we can't provide any details, only the functionality is there without entering the data. It is like a dummy page made from html with tags and links to the various pages to the expressive features of the product.

4. Prototype testing: Once we build the prototype, the BA will test the prototype and perform one round of prototype testing.
5. Customer review and approval: Once the prototype testing is done, it will be handed over to the customer for their review and approval. If the customer is not happy with the given sample, we will change the prototype based on the customer's guidelines and feedback. This process will go on until the customer approves and is satisfied with the prototype. It is a bit time-consuming because we must perform the changes again and again in the prototype.
6. Design: After getting the approved prototype, we will start the high level and low-level design for the final product and consider all the suggestions given by the customer at the time of the final prototype.
7. Coding: Once the design phase has been completed successfully, we move to our coding phase, where the concerned developer starts developing the product based on their programming knowledge.
8. Testing: After the compilation of the development phase, it is handed over to the test engineer. And the test engineer tests the application functionality, and all inputs and outputs.
9. Installation and maintenance: Once our final product are developed and tested according to the final prototype, it will be deployed to production. The product will go through time-to-time maintenance to reduce any interruption, which helps to avoid significant failures.

When do we use the Prototype model?

Whenever the customer is new to the software industry or when he doesn't know how to give the requirements to the company. When the developers are new to the domain.

Advantages of Prototype Model

- o Reduce the risk of incorrect user requirement.
- o Good where requirement is changing/uncommitted.
- o Regular visible process aids management
- o Support early product marketing.
- o Reduce Maintenance cost.
- o Errors can be detected much earlier as the system is made side by side.

Disadvantages of Prototype Model

- o An unstable/badly implemented prototype often becomes the final product.
- o Require extensive customer collaboration.
- o Costs customer money

- Needs committed customer.
- Difficult to finish if customer withdraw.
- May be too customer specific, no broad market.
- Difficult to know how long the project will last.
- Easy to fall back into the code and fix without proper requirement analysis, design, customer evaluation, and feedback.
- Prototyping tools are expensive.
- Special tools & techniques are required to build a prototype.
- It is a time-consuming process.

Spiral Model

The spiral model refers to a test-driven software development model that was introduced for superimposing the shortcomings present in a conventional Waterfall model. The spiral model looks exactly like a spiral having multiple loops. The exact number of spiral loops is unknown, and they can differ from project to project. The spiral model facilitates risk handling management, and the final software project is delivered in the form of loops.

Each loop of the spiral model (Figure 9) is known as the phase of the whole software development process. The initial phase of the spiral model in its early development stages of the waterfall life cycle is required to develop the final software product. The total number of faces required to develop the software can differ from project managers and depends on associated risks.

In this model, we create the application module by module and hand it over to the customer so that they can start using the application at a very early stage. And we prepare this model only when the module is dependent on each other. In this model, we develop the application in the stages because sometimes the client gives the requirements in between the process.

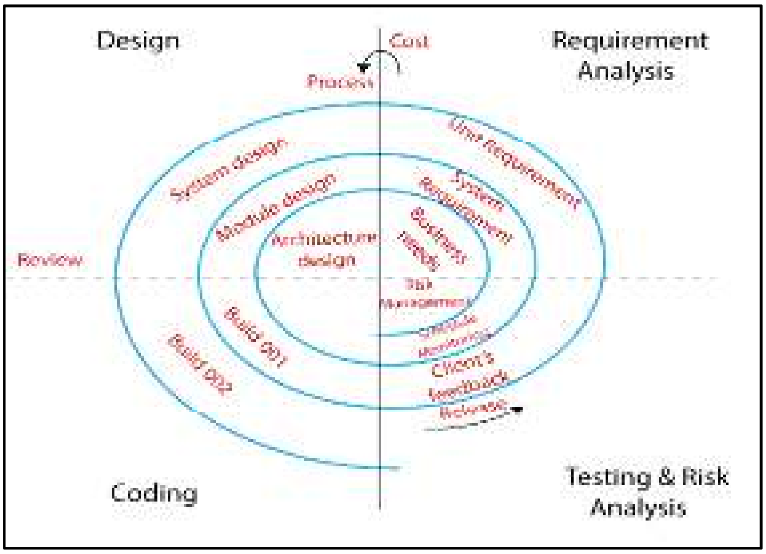


Figure 9: Spiral Model

The different phases of the spiral model are as follows:

1. Requirement analysis: The spiral model process starts with collecting business needs. In this, the following spirals will include the documentation of system requirements, unit requirements, and the subsystem needs. In this stage, we can easily understand the system requirements because the business analyst and the client have constant communication. Once the cycle is completed, the application will be deployed in the market.

2. Design: The second stage of the spiral model is designed, where we will plan the logical design, architectural design, flow charts, decision tree, and so on.
3. Coding: After the compilation of the design stage, we will move to our next step, which is the coding stage. In this, we will develop the product based on the client's requirements and get the client's feedback as well. This stage refers to the construction of the real application in every cycle. The spirals had excellent clarity of the requirements, and the design details of an application are known as the build with having version numbers. After that, these builds are transferred to the client for their responses.
4. Testing and risk analysis: Once the development is completed successfully, we will test the build at the end of the first cycle and analyze the risk of the software on the different aspects such as managing risks, detecting, and observing the technical feasibility. And after that, the client will test the application and give feedback.

Advantages and Disadvantages of the Spiral Model

Advantage	Disadvantage
Flexible changes are allowed in spiral model.	It is not suitable for the small and low-risk product because it could be costly for a smaller project.
The development can be distributed into smaller parts.	It is a traditional model, and thus developers only did the testing job as well.
The customer can use the application at an early stage also.	There is no requirement of review process and no parallel deliverables allowed in the spiral model.
More clarity for Developers and Test engineers	In the spiral model, management is a bit difficult; that's why it is a complex process.
It will provide the wide use of prototypes.	The maximum number of intermediate phases needs unnecessary paperwork.

5.8 Choice of Software Process Models

A structured set of activities required to develop a process model:

- **Specification:** The team defines the main functionality of the software program they're building. They also consider the constraints of the project and the specific features that should exist in the final software program.
- **Design and implementation:** The team designs the software around the specification phase's parameters and programs the software. This includes all of the coding, planning, 3D design and initial planning aside from defining the project's specifications.
- **Verification and validation:** The team verifies that the completed software program conforms to the customer's needs and meets quality expectations. The team presents the prototype to the customer for review.
- **Evolution:** The team listens to customer feedback and adjusts the software to meet new parameters or improve original parameters for better functionality. This can be an ongoing process for the team if they offer post-development support for their software.

A process model is an abstract representation of a process. It presents a description of a process from some perspective. A process model or process model is a simplified representation of a software process, presented from a specific perspective.

Did you Know?

The linear sequential model or the waterfall model assumes that a complete system is delivered at the end of the complete software development cycle. It is designed for linear development. The prototype model is designed to make the developer and the customer understand the requirements in a better way. It does not deliver a production system at once. However, these models are not evolutionary, that is, iterative in nature. Iterative models help software engineers to develop more complex software.

Summary

- The purpose of the project approach is to identify the project management methodologies that will be used on the project.
- The approach should be based on the project management framework but should also contain reference to and iterative development, or prototyping methodologies that will be utilized. It is imperative to offer enough description of the approach, but the description should not be too detailed.
- Waterfall approach has extremely strict separate stages, with no overlap, and high levels of planning and process control.
- In iterative approach, the team produces succeeding releases that eventually evolve into a complete product. This is a good approach when there are many unknowns, or when speed is of the essence.
- The objective of the User Acceptance Testing (UAT) stage is to ensure that the information management solution meets the agreed requirements.
- The project technical plan is more or less the WBS, it is a non-graphical non-schematic representation of the WBS.
- A technical plan should be created as part of the business plan, this allows more accurate budgeting for things such as capital equipment, land, energy costs, etc.
- The software processes in software engineering refer to the methods and techniques used to develop and maintain software.
- The software processes are the activities for designing, implementing, and testing a software system.

Keywords

Software: Software is the set of instructions in the form of programs to govern the computer system and to process the hardware components.

Software Process: A software process model is an abstract representation of the development process. A software process includes the set of activities and associated outcome that produces a software product.

Software validation: In this process, evaluation of the software product is done to ensure that the software meets the business requirements as well as the end user's needs.

Waterfall: A linear, sequential approach to software development, with distinct phases such as requirements gathering, design, implementation, testing, and maintenance.

DevOps: A set of practices that aims to improve collaboration and communication between development and operations teams, with an emphasis on automating the software delivery process.

Technical Plan: The project technical plan illustrates a detailed breakdown of the relationships between the major activities required by the project.

Self Assessment

1. In _____________ process, the evaluation of the software product is done to ensure that the software meets the business requirements as well as the end user's needs.

A. Software specifications

B. Software development

C. Software validation

D. Software evolution

2. The software process involves the process(es) for ___________ a software system.

A. Designing

B. Implementing

C. Testing

D. All the above.

3. WBS stands for _______________.

A. Work Break Software

B. Work Breakdown Structure

C. Work Better Services

D. Work Breakdown Shift

4. In which of the following phase, the objective is to ensure that the information management solution meets the agreed requirements.

A. User Acceptance Test (UAT)

B. Planning

C. Analysis

D. Business Case Analysis

5. Which of the following is NOT a project approach?

A. Waterfall

B. Iterative

C. Agile

D. Rapid Task Force

6. Waterfall approach has extremely strict separate stages, with no overlap, and high levels of planning and process control.

A. True

B. False

7. __________ is the set of instructions in the form of programs to govern the computer system and to process the hardware components.

A. Software

B. Instruction format

C. Pipeline

D. Processor cycle

8. V-Model also referred to as the _____________ model.

A. predictive
B. verification and validation
C. indicative
D. verifier

9. In a waterfall model, each phase must be completed before the next phase can begin and there is _______________ in the phases.

A. overlapping
B. no overlapping
C. Both (a) and (b)
D. None of the above

10. Incremental Model is a process of software development where requirements are divided into multiple standalone modules of the software development cycle.

A. True
B. False

11. In which of the following, the detailed description of a software system to be developed with its functional and non-functional requirements.

A. Software development
B. Software validation
C. Software specifications
D. Software evolution

12. The project technical plan is more or less the WBS, it is a non-graphical non-schematic representation of the WBS.

A. True
B. False

13. RAD stands for

A. Rotational Application Development
B. Rapid Application Development
C. Routine Application Development
D. Reverse Application Development

14. Which of the following statement is/are TRUE for RAD model?

A. The RAD model is a type of incremental process model in which there is an extremely short development cycle.
B. When the requirements are fully understood, and the component-based construction approach is adopted then the RAD model is used.
C. The various phases in RAD are Requirements Gathering, Analysis and Planning, Design, Build or Construction, and finally Deployment.
D. All the above.

15. A _______________ model is an abstract representation of the development process.

A. software product
B. software process

C. software enhancement

D. software promotion

Answers for Self Assessment

1.	C	2.	D	3.	B	4.	A	5.	D
6.	A	7.	A	8.	B	9.	B	10.	A
11.	C	12.	A	13.	B	14.	D	15.	B

Review Questions

1. Explain the waterfall model with its advantages and disadvantages.
2. Illustrate a structured set of activities required to develop a process model.
3. Discuss the different project approaches.
4. Discuss the difference between the validation and verification phase of V-model.
5. What is the need of using the software process models in Software project management?
6. Which factors play a significant role in choosing a software process model?
7. Write briefly about different types of software process models.
8. Indicate the steps involved in the Prototype model.
9. Differentiate Waterfall model and Prototype model.
10. Write a short note on:
    (a) Agile model
    (b) Prototype model

Further Readings

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Web Links

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Software Processes - javatpoint

Software Processes in Software Engineering - GeeksforGeeks

Waterfall Model (Software Engineering) - javatpoint

The 5 Most Popular Project Management Approaches That Work (g2.com)

Types of Project Management: Methodologies, Industries, and More | Coursera

Unit 06: Effort Estimation

CONTENTS

Objectives

After studying this unit, you will be able to:

- understand the concept of effort estimation and its importance.
- discuss the elements of a successful estimate.
- know the effort estimation process and techniques used for it.
- analyse the problems associated with the estimation.
- learn about the Albrecht Function Point Analysis (FPA) and COCOMO model.

Introduction

The software developers use various techniques when planning for program releases. Effort estimation is one way to evaluate a project and understand its schedule, budget and prioritization needs. Learning about this planning process can help you apply it to new development or project management initiatives.

Effort estimation is a process in which project managers evaluate how much time and money they need to complete a project. This technique is common in software development, where technology professionals define the resources and schedule for developing a new application or releasing an update. These forecasts help create accurate estimates that often require approval before work on a project begins. Effort estimation is the process of estimating how much effort your project will take to bring to life. It is expressed in terms of person-hours or money.

Effort estimation is a common tool as part of the Agile methodology, which is a framework that divides a project into smaller phases. The project managers typically estimate the effort a software or other technology development project requires before commencing. Using these estimates, they efficiently allocate resources to meet the project's deadline and provide value to their clients and customers. Understanding how project managers perform these estimations can help to make accurate predictions regarding resource allocation.

What is an Effort Estimate?

An effort estimate is used to determine the likely effort of a project. It also helps to assess the feasibility of a project and thus, decide for or against a project. The important parts of this are capacity, resources, time and cost planning. A procedure for estimating effort should be simple to perform, user-friendly and as accurate as possible.

Notes: A project manager can help the team to create successful estimates for any software project by using sound techniques and understanding what makes estimates more accurate.

Effort estimation will generate a lot more information than only effort and duration:

- Who will be responsible for each work package?
- What is the work package specification?
- What are the expected results of each work package?
- How is the achievement of the results measured?
- What are the prerequisites for the work package?
- What are the conditions under which the work has to be done?
- What are the required start and end times?
- What and how much material is needed for each work package, at what cost?
- What tools are needed for each work package, and at what rates?

6.1 Pre-requisites for Effort Estimation

Estimation of effort has various benefits for a project manager, including assisting with drafting a project plan, predicting costs, drafting budgets, and allocating resources to the individuals working on the project. The project managers usually conduct estimation during the early stages of the software development life cycle.

A realistic effort estimate requires you to have a clear understanding of certain elements of the project:

- The purpose and scope of the project (If working with a client, what are their expectations?)
- What needs to be done to achieve it.
- What resources should be allocated.
- Timeline.

6.2 Importance of Effort Estimation

Figure 1 depicts the importance of effort estimation.

Figure 1: Effort Estimation Importance

Understanding a project: When estimating the effort for development, it can help team members to understand each task they complete, along with any dependencies. Although you might have a clear scope, conversations you have when estimating effort can help clarify project requirements and user requests.

Improving collaboration: Collaboration is a key concept in the Agile framework, and teams meet regularly to discuss priorities and status to accomplish this. During estimation meetings, each team member can express their opinions on efforts, priorities and resource needs.

Creating an accurate budget: When you evaluate the effort to complete a project, you can determine what team members, tools and time you need. This can help you create an accurate project budget by estimating wages and the cost of each resource.

Making an accurate schedule: Organizations often rely on accurate delivery schedules and provide this information to employees and customers. Using the various estimation techniques can help ensure you build an accurate schedule based on expert input and historical data.

Managing resources and assignments: By evaluating the resources you need for a project and the tasks to complete; you can estimate what resources you need. This can help if development teams, such as QA, share resources or assignments to ensure each can meet their schedules.

Improving risk management: Estimating effort at the start of a project can help you identify and manage risks, like breaching a budget or schedule. With these identified, you can create mitigation plans and prioritize monitoring high-risk situations.

6.3 Elements of a Successful Estimate

A sound estimate starts with a Work Breakdown Structure (WBS). A WBS is a list of tasks that, if completed, will produce the final product. The way the work is broken down dictates how it will be done. There are many ways to decompose a project into tasks. The project can be broken down by feature, by project phase (requirements tasks, design tasks, programming tasks, QA tasks, etc.), or by some combination of the two. Ideally, the WBS should reflect the way previous projects have been developed. A useful rule of thumb is that any project can be broken down into between 10 and 20 tasks. For large projects (for example, a space shuttle), those tasks will be very large ("Test the guidance system"); for small projects (like writing a simple calculator program), the tasks are small ("Build the arithmetic object that adds, multiplies, or divides two numbers").

The team must take care in generating the WBS—if the tasks are incorrect, they can waste time going down the wrong path. Once the WBS is created, the team must create an estimate of the effort required to perform each task. The most accurate estimates are those that rely on prior experience. The team members should review previous project results and find how long similar tasks in previous projects took to complete. The sources of delays in the past should be taken into account when making current estimates. Postmortem reports are a good source of this information.

No estimate is guaranteed to be accurate. People get sick or leave the organization; teams run into unforeseen technical problems; the needs of the organization change. The unexpected will almost certainly happen. Therefore, the goal of estimation is not to predict the future. Instead, it is to gauge an honest, well-informed opinion of the effort required to do a task from those people in the organization who have the most applicable training and knowledge.

If two people widely disagree on how long a task will take, it's likely that the source of that disagreement is that each person made different assumptions about details of the work product or the strategy for producing it. In other words, any disagreement is generally about what is required to perform the task itself, not about the effort required to complete it. For example, given the same vision and scope document for a tool that sets the computer clock, two different developers might come up with wildly different estimates. By helping the programmers discuss the assumptions and come to a temporary resolution about their differences, the project manager can help them agree on a single estimate for the task.

A project manager can help the team create more accurate estimates by reducing the uncertainty about the project. The most effective way to do this is to do a thorough job creating a vision and scope document —the more accurate and detailed it is, the more information the team has to work with when generating their estimate. The project manager can also ensure that the team has reached a consensus on the tasks that must be performed. Finally, the project manager can lead the team in a discussion of assumptions.

Assumptions Make Estimates More Accurate

Once the team has agreed upon a WBS, they can begin to discuss each task so they can come up with an estimate. At the outset of the project, the team members do not have all of the information they need in order to produce estimates; nevertheless, they need to come up with numbers. To deal with incomplete information, they must make assumptions about the work to be done. By making assumptions, team members can leave placeholders for information that can be corrected later, in order to make the estimate more accurate.

For the estimates to be most effective, the assumptions must be written down. Important information is discovered during the discussion that the team will need to refer back to during the development process, and if that information is not written down, the team will have to have the discussion all over again. If an assumption turns out to be incorrect, the schedule will need to be adjusted; they will be able to point to the exact cause of the delay by showing that a documented assumption turned out to be incorrect. This will help the project manager explain any resulting schedule delay to others in the organization and avoid that source of delays in the future. The assumptions also provide a way to keep a record of team decisions, share those decisions with others, and find errors in their decisions.

The team should hold a brainstorming session to try to identify as many assumptions as possible. The bigger the list of assumptions, the lower the overall risk for the project. A project manager may get better results from this session by helping the team see how these assumptions can work to their benefit.

Distrust Can Undermine Estimates

Estimates can either be a source of trust or distrust between the project team and their managers. If the team knows that they are given the opportunity to fully justify their estimates, and that they will be allowed to re-estimate if the scope of the project changes, that they won't be punished for making an honest mistake in estimation, then each team member will work very hard to produce accurate estimates. In this case, estimation can be an effective tool for team motivation. Estimates are most accurate when everyone on the project team feels that he was actively part of the estimation process. Every team member feels a personal stake in the estimates and will work very hard to meet any schedule based on those estimates.

Distrust in a software organization can be a serious, endemic problem. It starts with a kernel of distrust between management and the engineering team; the distrust grows until management simply won't accept the team's estimates. For example, a senior manager may decide that the team plans to spend too much time testing the software, even though the team reached consensus and all team members stand behind the estimates.

A project manager must be especially careful to explain this and support that consensus when senior managers start to pick apart the team's estimates. If deadlines are handed down that do not allow enough time for the team to complete the work, it can lead to serious morale problems—and the project manager will be blamed for the delay, often by the same people who caused it in the first place.

An important part of running successful software projects is reaching a common understanding between the engineers, managers, and stakeholders. One way to do that is with a consistent set of practices. This allows the engineers' work to be transparent to the rest of the organization. Similarly, the managers' and stakeholders' need, and expectations must be transparent to the engineers.

Estimation is the calculated approximation of a result which is usable even if input data may be incomplete or uncertain. In project management (that is, for engineering), accurate estimates are the basis of sound project planning.

Many processes have been developed to aid engineers in making accurate estimates, such as:

- compartmentalization (i.e., breakdown of tasks),
- parametric estimating,
- structured planning,
- educated assumptions,
- delphi method,
- identifying dependencies,
- examining historical data,
- estimating each task,
- documenting the results.

The popular estimation processes for software projects include:

- COCOMO
- Proxy Based Estimation (PROBE)
- Wideband Delphi
- The Planning Game
- Program Evaluation and Review Technique (PERT)
- Event chain methodology

6.4 Problems Associated with the Estimation

Inaccurate estimates and misconceptions about the estimating process often contribute to failed projects. An inaccurate estimate leads to infeasible plans. When infeasible plans are implemented, the result is often missed deadlines, inadequate performance and/or poor quality. There can be multiple problems associated with the estimation process.

- How do inaccurate estimates lead to failed projects?
- Inaccurate estimation can be attributed to:
- Lack of past data on which to base estimates.
- Lack of estimating experience.
- Lack of a systematic estimation process, sound techniques, or models suited to the project's needs.
- Failure to include essential project activities and products within the scope of the estimates.
- Unrealistic expectations or assumptions.
- Failure to recognize and address the uncertainty inherent in software estimates.

Accommodating Reuse in the Estimates

Estimates for the amount of code that can be reused are a source of error and risk in estimating software cost. PL/PM tends to be overly optimistic about the effort that will be necessary to adapt the existing code. They often assume only a 10% change to a program's design and code will be necessary when in fact the changes are often more than 50%. Other factors that commonly contribute to size, cost and schedule risks are:

- Optimistic assessments of the software development environment and resources, and
- Misunderstood or constantly changing requirements.

The risk management should be revisited each time the project estimate is updated. The risk management plan update should not concentrate only on the risk areas identified originally.

Use of Past Data

Past data from the PKB and/or from the same project should be used to improve the accuracy of the estimates.

Granularity of Estimates

Estimates are to be given for each phase in the project.

For maintenance projects,

- For work requests >= (x) days, estimates are to be given for each phase in the work request.
- For work requests < (x) days, estimates may be given for the entire work request. However, it is desirable to give the estimates for each phase even for these work requests.

In addition to this, effort estimates are to be given for the following activities:

- Project management
- Documentation effort
- Reviews
- Configuration Management

Understanding the Tradeoffs

Once a project estimate is generated, some combination of functionality, schedule, cost and resources that can be accepted by management and customers should be produced. This requires a good understanding of the relationships between these variables. Here are some instances of tradeoffs:

- If the schedule is lengthened, the overall cost can be reduced, and fewer resources can be used. Sometimes, the schedule has to be lengthened only by a few weeks, to get a benefit. Usually, the management and customers may not want a delay, but it is worth negotiating an acceptable delay. A schedule can be shortened only in three ways:
  - Reducing the functionality (reducing the effort by doing less).
  - Increasing the team size (but only if there are tasks that can be done in parallel to take advantage of this), or
  - Keeping the team size constant but get them to work overtime.
- If the functionality cannot be reduced, choosing one of the two remaining alternatives will cost more.

Tracking and Reporting Estimation Activities

Comparing planned versus actual estimates over time allows the PL/PM to see how well they are estimating and also to see how their project is changing during project execution. If estimates are never tracked, it is not possible to determine how good the estimates were. The estimation work sheets should form a database of estimates. This database can be used by the PL/PM to either calibrate estimation models or for purposes of comparison when performing estimates for future projects. Estimation data, both planned and actual, should be provided to the PKB for the benefit of other similar projects.

6.5 Estimation Basis

The project work estimation has three phases: the initial first cut, commonly known as SWAG (scientific wild-ass guess), tracking the estimate against the actual numbers, and using the schedule to see what's happening in the project.

Phase 1: Create an Initial Estimate:

If you're a project manager, you probably try to estimate the work at the beginning of the project, even if you're assigned a project end date. Sometimes senior managers have trouble hearing what you've said in your estimate. Once you have a gross estimate at the beginning of the project, you can drill down and create estimates for each of the project components. Whether you try to create precise estimates or choose to use slack buffers to deal with incomplete estimates, you will have some project estimate total.

Notes: As the project unfolds, you'll be able to acquire feedback on how well you estimated using the second part of estimation, the EQF, or estimation quality factor.

Phase 2: Track EQF to Understand the Project Estimate

As you continue to manage the project, track your initial completion date estimate. Each month (or in a short project, each week), take five minutes out of your project team meeting and ask, "When do you think we will finish the project?" Track that estimate on a chart set up with the release dates on the Y axis, and the date that you asked the question on the X axis.

There are two good reasons for asking this question. First, you continue to focus your project staff on completing the project. People tend to work on what you, the project manager, focus on.Second, by asking your project staff, you can discover the various confidences they have in the release date. When you look at the EQF chart, you can see if people are concerned that the project won't meet its release date, or if they're feeling confident about meeting or beating the release date. Then you can deal with their concerns or your own.

Phase 3: Use EQF to Manage Project Concerns

We use the slope of the EQF to make queries like, "Tell me what's happened in the project to make you think we will meet/beat/miss the date." When people become more optimistic or pessimistic, we want to know why. The EQF not only gives me feedback on my initial estimate; it also gives me another technique to discuss the project state with the project team. And once we understand the project team's concerns, we can deal with them or elevate those concerns.

6.6 Estimation Techniques

For selecting an estimation technique, the following factors need to be considered:

- Whether the assumptions of the estimation technique match the project.
- Whether the data required by the method is available from a reliable source.
- Whether the activities covered by the method match the planned activities of the project.

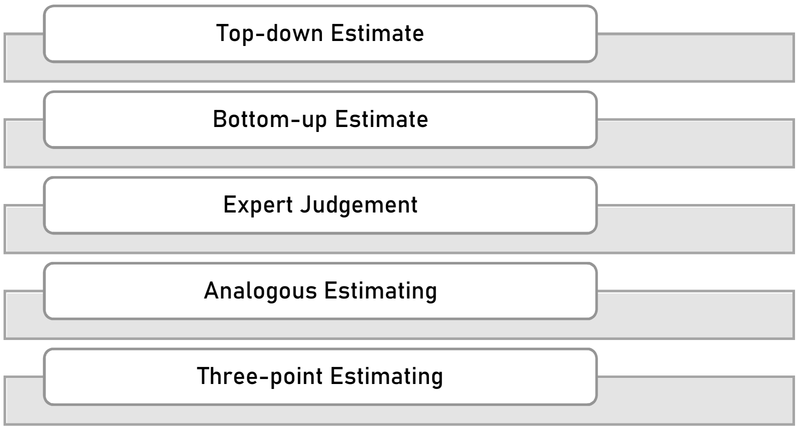

Figure 2: Estimation Techniques

The different estimation techniques are listed in Figure 2:

Top-down Estimate: Once more detail is learned on the project's scope, a top-down estimating technique assigns an overall time for the project and divides the project into parts according to the work breakdown structure. For example, let's imagine a project that must be finalized in one year. By fitting the scope of the project on the timeline, you can estimate how much time is available for each activity that needs to be performed. The top-down method is best applied to projects similar to those you have completed previously. If details are sketchy or unpredictable, the top-down approach is likely to be inefficient and cause backlogs.

Bottom-up Estimate: The bottom-up method is the opposite of top-down. It approaches the project as a combination of small workpieces. By making a detailed estimate for each task and combining them together, you can build an overall project estimate. Creating a bottom-up estimate usually takes more time than the top-down method but has a higher accuracy rate. However, for the bottom-up method to be truly efficient, the project must be separated at the level of work packages.

Expert Judgement: The expert judgment technique requires consulting the expert who will perform the task to ask how long it will take to complete. This method relies on your trust in the expert's insights and experience. While it may seem like the most accurate estimation method, there are two points to consider:

- The expert's estimates need to be objective. Estimates that are carried out very positively and overlook possible disruptions can create difficulties in meeting deadlines.
- You can only get an accurate answer to specific questions. Detailing the task description, framing it, and clarifying the requirements will allow the expert to understand the task fully and provide an accurate estimate.

Analogous Estimating: Analogous estimating is a technique for estimating based on similar projects completed in the past. If the whole project has no analogs, it can be applied by blending it with the bottom-up technique. In this case, you compare the tasks with their counterparts, then combine them to estimate the overall project.

Three-point Estimating: Three-point estimating is very straightforward. It involves three different estimates that are usually obtained from subject matter experts:

- Optimistic estimate
- Pessimistic estimate
- Most likely estimate

The optimistic estimate gives the amount of work and time that would be required if everything went smoothly. A pessimistic estimate provides the worst-case scenario. The result will be most realistic when the two are averaged with the most likely estimate.

6.7 Function Point Analysis

Function Point Analysis was initially developed by Allan J. Albrecht in 1979 at IBM and it has been further modified by the International Function Point Users Group (IFPUG). The initial definition is given by Allan J. Albrecht. Functional Point Analysis (FPA) gives a dimensionless number defined in function points, found to be an effective relative measure of function value delivered to the customer.

FPA is used to make estimates of the software project, including its testing in terms of functionality or function size of the software product. However, FPA may be used for the test estimation of the product. The functional size of the product is measured in terms of the function point, which is a standard of measurement to measure the software application.

Types of Functional Point Analysis

There are basically two types of Functional Point Analysis (

Figure 3),

- Transactional Functional Type
- Data Functional Type

Transactional Functional Type

External Input (EI): EI processes data or control information that comes from outside the application's boundary. The EI is an elementary process in which the data crosses the boundary from outside to inside. This data may come from a data input screen or another application. The data may be used to maintain one or more internal logical files. The data can be either control information or business information. If the data is controlled information, it does not have to update an Internal Logical File (ILF).

External Output (EO): EO is an elementary process that generates data or control information sent outside the application's boundary. Additionally, an EO may update an ILF. The data creates reports or output files sent to other applications. These reports and files are created from one or more ILFs and EIFs.

External Inquiries (EQ): EQ is an elementary process made up of an input-output combination that results in data retrieval from one or more ILFs and EIFs. The input process does not update any ILFs, and the output side does not contain derived data.

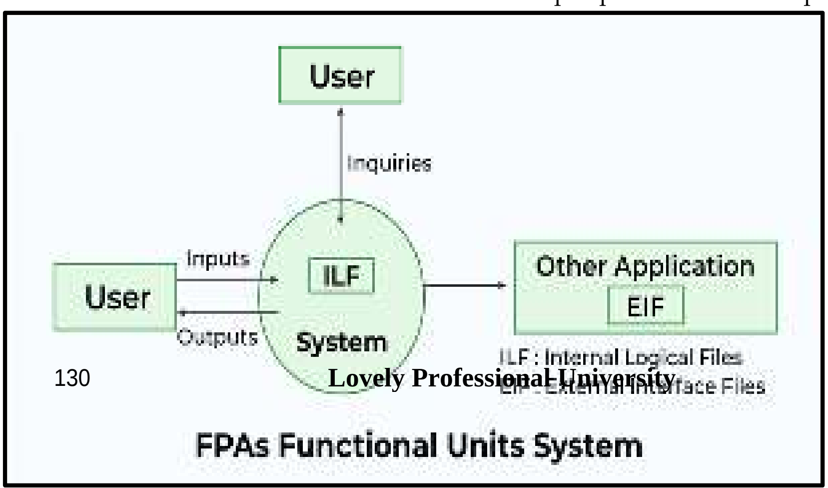

Figure 3: Functional Units System Representation

Data Functional Type

Internal Logical File (ILF): A user-identifiable group of logically related data or control information maintained within the boundary of the application. It resides entirely within the applications boundary and is maintained through external inputs.

External Interface File (EIF): A user identifiable group of logically related data that is used for reference purposes only. The data resides entirely outside the application and is maintained by another application. The external interface file is an internal logical file for another application.

Did You Know?

What are Internal Logical Files?

ILF stands for "Internal Logical File". ILFs represent data that is stored and maintained within the boundary of the application you are counting. When counting ILFs you are basically counting the data functions that your application is being built to maintain.

Computing Function Point Analysis

FPs of an application can be calculated with the help of the number of functions and types of functions used in applications. These are classified into five types:

Measurement Parameters	Examples
Number of External Inputs (EI)	Input screen and tables
Number of External Output (EO)	Output screens and reports
Number of external inquiries (EQ)	Prompts and interrupts.
Number of internal files (ILF)	Databases and directories
Number of external interfaces (EIF)	Shared databases and shared routines.

Notes: All these parameters are then individually assessed for complexity.

FP characterizes the complexity of the software system and hence can be used to depict the project time and the manpower requirement. The effort required to develop the project depends on what the software does. FP is programming language independent. The weights of 5 functional point attributes include (Table 1):

Table 1: Weights of Functional Point Attributes

Measurement Parameter	Low	Average	High
Number of external inputs (EI)	3	4	6
Number of external outputs (EO)	4	5	7
Number of external inquiries (EQ)	3	4	6
Number of internal files (ILF)	7	10	15
Number of External Interfaces (EIF)	5	7	10

The functional complexities are multiplied with the corresponding weights against each function, and the values are added up to determine the UFP (Unadjusted Function Point) of the subsystem (Table 2).

Table 2: Determination of UFP

Measurement Parameter	Count		Weighing Factor		
	Simple	Average	Complex		
Number of external inputs (EI)	32	*	3	4	6 = 128
Number of external outputs (EO)	60	*	4	5	7 = 300
Number of external inquiries (EQ)	24	*	3	4	6 = 96
Number of internal files (ILF)	8	*	7	10	15 = 80
Number of external interfaces (EIF)	2	*	5	7	10 = 40
Algorithms used Count total →					618

Below mentioned is the way how to compute FP (Table 3):

From the above tables, Functional Point is calculated with the following formula,

FP = Count-Total * [0.65 + 0.01 * ∑(fi)]= Count * CAF

Here, the count-total is taken from the chart.

CAF = [0.65 + 0.01 * ∑(fi)]

- ∑(fi) = sum of all 14 questions and it also shows the complexity factor– CAF.
- CAF varies from 0.65 to 1.35 and ∑(fi) ranges from 0 to 70.
- When ∑(fi) = 0, CAF = 0.65 and when ∑(fi) = 70, CAF = 0.65 + (0.01*70) = 0.65 + 0.7 = 1.35

Table 3: Questions

1	Reliable backup and recovery required
2	Data communications
3	Distributed functions
4	High Performance (time efficiency) required
5	? Heavily used configuration
6	On-line (interactive) data entry
7	Must be easy to use
8	On-line update
9	Complex user interface
10	Complex process
11	? Reusability
12	Ease of installation
13	Multiple installation sites
14	Easy to modify

Objectives of Functional Point Analysis

The basic and primary purpose of the functional point analysis is to measure and provide the software application functional size to the client, customer, and the stakeholder on their request. Further, it is used to measure the software project development along with its maintenance, consistently throughout the project irrespective of the tools and the technologies. The objectives of FPA are to measure the functionality that the user requests and receives.

- To measure the software development and maintenance independently of the technology used for implementation.
- It should be simple enough to minimize the overhead of the measurement process.
- It should be a consistent measure among various projects and organizations.

Benefits of Functional Point Analysis

- FPA is a tool to determine the size of a purchased application package by counting all the functions included in the package.
- It is a tool to help users discover the benefit of an application package to their organization by counting functions that specifically match their requirements.
- It is a tool to measure the units of a software product to support quality and productivity analysis.
- It is a vehicle to estimate the cost and resources required for software development and maintenance.
- It is a normalization factor for software comparison.

6.8 COCOMO Model

COCOMO (Constructive Cost Model) is a regression model based on LOC, that is, the number of Lines of Code. It is a procedural cost estimate model for software projects and is often used as a process of reliably predicting the various parameters associated with making a project such as size, effort, cost, time, and quality. It was proposed by Barry Boehm in 1981 and is based on the study of 63 projects, which makes it one of the best-documented models. This model is now generally called "COCOMO 81". It refers to a group of models and is used to estimate the development efforts which are involved in a project. COCOMO is based upon the estimation of lines of code in a system and the time.

COCOMO has also considered the aspects like project attributes, hardware, assessment of produce, etc. This provides transparency to the model which allows software managers to understand why the model gives the estimates it does. Moreover, the baseline COCOMO originally underlies a waterfall model lifecycle. The developments are done on multiple COCOMO models in parallel for cost estimates that cover a broader scope that exceeds the boundaries of traditional software development are discussed.

The COCOMO model has basically two parameters like effort calculation and development time to define the quality of any software product. The key parameters which define the quality of any software products, which are also an outcome of the COCOMO are primarily Effort & Schedule:

- Effort: Amount of labor that will be required to complete a task. It is measured in person-months units.

- o Schedule: Simply means the amount of time required for the completion of the job, which is, of course, proportional to the effort put in. It is measured in the units of time such as weeks, and months.

COCOMO (Constructive Cost Model) is a combination of parametric estimation equation and weighting method. Based on the estimated instructions (Delivered Source Instructions DSI), the effort is calculated by taking into consideration both the attempted quality and the productivity factors. COCOMO is based on the conventional top-down programming and concentrates on the number of instructions.

Different models of COCOMO have been proposed to predict the cost estimation at different levels, based on the amount of accuracy and correctness required. All of these models can be applied to a variety of projects, whose characteristics determine the value of the constant to be used in subsequent calculations.

6.9 Types of COCOMO Model

The COCOMO model is a software cost estimation model that uses a set of algorithms and formulas to predict the effort, time, and cost required for software development. The model assumes that there is a relationship between the size of the software and the effort required to develop it. The model considers several factors that influence software development, such as project characteristics, development team experience, software complexity, and development tools used. The software projects under COCOMO model strategies are classified into 3 categories, organic, semi-detached, and embedded (Table 4).

- **Organic/ Basic COCOMO Model:** Basic COCOMO model is static single-valued model that computes software development effort (and cost) as a function of program size expressed in estimated lines of code. By means of parametric estimation equations (differentiated according to the different system types), the development effort and the development duration are calculated on the basis of the estimated DSI. The breakdown to phases is realized in percentages. In this connection it is differentiated according to system types (organic batch, semidetached-on-line, embedded-real-time) and project sizes (small, intermediate, medium, large, very large). A software project is said to be an organic type if-
    - o Project is small and simple.
    - o Project team is small with prior experience.
    - o The problem is well understood and has been solved in the past.
    - o Requirements of projects are not rigid, such a mode example is payroll processing system.
- **Semi-Detached Mode/ Intermediate COCOMO:** Intermediate COCOMO model computes software development effort as a function of program size and a set of "cost drivers" that include subjective assessments of product, hardware, personnel, and project attributes. The estimation equations are now taking into consideration (apart from DSI) 15 influence factors; these are product attributes (like software reliability, size of the database, complexity), computer attributes (like computing time restriction, main memory restriction), personnel attributes (like programming and application experience, knowledge of the programming language), and project attributes (like software development environment, pressure of development time). A software project is said to be a Semi-Detached type if-
    - o Project has complexity.
    - o Project team requires more experience, better guidance, and creativity.
    - o The project has an intermediate size and has mixed rigid requirements such a mode example is a transaction processing system which has fixed requirements.
    - o It also includes the elements of organic mode and embedded mode.

- Few such projects are- Database Management System (DBMS), new unknown operating system, difficult inventory management system.

- **Embedded Mode/ Advanced COCOMO:** Detailed COCOMO or Advanced COCOMO model incorporates all characteristics of the intermediate version with an assessment of the cost driver's impact on each step, like analysis, design, etc. In this case the breakdown to phases is not realized in percentages but by means of influence factors allocated to the phases. At the same time, it is differentiated according to the three levels of the product hierarchy (module, subsystem, system); product-related influence factors are now taken into consideration in the corresponding estimation equations. A software project is said to be an Embedded mode type if-
  - A software project has fixed requirements of resources.
  - Product is developed within very tight constraints.
  - A software project requiring the highest level of complexity, creativity, and experience requirement falls under this category.
  - Such mode software requires a larger team size than the other two models.

Table 4: COCOMO Model Types

Type	Description	Size Metric	Effort Multipliers
Basic	Suitable for projects with familiar technologies and small development teams	KLOC (thousands of lines of code)	3 cost drivers: product attributes, hardware attributes, personnel attributes
Semi-Detached	Suitable for projects with moderate complexity and development teams	SLOC (source lines of code)	15 cost drivers: 3 basic cost drivers + 12 Semi-Detached cost drivers such as development flexibility and database size
Embedded	Suitable for large and complex projects with diverse technologies and large development teams	SLOC and/or Function Points	17 cost drivers: 15 Semi-Detached cost drivers + 2 additional cost drivers for modern software engineering practices such as reuse and software tools

Table 5: Software Project Types for COCOMO

Type of Software Project	a	b	c	d
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

Table 5 shows the software project types for COCOMO model. These are the effort multipliers for different types of software projects in the COCOMO model. The effort multipliers are used to adjust the effort required for a project based on the project's characteristics. The project characteristics that are considered include product, hardware, personnel, and project attributes. The effort multipliers are represented by four letters: a, b, c, and d. The values for these multipliers vary depending on the type of software project. For example, for organic projects, the values for a, b, c, and d, are 2.4, 1.05, 2.5, and 0.38, respectively. Similarly, for semi-detached projects, the values for a, b, c, and d, are 3.0, 1.12, 2.5, and 0.35, respectively. For embedded projects, the values for a, b, c, and d, are 3.6, 1.20, 2.5, and 0.32, respectively.

The effort multipliers are used in the COCOMO model to calculate the effort required for a project based on its size in Lines of Code (LOC). The model considers the project's characteristics and adjusts the effort required accordingly. This helps in providing a reliable estimate of the effort required for a software project and in identifying critical areas that need more attention during software development.

Table 6: COCOMO Model Formulas

COCOMO Model	Effort Formula	Schedule Formula	Purpose
Basic	Effort = a * (KLOC)^b	Schedule = c * (Effort)^d	Estimate effort and schedule for small to medium-sized projects
Intermediate	Effort = a * (KLOC)^b * (EAF)	Schedule = c * (Effort)^d	Estimate effort and schedule for larger and more complex projects
Detailed	Effort = (a * (KLOC / 1000)^b) * EAF * (SF)^i	Schedule = c * (Effort)^d	Estimate effort and schedule for very large and complex projects

In each of these formulas, KLOC refers to the estimated number of lines of code required for the project, and a, b, c, and d, are coefficients that depend on the project type (organic, semi-detached, or embedded). EAF (Effort Adjustment Factor) is a multiplier that accounts for various project factors, and SF (Scale Factor) is a multiplier that accounts for other project factors such as team experience and development process maturity (Table 6).

6.10 Applications od COCOMO Model

The COCOMO model can be applied in the following ways:

- Estimating the effort required to develop a software project.
- Estimating the cost of software development.
- Identifying the critical areas that need more attention during software development.
- Identifying the risks associated with the project and mitigating them.

Medium and Large Projects: For small projects, the attempt for an estimation according to intermediate and detailed COCOMO is too high; but the results from basic COCOMO alone are not sufficiently exact.

Technical Application: For software projects developing commercial applications, COCOMO usually comes up with overstated effort estimation values therefore COCOMO is only applied for the development of technical software. This circumstance is due to the fact that the ratio DSI and man months implemented in the COCOMO estimation equation fits the efficiency rate in a technical development; with regard to commercial software development a higher productivity rate DSI/man-month can be assumed.

Advantages of the COCOMO Model

- There are several advantages of using the COCOMO model:
- It provides a reliable estimate of the effort required to develop a software project.
- It helps in identifying the critical areas that need more attention during software development.

- It helps in identifying the risks associated with the project and mitigating them.
- It helps in reducing the overall cost of software development.

Disadvantages of the COCOMO Model

There are also some disadvantages to using the COCOMO model:

- It is based on historical data, which may not be applicable to the current project.
- It assumes that the project environment and resources are the same for all projects, which may not be true.
- It does not take into account the complexity of the project.

Limitations of the COCOMO Model

There are some limitations to the COCOMO model that need to be considered. The model may not work for all types of software projects. For example, it may not be suitable for projects that involve new and emerging technologies. The model is based on the assumption that the project requirements are well-defined, which may not always be the case. The model does not account for the quality of the software, which is an essential factor in software development.

Best Practices for Using COCOMO Model

To ensure that the COCOMO model is used effectively, some best practices need to be followed:

- Use historical data that is relevant to the project and has similar characteristics.
- Adjust the model parameters to reflect the project's characteristics.
- Involve domain experts in the estimation process to ensure that the project requirements are well-defined.
- Use multiple estimation techniques to validate the results.

Summary

- Estimation of effort has various benefits for a project manager, including assisting with drafting a project plan, predicting costs, drafting budgets, and allocating resources to the individuals working on the project. The project managers usually conduct estimation during the early stages of the software development life cycle.
- Effort estimation is a process in which project managers evaluate how much time and money they need to complete a project. This technique is common in software development, where technology professionals define the resources and schedule for developing a new application or releasing an update.
- Effort estimation is the process of estimating how much effort your project will take to bring to life. It is expressed in terms of person-hours or money.
- An effort estimate is used to determine the likely effort of a project. It also helps to assess the feasibility of a project and thus, decide for or against a project.
- FPA is used to make estimates of the software project, including its testing in terms of functionality or function size of the software product.
- FPA is a tool to determine the size of a purchased application package by counting all the functions included in the package.
- FPA is a tool to help users discover the benefit of an application package to their organization by counting functions that specifically match their requirements.

- COCOMO (Constructive Cost Model) is a combination of parametric estimation equation and weighting method. Based on the estimated instructions (Delivered Source Instructions DSI), the effort is calculated by taking into consideration both the attempted quality and the productivity factors. COCOMO is based on the conventional top-down programming and concentrates on the number of instructions.

Keywords

Effort Estimation: Effort estimation is the process of estimating how much effort your project will take to bring to life. It is expressed in terms of person-hours or money.

Effort Estimate: An effort estimate is used to determine the likely effort of a project. It also helps to assess the feasibility of a project and thus, decide for or against a project. The important parts of this are capacity, resources, time and cost planning. A procedure for estimating effort should be simple to perform, user-friendly and as accurate as possible.

COCOMO Model: COCOMO (Constructive Cost Model) is a regression model based on LOC, i.e number of Lines of Code.

Internal Logical File (ILF): A user-identifiable group of logically related data or control information maintained within the boundary of the application. It resides entirely within the applications boundary and is maintained through external inputs.

External Interface File (EIF): A user identifiable group of logically related data that is used for reference purposes only.

Self Assessment

1. While estimating the cost of the software, Lines of Code (LOC) and Function Points (FP) are used to measure which of the following?

A. Length of Code
B. Size of Software
C. Functionality of Software
D. None of the above

2. In functional point analysis, the number of complexity adjustment factors is

A. 10
B. 12
C. 14
D. 20

3. COCOMO stands for,

A. Constructive Cost Model
B. Construction Cost Model
C. Conventional Costing Model
D. Convergence Costing Model

4. Which of the following statement(s) is/are TRUE for COCOMO model?

A. It is a combination of parametric estimation equation and weighting method.
B. COCOMO is based on conventional top-down programming.
C. COCOMO concentrates on the number of instructions.
D. All the above.

5. Functional Point basically determines the size of the application system on the basis of the functionality of the system.
A. True
B. False

6. The statement reflecting the concept of Function Point Analysis is
A. FPA is used to make estimates of the software project, including its testing in terms of functionality or function size of the software product.
B. FPA is a tool to determine the size of a purchased application package by counting all the functions included in the package.
C. FPA is a tool to help users discover the benefit of an application package to their organization by counting functions that specifically match their requirements.
D. All the above.

7. _____________ is the process of estimating how much effort your project will take to bring to life.
A. Effort justification
B. Effort estimation
C. Effort identification
D. Effort analyzation

8. ____________ is a file containing user-identifiable group of logically related data or control information maintained within the boundary of the application.
A. Input Logical File
B. Extern Logical File
C. Internal Logical File
D. External Interface File

9. Effort estimation is expressed in terms of person-hours or money.
A. True
B. False

10. There is no role of Work Breakdown Structure (WBS) in making a sound estimate.
A. True
B. False

11. In an effort estimate, which of the following is/are an important part to be considered for making an estimate.
A. Capacity
B. Resources
C. Time and cost
D. All the above.

12. ________________ model is a static single-valued model that computes software development effort (and cost) as a function of program size expressed in estimated lines of code.
A. Effort model
B. Waterfall model
C. COCOMO model
D. Analysis model

13. A ________________ model computes software development effort as a function of program size and a set of “cost drivers” that include subjective assessments of product, hardware, personnel, and project attributes.
A. Basic COCOMO
B. Advanced COCOMO
C. Intermediate COCOMO
D. Embedded COCOMO

14. DSI in COCOMO model stands for,
A. Delivered Source Instructions
B. Degree Source Instruction
C. Delivery System Instructions
D. Duplicate Source Instruction

15. COCOMO model for effort estimation can also be used for,
A. estimating the cost of software development.
B. identifying the critical areas that need more attention during software development.
C. identifying the risks associated with the project and mitigating them.
D. All the above.

Answers for Self Assessment

1.	B	2.	C	3.	A	4.	D	5.	A
6.	D	7.	B	8.	C	9.	A	10.	B
11.	D	12.	C	13.	C	14.	A	15.	D

Review Questions

1. List and explain the five components of the Functional Point?
2. Indicate the various factors highlighting the importance of effort estimation.
3. What are the problems associated with estimation?
4. What are the benefits and objectives of Function Point Analysis?
5. Which factors need to be considered for selecting an estimation technique?
6. What are the different types of Functional Point Analysis?
7. A sound estimate starts with a work breakdown structure (WBS). Explain.
8. How inaccurate estimates lead to failed projects?

9. Discuss the COCOMO model in detail.
10. Write a short note on:
    (a) Function Point Analysis
    (b) Effort estimation

Further Readings

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Unit 07: Activity Planning

CONTENTS

Objectives

After studying this unit, you will be able to:

- know about the activity planning and its objectives.
- understand the activity plan and project scheduling.
- analyze the formulation and importance of the project schedule and time dimension.
- explore the network planning and network diagrams in detail in Software Project Management.
- learn in detail about Critical Path Method (CPM)and the framework for CPM/PERT network.

Introduction

Project time management includes two high-level groups of processes for planning and scheduling project activities and tasks necessary for timely completion of the project. Project activities planning and scheduling is the first process group of project time management. Developing the project implementation schedule is the second group.

A careful planning up front in the software project reduces the risk of costly rework or failure down the road. A series of planning activities must be completed before the project moves forward. The project sponsors frequently minimize the value of planning, desiring instead to get the project underway immediately. As a project manager, the job is to act in the best interest of the sponsor, even if that means standing firm while developing the project plan.

Activity planning involves having worked out a method of doing the project; identifying the tasks to be carried; assessing the time needed to do each task; need to allocate dates/times for the start and end of each activity.

Identifying Activities

Work-based: draw-up a Work Breakdown Structure (WBS) listing the work items needed.

Product-based approach

- list the deliverable and intermediate products of project– product breakdown structure (PBS).
- Identify the order in which products have to be created.
- work out the activities needed to create the products.

Need for Activity Planning

- Assess the feasibility of the planned project completion date.
- Identify when resources will need to be deployed to activities.
- Calculate when costs will be incurred.
- This helps the co-ordination and motivation of the project team.

Pre-requisites for Activity Planning

A project is:

- composed of a number of activities.
- may start when at least one of its activities is ready to start.
- completed when all its activities are completed.

An activity,

- must have clearly defined start and endpoints.
- must have resource requirements that can be forecasted: these are assumed to be constant throughout the project.
- must have a duration that can be forecasted.
- may be dependent on other activities being completed first (precedence networks).

Figure 1 represents an example for the activity planning.

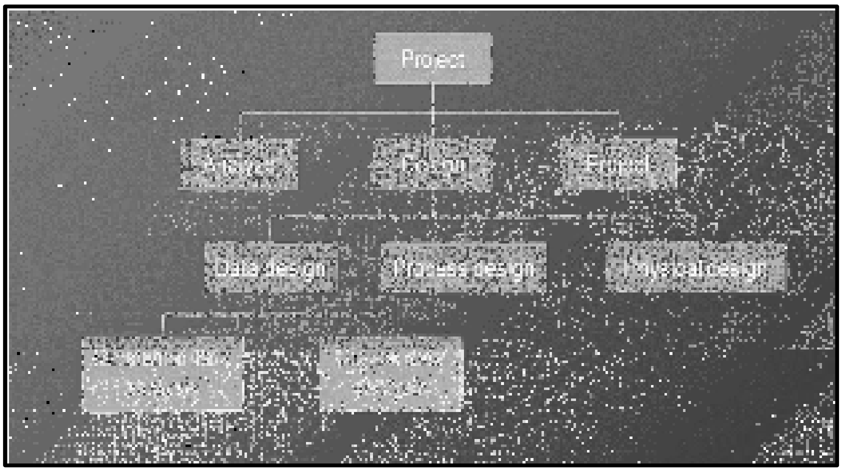

Figure 1: Example Representation for Activity Planning

7.1 Inclusions in Activity Planning

Review Scope- It is important to recommend nailing down the project scope before anything else. The scope outlines the main objectives and establishes boundaries for the project. The boundaries are important to frame the project by detailing what things are inside and outside the scope of the project (Figure 2).

Define Success- A software project planning activity defines what success looks like before the project begins. In a 2007, Gartner research study on why information technology projects succeed or fail, survey participants indicated that, in part, failure resulted from inadequately defining "critical success factors" at the start of the project. Without stakeholder agreement, some degree of failure is likely, especially in complex projects.

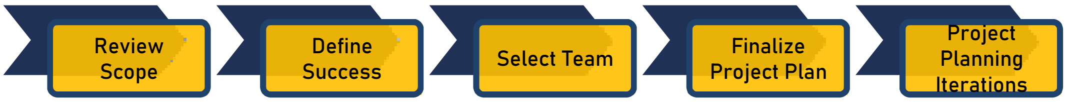

Figure 2: Activity Planning Inclusions

Select Team- Selecting the right team members depends on a clear understanding of the project scope and success criteria. The team members define the work that needs to be done throughout the course of the project. They provide estimates of how much time each piece of work takes and what they need in order to complete their assignments. The team members define all dependencies between each work product. Highly experienced and qualified experts make the planning process more reliable.

Finalize Project Plan- As project manager, the job is to tie together all the information collected from the sponsor, team members and other stakeholders. Combining this information with the project management requirements into a comprehensive document or computerized project management system and present the overall project plan to the sponsor. Negotiating the resolutions to outstanding issues and fine-tune the plan. Obtaining the sponsor approval, funding and team members, and then commencing with the project.

Project Planning Iterations- Project planning activities are never fully done until the project is complete. Throughout the project, issues arise that require to adjust the plan. Just as with the initial planning phase, one must seek input from team members to understand the nature of the work and how much time to assign to it, defining requirements and dependencies accordingly. Present the revised plan to the sponsor for approval. Never fear negotiating things needed to complete the project successfully.

Task: In your words, explain what you have understood about the aims of activity planning.

Steps in Activity Planning

To plan and schedule project activities and tasks the project manager needs to take the next four steps:

Set up activities- The first step of project activities planning and scheduling requires the project manager to define what number of actions and tasks are necessary for producing project deliverables in a timely manner. The input for this process will be the project deliverables statement. The project manager can use this document to define high-level activities that will be used later in creating the project implementation schedule. The project manager should also work on developing project activities templates that help simplify the process of project scheduling and planning. In cooperation with experts and the project team, the manager should make project activities lists that will be the output of the process for project activities planning and scheduling. For each of the listed activities accurate milestones should be identified and approved. All the identified milestones should be gathered into a single milestones list.

Define relationships between activities- The next step for planning project activities and tasks requires the project manager to make a sequence of all the activities identified at the previous step. The manager will use project activities lists, the milestones list and the product scope statement to define relationships among the activities. With the help of project management software that person can set up priorities for each of the project activities and make task sequences organized and sorted by importance and urgency. There is also a need to define dependencies between the activities.

The dependencies can be internal and external. The activities with internal dependencies refer to any actions that the project team will take to produce the deliverables within the existing working environment. The activities with external dependencies refer to non-project factors that define success of project-related activities. Both types of activity dependencies should be identified and added to sequenced and prioritized activity lists. Once the relationships are defined, the project manager should update project activities templates, outline the dependencies, and link them to the product scope statement.

Estimate resources required for performing activities- At this step, the project manager needs to review stakeholder requirements and the product scope statement to estimate an amount of resources required for performing project activities and tasks. Also, expert judgments and alternatives analysis should be used for this purpose. The constraint of time needs to be considered when estimating activity resources. The project manager, in cooperation with experts and the team, should develop resource calendars and define types of required resources. Once all this information is collected and analyzed, it should be used to make a decomposition of activity resources categorized by types, priorities, and time. This decomposition is critical to creating the project implementation schedule.

Estimate durations for activities- The final step in project activity planning and scheduling requires the project manager to define and estimate the amount of working time required for accomplishing each identified activity. This is about setting up durations for project activities and tasks. The duration will depend on 1) the amount of work effort and 2) the availability of activity resources. The project manager should review the resource decomposition and project activities templates to estimate the number of work periods required for completing the identified activities and producing the deliverables. The output of this process is activity estimates that are linked to resource calendars. This information will be used later in developing the implementation schedule.

Did you Know?

What is the resource calendar?

A resource calendar is a calendar that is used to reflect specific working hours, vacations, leaves of absence, and planned personal time for individual resources. A resource calendar differs from a base calendar in that it only reflects working and non-working times for individual resources.

7.2 Activity Plan

Activity plans, also known as work breakdown structures, are essential to software project management. An activity plan helps to break down a project into its individual tasks, which then can be organized and assigned to team members. Once the tasks have been identified and assigned, they can be tracked and monitored throughout the project (Project Management Tools). An activity plan is a tool used to organize a project into its tasks. It is designed to help teams identify the activities that must be completed to achieve the desired outcome.

The activity plan serves as a roadmap for the entire project by breaking down large goals into smaller objectives and assigning them to specific people or teams. This allows for better tracking of progress and ensures that tasks are completed on time. Furthermore, it ensures that everyone involved has a clear understanding of their role within the project.

Benefits of Using an Activity Plan

Using an activity plan offers many benefits for software projects:

- Breaking down complex projects into smaller chunks makes it easier for teams to identify issues before they become significant problems.
- Additionally, it allows team members to focus on specific tasks rather than being overwhelmed by the bigger picture. Having clear deadlines also helps ensure that tasks are completed on time and keeps everyone accountable for their work.
- Finally, having a well-defined activity plan makes it easier for managers to track progress and adjust if necessary.

Activity Planning Software

Once you have identified your objectives and determined the scope of your project, one will need appropriate software solutions to create detailed plans for each activity within the timeline. For example, Gantt charts can help visualize each task about their predecessors or successors as well as provide an overview of progress on the entire project so as to know where adjustments may be required if deadlines are not being met or if tasks are taking longer than expected. Additionally, tools such as Microsoft Project or Trello can help streamline activity planning by allowing teams to collaborate on tasks while managing resources easily from one central dashboard.

Asana: Asana is one of the most popular projects tracking tools available today. It offers an intuitive interface that allows you to easily organize tasks and collaborate with other members of your team. You can also create deadlines and assign tasks to specific people. Plus, with its powerful analytics features, you can track progress and measure performance with ease.

Trello: Trello is another great tool for managing projects, tasks, and teams. Its visual interface makes it easy to keep track of what needs to be done and who's responsible for each task. Plus, it has powerful collaboration features so you can communicate with teammates in real time and get feedback quickly.

Monday: Monday is a comprehensive project management platform that helps teams stay organized while they work on their projects. It comes with a variety of useful features such as task boards, timeline views, Gantt charts, resource management tools, and more. Plus, its intuitive interface makes it easy to use even for first-time users.

Basecamp: Basecamp is another popular project management tool that helps teams collaborate efficiently while keeping track of their progress along the way. It offers all the features you'd expect from a leading project-tracking tool including task lists, file-sharing capabilities, communication tools, time-tracking features, and more.

Jira: Jira is an enterprise-level project management tool designed specifically for large organizations that need to manage complex projects across multiple teams and departments. With Jira's advanced reporting capabilities and customizable dashboards, managers can easily monitor the status of their projects in real-time without having to manually check in on them all the time."

Zoho Projects: Zoho Projects is a great tool for managing projects with teams across multiple locations and time zones. It offers a wide range of features, such as task and calendar management, collaboration tools, reporting capabilities, and more. Additionally, Zoho Projects integrates with various third-party applications like Google Drive and Dropbox so you can easily share files between systems.

Clarity: Clarity is another great option for businesses looking for an efficient way to keep up with their projects. It offers features such as customizable templates for different types of projects, automated workflows that help streamline processes, comprehensive reporting capabilities so teams can stay up to date on their progress toward goals, and much more.

7.3 Project Scheduling

Project-task scheduling is a significant project planning activity. It comprises deciding which functions would be taken up when. No matter the size or scope of your project, the schedule is a key part of project management. The schedule tells when each activity should be done, what has already been completed, and the sequence in which things need to be finished.

Project Schedule

Can you imagine starting a long car trip to an unfamiliar destination without a map or navigation system? You're pretty sure you have to make some turns here and there, but you have no idea when or where, or how long it will take to get there. You may arrive eventually, but you run the risk of getting lost, and feeling frustrated, along the way. Essentially, driving without any idea of how you're going to get there is the same as working on a project without a schedule. Luckily, drivers have fairly accurate tools they can use. Scheduling, on the other hand, is not an exact process. It's part estimation, part prediction, and part 'educated guessing.' Because of the uncertainty involved, the schedule is reviewed regularly, and it is often revised while the project is in progress.

Notes: It continues to develop as the project moves forward, changes arise, risks come and go, and new risks are identified. The schedule essentially transforms the project from a vision to a time-based plan.

Importance of Project Schedule

Schedules also help do the following:

- They provide a basis for monitoring and controlling the project activities.
- They help to determine how best to allocate resources so one can achieve the project goal.
- They help to assess how time delays will impact on the project.
- One can figure out where excess resources are available to allocate to other projects.
- They provide a basis to help track the project progress.

To schedule the project plan, a software project manager wants to do the following:

- o Identify all the functions required to complete the project.
- o Break down large functions into small activities.
- o Determine the dependency among various activities.
- o Establish the most likely size for the time duration required to complete the activities.
- o Allocate resources to activities.
- o Plan the beginning and ending dates for different activities.
- o Determine the critical path. A critical way is the group of activities that decide the duration of the project.

The first method in scheduling a software plan involves identifying all the functions required to complete the project. A good judgment of the intricacies of the project and the development process helps the supervisor to identify the critical role of the project effectively. Next, the large functions are broken down into a valid set of small activities which would be assigned to various engineers.

The WBS formalism supports the manager to breakdown the function systematically after the project manager has broken down the purpose and constructs the work breakdown structure; he/she has to find the dependency among the activities. The dependency among the various activities determines the order in which the various events would be carried out. If activity A necessary the results of another activity B, then activity A must be scheduled after activity B. In general, function dependencies describe a partial ordering among functions, that is, each service may precede a subset of other functions, but some functions might not have any precedence ordering describe between them (called concurrent function). The dependency among the activities is defined in the pattern of an activity network.

Once the activity network representation has been processed out, resources are allocated to every activity. The resource allocation is usually done using a Gantt chart. After resource allocation is completed, a PERT chart representation is developed. The PERT chart representation is useful for program monitoring and control.

For task scheduling, the project plan needs to decompose the project functions into a set of activities. The time frame when every activity is to be performed is to be determined. The end of every action is called a milestone. The project manager tracks the function of a project by auditing the timely completion of the milestones. If he examines that the milestones start getting delayed, then he/she has to handle the activities carefully so that the complete deadline can still be met.

1. **Schedule Inputs-** You need several types of inputs to create a project schedule such as:

- Personal and project calendars: Understanding working days, shifts, and resource availability is critical to completing a project schedule.

- Description of project scope: From this, you can determine key start and end dates, major assumptions behind the plan, and key constraints and restrictions. You can also include stakeholder expectations, which will often determine project milestones.
- Project risks: You need to understand these to make sure there's enough extra time to deal with the identified risks – and with unidentified risks (risks are identified with thorough Risk Analysis).
- Lists of activities and resource requirements: Again, it's important to determine if there are other constraints to consider when developing the schedule. Understanding the resource capabilities and experience you have available – as well as company holidays and staff vacations– will affect the schedule. A project manager should be aware of deadlines and resource availability issues that may make the schedule less flexible.

2. **Scheduling Tools-** Here are some tools and techniques for combining these inputs to develop the schedule:

- Schedule Network Analysis: This is a graphic representation of the project's activities, the time it takes to complete them, and the sequence in which they must be done. Project management software is typically used to create these analyses– Gantt charts and PERT Charts are common formats.
- Critical Path Analysis: This is the process of looking at all of the activities that must be completed and calculating the 'best line'– or critical path– to take so that you'll complete the project in the minimum amount of time. The method calculates the earliest and latest possible start and finish times for project activities, and it estimates the dependencies among them to create a schedule of critical activities and dates.
- Schedule Compression: This tool helps shorten the total duration of a project by decreasing the time allotted for certain activities. It's done so that you can meet time constraints, and still keep the original scope of the project. You can use two methods here:
  - Crashing: This is where you assign more resources to an activity, thus decreasing the time it takes to complete it. This assumes that the time you save will offset the added resource costs.
  - Fast-Tracking: This involves rearranging activities to allow more parallel work. This means that things you would normally do one after another are now done at the same time. However, do bear in mind that this approach increases the risk that you'll miss things, or fail to address changes.

3. **Project Review:** Once you have outlined the basic schedule, you need to review it to make sure that the timing for each activity is aligned with the necessary resources. Here are tools commonly used to do this:
   - 'What if' scenario analysis– This method compares and measures the effects of different scenarios on a project. You use simulations to determine the effects of various adverse, or harmful, assumptions– such as resources not being available on time, or delays in other areas of the project. You can then measure and plan for the risks posed in these scenarios.
   - Critical Chain Method: This also addresses resource availability. You plan activities using their latest possible start and finish dates. This adds extra time between activities, which you can then use to manage the work disruptions.
   - Risk Multipliers: Risk is inevitable, so you need to prepare for its impact. Adding extra time to high-risk activities is one strategy. Another is to add a time multiplier to certain tasks or certain resources to offset overly optimistic time estimation.

7.4 Network Planning

Network planning is a common term for methods where projects are studied as a series of interrelated activities to plan, manage, and control projects. According to Guide to the Project Management Body of Knowledge, project schedule management includes various processes required to manage the project's timely completion. These processes refer to, among other things, how to sequence activities and estimate activities' duration. Moreover, they include developing and controlling the schedule. The network planning methods help in this process. The main objectives of network planning are determining the project duration and the critical path. Moreover, find out how to speed up a project if that becomes necessary. As a result, it is a basis for scheduling.

The most well-known network planning techniques are the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT). These methods include describing each of the activities involved in the project, the order in which must carry out the activities, and the activities carried out in tandem with other activities.

Using network planning methods results in showing activities that can be completed simultaneously and increases efficiency. Moreover, it helps in decision making and saves time, and therefore decreases cost. Conversely, creating it uses merely estimates, which may be inaccurate. Furthermore, large scale projects are often complex and detailed, and thus performing network planning on them can be time-consuming.

Network planning can research various issues such as project scheduling, risk analysis, cost minimization, or net present value maximization. Therefore, it can find the most appropriate balance between risk, quality, length, and cost. Moreover, using network planning in project management allows project teams to visualize all the tasks that need to be done during a project's lifecycle. It also provides essential context, such as length of the job, sequence, and dependence on the project schedule. Furthermore, it helps to find the critical path, free and total float, among other things

Network planning is a sequential categorization of the activities involved in the project's execution, accompanied by a graphical presentation of the actions required for the project as a whole. Therefore, network planning is a distributed model of work to be done in a project. A hierarchy of interdependent job elements, which are processes, tasks, and activities, is sequenced and prioritized to identify and describe the overall project effort. Typically, the project network is constructed and built using charts and hierarchical diagrams or often termed project network diagrams.

Network Planning Model

Network planning model is a pictorial representation of the sequence in which the project work can be done. The whole idea here is look at the work visually and think about in what order (sequence) the work needs to occur. In many cases, this step is an excellent team activity. At this time, you don't want to concern yourself with resource constraints: just focus on logical sequence of the work. When one completes this task, you want to be clear on three things:

For each task, what other tasks must be completed first? For the project, what tasks could be done at the same time (concurrently, in parallel)? For the project, where are your external dependencies? What tasks need an external event or task to complete, before it can start?

Network planning model is a type of project management model that uses network diagrams to visualize the timeline of a project. By breaking tasks down into smaller components, a network planning model can be used to identify dependencies and optimize the project timeline. It can also help project managers identify potential risks or conflicts that may arise during the execution of a project.

The network planning model in software project management is a model that uses graphical representations of activities and events to visualize the sequence of tasks necessary to complete the project. It is used to identify the duration, order of activities, and dependencies among tasks. Network modeling also provides insight into resource utilization, scheduling, and budgeting.

Network planning model is a type of project management process which helps the organizations to properly plan and evaluate the potential risks and costs associated with a particular project. It starts with the identification of all tasks and activities required to complete the project and then uses a network diagram to visualize the sequence and dependencies between each task.

The model further involves analyzing the diagram in order to optimize the project cycle and minimize risks and costs. This model can also be used to determine the critical path that needs to be followed in order to finish the project on time and within the budget.

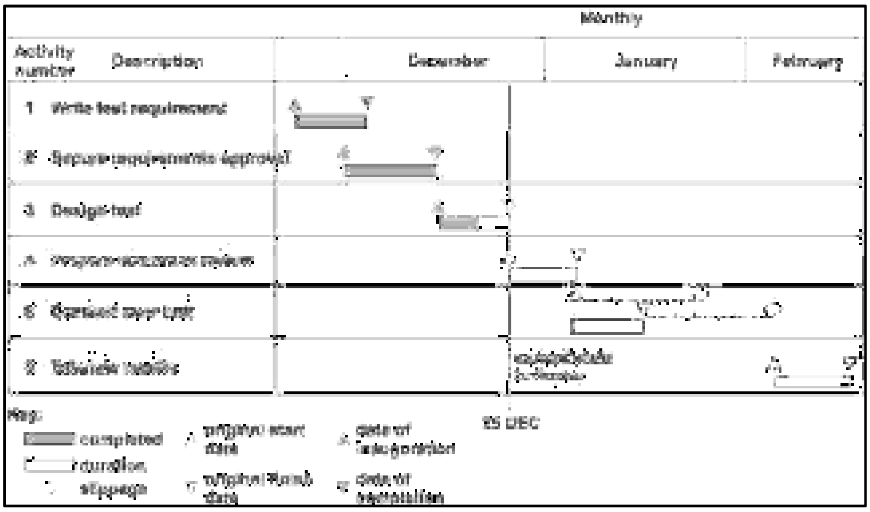

Figure 3: Gantt Chart Example Representation

To formulate a network model in software project management, the project manager must first create a project charter that outlines the timeline, budget, and scope of the project. Once this is established, the project manager can use the network planning model to map out the tasks, duration of each task, and dependencies between them. This type of model is a great tool for project managers to plan and optimize the timeline of a project. There are two ways to build a project schedule:

- **Gantt chart-** The Gantt chart is the older of the two and is used effectively in simple, short-duration types of projects (Figure 3). To build a Gantt chart, the project manager begins by associating a rectangular bar with every activity. The length of the bar corresponds to the duration of the activity. He or she then places the bars horizontally along a timeline in the order in which the activities should be completed. There can be instances in which activities are located on the timeline so that they are worked on concurrently with other activities. The sequencing is often driven more by resource availability than any other consideration. There are two drawbacks to using the Gantt chart:
  - Because of its simplicity, the Gantt chart does not contain detailed information. It reflects only the order imposed by the manager and, in fact, hides much of that information. Unless you are intimately familiar with the project activities, you cannot tell from the Gantt chart what must come before and after what.
  - Second, the Gantt chart does not tell the project manager whether the schedule that results from the Gantt chart completes the project in the shortest possible time or even uses the resources most effectively.

Task: The Gantt chart reflects only when the manager would like to have the work done. Explain.

- **Network diagram-** The network diagram provides a visual layout of the sequence in which project workflows. It includes detailed information and serves as an analytical tool for project scheduling and resource management problems as they arise during the life of the project. In addition, the network diagram allows you to compute the earliest time at which the project can be completed. That information does not follow from a Gantt chart.

7.5 Network Diagram

A network diagram is a project management chart that is populated with boxes noting tasks and responsibilities, and then arrows that map the schedule and the sequence that the work must be completed. Therefore, the project network diagram is a way to visually follow the progress of each phase of the project life cycle to its completion. Network diagrams can be used for detailed project planning, during implementation as a tool for analyzing scheduling alternatives, and as a control tool:

- **Planning**: Even for large projects, the Network Planning Model gives a clear graphical picture of the relationship between project activities. It is, at the same time, a high-level and detailed-level view of the project.
- **Implementation:** For those project managers who use automated project management software tools, you will update the project file with activity status and estimate-to-completion data. The network diagram is then automatically updated and can be printed or viewed.
- **Control**: While the updated network diagram retains the status of all activities, the best graphical report for monitoring and controlling project work will be the Gantt chart view of the network diagram. The Gantt chart cannot be used for control purposes unless you have done network scheduling or incorporated the logic into the Gantt chart.

Benefits of Network Diagrams

The network diagram literally illustrates the project's scope. That's because the project network diagram collects all the activities, milestones and deliverables defined on the work breakdown structure of the project. The Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) are good examples of how to use network diagrams in project management. The project managers use these methods to estimate the duration of the project and create a project schedule.

The project managers use a network diagram to track the project schedule network, allowing them to see the progress of each activity. Then they can share the status with the rest of the project management team. This is especially helpful for those who better understand information that is delivered visually. For those team members, project network diagrams will help with the performance of their tasks and increase the project's productivity.

A project network diagram helps project managers simplify a complex project plan, enabling them to see the project network. It's important to have an overview of any project, see when it starts and finishes, and quickly note all the activities and how they work together.

Types of Project Network Diagrams

Project network diagrams can be divided into two types, the Arrow Diagram Method (ADM) and the Precedence Diagram Method (PDM). The main difference between an ADM and a PDM project network diagram is the way they represent tasks and milestones.

Arrow Diagram Method (ADM)

As expected, the arrow diagramming method uses arrows to represent the project activities, with the tail of the arrow being its start and the point the finish. The length of the arrow is the duration of the activity. The arrows connect nodes or boxes that are milestone symbols of the start and finish of the activity in sequence. The arrow diagramming technique (ADM) refers to a schedule network diagramming technique in which arrows represent schedule activities within a specified project (Figure 4). The arrow's tail or base defines the start of the operation in the schedule. The pointed end of the arrow illustrates the endpoint of a selected process within the schedule. The duration of the arrow will loosely reflect the time between. The points to which these planning operations are connected are referred to as nodes.

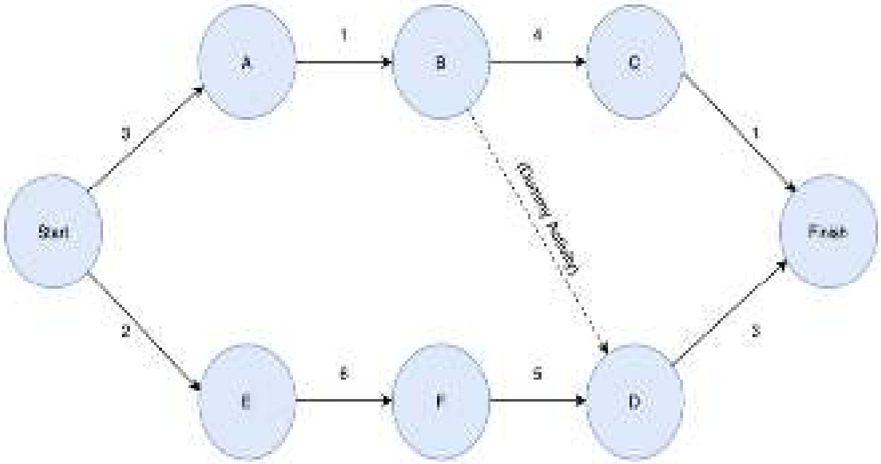

Figure 4: Illustration of the Arrow Diagramming Technique

To illustrate the sequence or order in which these activities should occur, the relation of these schedule activities is performed. This link point, or node, is typically represented by a small circle or sphere. An operation with a length of zero can be seen in the ADM graph. These operations are referred to as dummy operations and are usually represented using dotted lines.

Dummy activities express dependencies between tasks. The activity B-D in the below diagram is a dummy activity. An example of why a project manager might need a dummy activity is if activity C is about tiling a floor. It can only start once the concrete is poured (Activity B) and the permits are gotten in activity D. In contrast, activities B and D are not directly linked, the project manager needs to draw a dummy activity between B and D to demonstrate that C is dependent on D being finished. Moreover, there is also not possible for an ADM chart to encapsulate lead and lag times without new nodes and activities being implemented.

Precedence Diagramming Method (PDM)

Precedence Diagramming Method (PDM) or Activity-on-the-Node (AON) refers to a selected project management technique (Figure 5). The project manager employs a schedule network diagramming technique to graphically represent any known and preexisting schedule activities via the utilization of boxes (which also can be mentioned as nodes). Once all of these basic schedule tasks have been graphically displayed in this box or node format, all of the individual boxes are connected using a line describing any logical relationship found to occur.

The fundamental and most important advantage of using the precedence diagramming system's style methodology is that it helps the project manager view all plan tasks and their relationships with each other rapidly and efficiently.

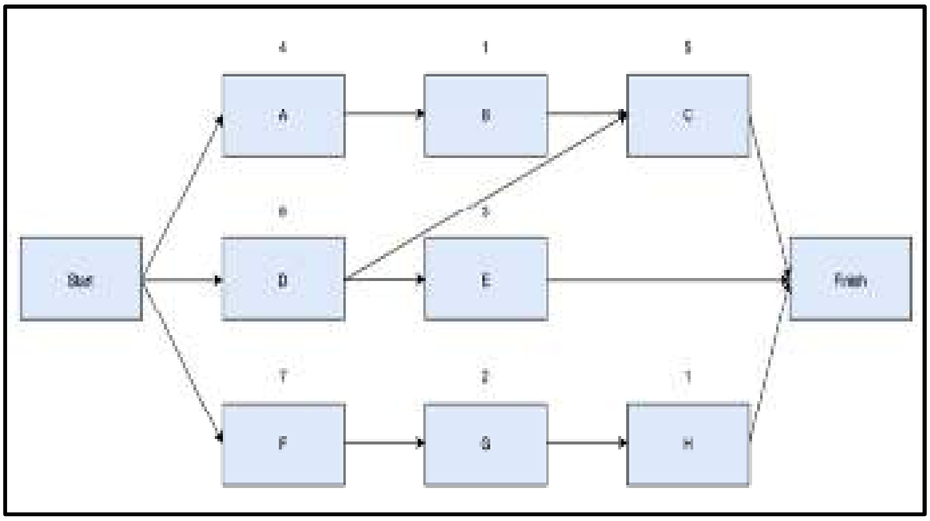

Figure 5: Illustration of the Precedence Diagramming Method

The networks flow from left to right in both arrow diagrams and precedence diagrams. Each activity is marked with a unique name, and once all its previous activities are complete, the activity may start. For example, as per the node diagram activity shown above, activity C cannot begin until activity B and activity D have been completed. The nodes for start and stop should be distinctive.

1. Reading the Network Diagram

Example: Each activity in the network diagram is represented by a rectangle that is called an activity node. The entries in the activity node describe the time-related properties of the activity. Some of the entries describe characteristics of the activity, such as its expected duration (E), while others describe calculated values (ES, EF, LS, LF) associated with that activity (Figure 6).

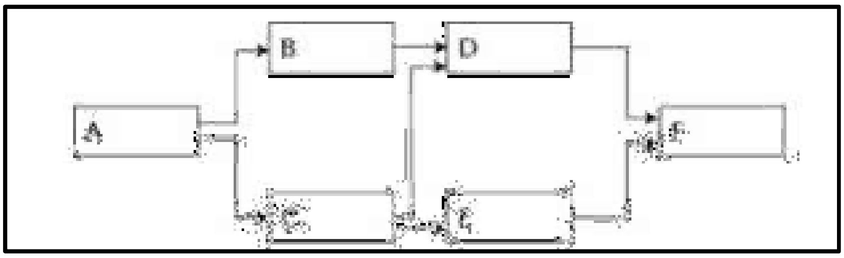

Figure 6: Reading the Network Diagram

In order to create the network diagram using the PDM, you need to determine the predecessors and successors for each activity. Here, you need to look for the technical dependencies between activities. Once an activity is complete, it will have produced an output, a deliverable, which becomes input to its successor activities. The work on the successor activities requires only the output from its predecessor activities.

The network diagram is logically sequenced. It is read from left to right. Every activity in the network, except the 'start' must have at least one activity that comes before it (its immediate predecessor). Similarly, every activity in the network, except the 'end' must have at least one activity that comes after it (its immediate successor).

Caution: An activity begins when its predecessors have been completed. The start activity has no predecessor, and the end activity has no successor.

2. Reading the Dependencies

Dependency is simply a relationship that exists between pairs of activities. To say that activity B depends on activity A means that activity A produces a deliverable that is needed in order to do the work associated with activity B. There are four types of activity dependencies (Figure 7).

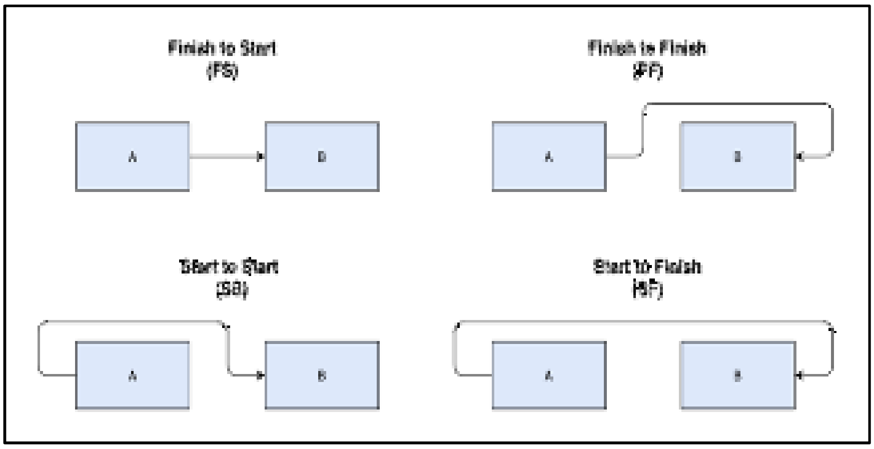

Figure 7: Dependencies

In the precedence diagram method, each node or box is an activity. There are arrows, but in this case, they represent task dependencies. There are four types of task dependencies:

- **Finish to start:** This means an activity cannot start before its predecessor is finished. The next activity (successor) in this relationship cannot be initiated before the first one (predecessor) is finished. In network diagrams, this is the most common form of dependency used. An example of this kind of dependency is that it is impossible to begin floor tiling until the waterproofing is finished. In the ADM graph, the only relation between the nodes can be expressed by an activity that is of Finish to Start dependency.
- **Start to start:** Use this when two activities can begin simultaneously. In the Start to start dependency, the second activity cannot be initiated until the first activity begins. This is used to demonstrate that two activities will start simultaneously. This relationship is useful when crashing a schedule. If the paintwork is started on one floor, for example, then if ready, the project manager will begin painting on the other floor. In the project manager's schedule, this will save time.
- **Finish to finish:** Use this when activities must finish together. In this type of dependency, it is impossible to complete the second activity before the first activity ends. Typically, this connection is used to achieve a milestone at the end. For instance, if the project manager is asked to finish a concrete work and the client has put it as a milestone on the project manager’s schedule. This milestone will be automatically reached after the project manager completes the last task like poring on concrete.
- **Start to finish:** Use this when one activity cannot finish until another one starts. In this relationship, once the first activity begins, the second activity cannot be completed. This is an unusual dependency; however, an example of this dependency is before the project manager can start turning off the old system, the implementation of a new accounting system needs to be completed.

3. Constraints

The type of dependency that describes the relationship between activities is determined as the result of constraints that exist between those activities. Each type of constraint can generate any one of the four dependency relationships. There are four types of constraints:

- Technical constraints- Technical dependencies between activities arise when one activity (the successor) requires output from another (the predecessor) before work can begin on it. In the simplest case, the predecessor must be completed before the successor can begin.

- Management constraints- A second type of dependency arises as the result of a management-imposed constraint. For example, suppose the product manager on a software development project is aware that a competitor is soon to introduce a new product with similar features to theirs. Rather than following the concurrent design-build strategy, the product manager wants to ensure that the design of the new software will yield a product that can compete with the competitor's new product. He or she expects design changes in response to the competitor's new product and, rather than risk wasting the programmers' time, imposes the FS dependency between the design and build activities.
- Interproject constraints- Interproject constraints result when deliverables from one project are needed by another project. Such constraints result in dependencies between the activities that produce the deliverable in one project and the activities in the other project that require the use of those deliverables. For example, suppose the new piece of test equipment is being manufactured by the same company that is developing the software that will use the test equipment. In this case, the start of the testing activities in the software development project depends on the delivery of the manufactured test equipment from the other project. The dependencies that result is technical but exist between activities in two or more projects, rather than within a single project.
- Date constraints- Date constraints impose start or finish dates on an activity that force it to occur according to a particular schedule. In our date-driven world, it is tempting to use the requested date as the required delivery date. These constraints generally conflict with the schedule that is calculated and driven by the dependency relationships between activities.

Task: What does FS dependency signifies?

4. Using the Lag Variable

Pauses or delays between activities are indicated in the network diagram through the use of lag variables. Lag variables are best defined by way of an example. Suppose that the data is being collected by mailing out a survey and is entered as the surveys are returned. Imposing an SS (Start to start) dependency between mailing out the surveys and entering the data would not be correct unless we introduced some delay between mailing surveys and getting back the responses that could be entered.

5. Creating an Initial Project Network Schedule

In order to establish the project schedule, you need to compute two schedules: The early schedule, which we calculate using the forward pass (This schedule consists of the earliest times at which an activity can start and finish. These are calculated numbers that are derived from the dependencies between all the activities in the project).

The late schedule, which we calculate using the backward pass (The late schedule consists of the latest times at which an activity can start and finish without delaying the completion date of the project. These are also calculated numbers that are derived from the dependencies between all of the activities in the project).

Types of Project Precedence Network Diagrams

There are two main types of project precedence network diagrams:

PERT- Project Evaluation Review Technique, or PERT, is used to identify the time it takes to finish a particular task or activity. It is a system that helps in the proper scheduling and coordination of all tasks throughout a project. It also helps in keeping track of the progress, or lack thereof, of the overall project.

Critical Path Method- The critical path method (CPM) is a project management technique that's used by project managers to create an accurate project schedule. The CPM method, also known as critical path analysis (CPA), consists in using the CPM formula and a network diagram to visually represent the task sequences of a project. Once these task sequences or paths are defined, their duration is calculated to identify the critical path.

7.6 Network Diagram Software Tools

Google Draw- Google has a tool for everything you do, so it almost goes without saying that they have network diagram software. Google Draw is completely free (you don't even have to put in your credit card). It can help you make flowcharts, UML diagrams, entity relations, mockups and, of course, project network diagrams. The data is stored on Google Drive, but it can also store data on Dropbox and OneDrive. Google draw can import from a variety of different file formats, and it has 27 languages and is easy to share. It's fast and has real-time collaborative support when connected to a Google account.

On the downside, there aren't a lot of templates and shapes to choose from to create a project network diagram. In addition to this, its features are too limited to be considered a network diagram software for project management. It can be a bit of an uphill battle to learn if you don't have a design background. This platform is best if you want to collaborate with other Google features and only make network diagrams occasionally.

Dia- Dia is an open-source network diagram tool that can be used to make network diagrams. It's fairly easy to learn and can make basic project schedule network diagrams. Dia saves XML formatted documents, which are reduced automatically to save space. It's available for Linux, Mac and Windows. Dia is free and makes a good entry-level option for people looking to get familiar with making project network diagrams, as well as UML diagrams and flow charts.

This network diagram software has a friendly user interface, which helps users, and is also easy and fast to install because of its small file size. However, the software doesn't have visual appeal. It's a bit too simple, and some have criticized it as ugly because of its black-and-white design, which could be improved with color.

Gliffy- While Gliffy is free, the free version is very limited. If you like it, you'll probably want to pony up for the full version, with a subscription cost. Gliffy is a web-based app and not suited if you're looking to make more technical diagrams. However, it's a free network diagram software which is a good first step into network diagramming. As a manager, one has to regulate the pressure and workload which is imposed upon the team; one must protect from the unreasonable demands of the rest of the company.

Once the manager has arrived at what is considered to be a realistic schedule, he/she must fight for it. Never let the outside world deflect the manager from what is practically achievable. If there is an imposition of a deadline which is impossible, clearly the manager needs to state it and give reasons. One will need to give some room for compromise, however, since a flat NO will be seen as obstructive. Since one wants to help the company, one should look for alternative positions.

7.7 Time Dimension

One can offer a prototype service or product at an earlier date. This might, in some cases, be sufficient for the customer to start the next stage of his/her own project on the understanding that the project would be completed at a later date and the final version would then replace the prototype. The complexity of the product, or the total number of units, might be reduced. This might, in some cases, be sufficient for the customer's immediate needs. The future enhancements or more units would then be the subject of a subsequent negotiation which would be likely to succeed since one will have already demonstrated the ability to deliver on time. One can show on an alternative schedule that the project could be delivered by the deadline if certain (specified) resources are given to or if other projects are rescheduled. Thus, one can provide a clear picture of the situation and a possible solution; it is up to the manager then how he/she proceeds.

7.8 Critical Path Management (CPM)

A network planning diagram allows the project manager to assess a project's most likely sequence of events and provides the basis for a practical project schedule. It will enable the project manager to measure the total duration needed for the project, determine the order in which tasks need to be completed, and highlight those tasks vital to the project's timeline. Once the WBS is complete, the project manager will have a list of tasks at different decomposition stages to accomplish the project's goal. To allow a schedule to be generated, the project manager now decides the task dependencies and each task's length.

Each terminal element represents an operation at the lowest level of the Work Breakdown Structure (WBS) related to a work package. However, although the WBS does not attempt to decide the sequence of events or the length of any activity, the network planning diagram attempts to determine the series of activities that take place and the other activities (if any) on which the activity depends. When conducting network planning diagram, there is a range of techniques used, Critical Path Management (CPM) and the Project Evaluation and Review Technique (PERT) are some of the most widely used methods.

In project management, the critical path is the longest sequence of tasks that must be completed to execute a project. The tasks on the critical path are called critical activities because if they're delayed, the whole project completion will be delayed. To find the critical path, project managers use the critical path method (CPM). Every terminal element (or activity) is represented by a node on a graph in some techniques, while it is characterized by an edge in others (the line connecting two nodes). Only one path for every terminal element must lie through the network. The multiple sequences of activities are included in the network planning that specifies one or another aspect of work, for example, a process or phase. The main criterion for the network planning efficiency is that each sequence of activities should have a finite and measurable outcome and never contain circular references. If there is a circular reference in an operation chain, it creates a closed loop, resulting in an endless cycle.

There are many variations of CPM/PERT which have been useful in planning costs, scheduling manpower and machine time. CPM/PERT can answer the following important questions:

- How long will the entire project take to be completed? What are the risks involved?
- Which are the critical activities or tasks in the project which could delay the entire project
- if they were not completed on time?
- Is the project on schedule, behind schedule or ahead of schedule?
- If the project has to be finished earlier than planned, what is the best way to do this at the least cost?

The critical path method (CPM) is a project management technique that's used by project managers to create an accurate project schedule. The CPM method, also known as critical path analysis (CPA), consists in using the CPM formula and a network diagram to visually represent the task sequences of a project. Once these task sequences or paths are defined, their duration is calculated to identify the critical path.

When Should You Use Critical Path Analysis (CPA)?

CPA is another way of referring to the critical path method. As noted, it's used by industries with complex projects, such as aerospace, defense, construction, and product development.

Therefore, CPA is a crucial first step in developing a project schedule. It's done early in the life cycle of a project, usually in the planning phase, but it's not unheard of to have CPM as part of a project proposal before the project has been approved. By understanding which are the critical tasks in a project you can focus on getting those done if time, resources and costs are an issue. Knowing this in advance of executing a project will help you deliver that project successfully.

Finding the critical path is very helpful for project managers because it allows them to:

- Accurately estimate the total project duration.
- Estimate the time that's necessary to complete each project task.
- Identify critical activities which must be completed on time and require close supervision.

- Find out which project tasks can be delayed without affecting the project schedule by calculating slack for each task.
- Identify task dependencies, resource constraints and project risks.
- Prioritize tasks and create realistic project schedules.

Benefits of Using CPM in Project Management

There are many reasons to use the critical path method. It's a great project management tool to help you deliver your project on time and within budget. Other benefits include:

- CPM improves team communication- It fosters better communication within the project team. Everyone is involved in providing input and that brings the expertise of various project team members together for the better good of the project as a whole. This includes subcontractors, architects, electricians, construction managers, etc.
- CPM helps prioritize tasks- Naturally, having determined the critical path is going to help you prioritize your work. You know the tasks that must be done and that gives you wiggle room if there are issues with time or cost. You might not get every activity done, but you'll get the ones finished that are critical to the project.
- CPM & PERT help create accurate schedules- The critical path method will help you make a more accurate project schedule, especially when you use it in conjunction with PERT charts. You can estimate better and discover areas of risk and prepare to respond to them to avoid costly delays.
- CPM & Gantt Charts help map out project plans- Another benefit is the visual nature of CPM, especially when mapped on the timeline of a Gantt chart. Having a visual element to communicate the project schedule is always a plus. Not everyone absorbs information in the same way. Visual tools help teams better understand what's expected of them and when it's expected.

Framework for PERT and CPM

CPM and PERT are both project scheduling techniques. But they aren't interchangeable. We've been talking about CPM, but before we compare it to PERT let's define the term. PERT is used to get accurate time estimates for complicated projects. It uses an algorithm to calculate the estimated duration for unpredictable activities. It focuses on events and milestones on a PERT chart with nodes in the wireframe when developing projects. However, while these are two different techniques, PERT and CPM can be used together for project planning and scheduling. The difference between them lies in that PERT is about time planning and time management, while CPM is about time and budgeting. PERT delivers a project quickly and CPM gets the project done on budget and on time.

Essentially, there are six steps which are common to both the techniques. The procedure is listed below:

1. Define the project and all of its significant activities or tasks. The project (made up of several tasks) should have only a single start activity and a single finish activity.
2. Develop the relationships among the activities. Decide which activities must precede and which must follow others.
3. Draw the "Network" connecting all the activities. Each Activity should have unique event numbers. Dummy arrows are used where required to avoid giving the same numbering to two activities.
4. Assign time and/or cost estimates to each activity.
5. Compute the longest time path through the network. This is called the critical path.

6. Use the Network to help plan, schedule, monitor and control the project.

The key concept used by CPM/PERT is that a small set of activities, which make up the longest path through the activity network control the entire project.

Notes: If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Critical Path Diagram

Critical Path Method Steps- Here, we will discuss how to calculate the critical path in 8 steps.

1. Collect Project Activities- Use a work breakdown structure to collect all the project activities that lead to the final deliverable.
2. Identify Task Dependencies- Determine which tasks are dependent on other tasks before they can begin. Use your judgment and your team members' feedback. Failing to define task dependencies correctly makes the critical path method useless.
3. Create a Critical Path Diagram- A CPM diagram or network diagram depicts the order of activities.
4. Estimate the Timeline- To use the critical path method, you'll need to estimate the duration of each task. Use data from past projects and other sources of information such as subject matter experts.
5. Use the Critical Path Formula- The critical path uses an algorithm, also referred to as the CPM formula. That algorithm has two parts, the forward pass and the backward pass. The forward pass is determined by using the earliest start for each activity (ES) and the earliest finish (EF). The ES of an activity equals the EF of the one before it. The EF is calculated by EF = ES + t (the duration of an activity). The backward pass assigns the last activity's EF as its latest finish. Then use the CPM formula to find the LS, which is LF – t. For the activities before that, LF is the smallest of the start times for the next activity.
6. Identify the Critical Path- The activities with 0 float make up the critical path. All of these critical path activities are dependent tasks except for the first task in your CPM schedule. All project tasks with positive slack are parallel tasks to the critical path activities.
7. Revise During Execution- Continue to update the critical path diagram as you go through the project execution phase. These critical path analysis steps determine what tasks are critical and which can float, meaning they can be delayed without negatively impacting the project schedule. Now you have the information you need to plan the critical path schedule more accurately and have more of a guarantee you'll meet your project deadline.

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

Summary

- Activity planning involves having worked out a method of doing the project; identifying the tasks to be carried; assessing the time needed to do each task; need to allocate dates/times for the start and end of each activity.

- A careful planning up front in the software project reduces the risk of costly rework or failure down the road.
- A software project planning activity defines what success looks like before the project begins. In a 2007, Gartner research study on why information technology projects succeed or fail, survey participants indicated that, in part, failure resulted from inadequately defining "critical success factors" at the start of the project.
- Project-task scheduling is a significant project planning activity. The schedule tells when each activity should be done, what has already been completed, and the sequence in which things need to be finished.
- The first method in scheduling a software plan involves identifying all the functions required to complete the project.
- For task scheduling, the project plan needs to decompose the project functions into a set of activities. The time frame when every activity is to be performed is to be determined.
- The critical path analysis method calculates the earliest and latest possible start and finish times for project activities, and it estimates the dependencies among them to create a schedule of critical activities and dates.
- Network planning is a common term for methods where projects are studied as a series of interrelated activities to plan, manage, and control projects.

Keywords

Activity Planning: Project activities planning and scheduling is the first process group of project time management. Developing the project implementation schedule is the second group.

Activity Plan: Activity plans, also known as work breakdown structures, are essential to software project management. An activity plan helps to break down a project into its individual tasks, which then can be organized and assigned to team members.

Resource Calendar: A resource calendar is a calendar that is used to reflect specific working hours, vacations, leaves of absence, and planned personal time for individual resources.

Project Schedule: The schedule tells when each activity should be done, what has already been completed, and the sequence in which things need to be finished.

Schedule Network Analysis: This is a graphic representation of the project's activities, the time it takes to complete them, and the sequence in which they must be done.

Critical Path Analysis: This is the process of looking at all of the activities that must be completed and calculating the 'best line'– or critical path– to take so that you'll complete the project in the minimum amount of time.

'What if' scenario analysis: 'What if' scenario analysis method compares and measures the effects of different scenarios on a project.

Network Planning: Network planning is a common term for methods where projects are studied as a series of interrelated activities to plan, manage, and control projects.

Self Assessment

1. Project time management includes two high-level groups of processes for planning and scheduling project activities and tasks necessary for timely completion of the project.

A. True

B. False

2. A ___________ is a calendar that is used to reflect specific working hours, vacations, leaves of absence, and planned personal time for individual resources.

A. Activity calendar
B. Significance calendar
C. Resource calendar
D. Absence calendar

3. Activity plans, also known as ______________.

A. work ratio structure
B. workload structuring
C. Task structure
D. work breakdown structures

4. A(n) ___________ helps to break down a project into its individual tasks, which then can be organized and assigned to the team members.

A. activity plan
B. task plan
C. initial plan
D. work plan

5. ____________ are those tasks which cannot be delayed in any circumstance and there is 0 slack time between the tasks means that if one task is finished the next task immediately start without any delay.

A. Zero tasks
B. Critical task
C. Delay tasks
D. Non-slack tasks

6. Which of the following is/are example(s) for Activity Planning Software?

A. Jira
B. Monday
C. Asana
D. All the above.

7. Which of the following statement(s) is/are TRUE for project-task scheduling?

A. It is a significant project planning activity and comprises deciding which functions would be taken up when.
B. No matter the size or scope of your project, the schedule is a key part of project management.
C. The schedule tells when each activity should be done, what has already been completed, and the sequence in which things need to be finished.
D. All the above.

8. PERT stands for

A. Project Execution Review Techniques
B. Project Evaluation Review Technique

C. Process Evaluation Reporting Techniques
D. Process Execution Reporting Technology

9. After resource allocation is completed, a PERT chart representation is developed. The PERT chart representation is useful for program monitoring and control.
A. True
B. False

10. _______________ is a graphic representation of the project's activities, the time it takes to complete them, and the sequence in which they must be done.
A. Activity Analysis
B. Time Analysis
C. Schedule Network Analysis
D. Criticality Analysis

11. Which of the following statement(s) refer(s) to network planning?
A. It is a sequential categorization of the activities involved in the project's execution, accompanied by a graphical presentation of the actions required for the project as a whole.
B. It is a distributed model of work to be done in a project.
C. It is a hierarchy of interdependent job elements, which are processes, tasks, and activities, sequenced and prioritized to identify and describe the overall project effort.
D. All the above.

12. _____________ model is a type of project management model that uses network diagrams to visualize the timeline of a project.
A. Activity planning
B. Network planning
C. Critical planning
D. Workload planning

13. The statement reflecting the network diagram is:
A. It provides a visual layout of the sequence in which project workflows.
B. It includes detailed information and serves as an analytical tool for project scheduling and resource management problems as they arise during the life of the project.
C. It allows us to compute the earliest time at which the project can be completed.
D. All the above.

14. CPM stands for,
A. Crucial Path Methodology
B. Critical Path Method
C. Critical Program Mode
D. Crucial Program Mode

15. In project management, the critical path is the shortest sequence of tasks that must be completed to execute a project.
A. True

B. False

Answers for Self Assessment

1.	A	2.	C	3.	D	4.	A	5.	B
6.	D	7.	D	8.	B	9.	A	10.	C
11.	D	12.	B	13.	D	14.	B	15.	B

Review Questions

1. Differentiate CPM with PERT?
2. Discuss in detail, the steps for Critical Path Diagram.
3. How useful are the network diagrams? Elaborate.
4. Which are the two ways to build a project schedule? Explain.
5. What are the different types of Network Diagrams?
6. Discuss the significance of using Network Diagrams?
7. Discuss about the network planning models.
8. Write a short note on:
   (a) Critical Path Analysis
   (b) Network Diagram
9. What is activity planning? What are the inclusions in activity planning?
10. What are the steps in activity planning?

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Unit 08: Risk Management

CONTENTS

Objectives

After studying this unit, you will be able to:

- learn about risks and their categories.
- explore the concept of risk management and its importance.
- know about the software risk management steps and techniques.
- understand the risk management plan and risk management cycle.
- analyze the metrics of risk management.
- know the basics of the PERT technique.

Introduction

Risk management is the process of identifying and dealing with these events before or as they happen. Risk can come in many different forms—employee sickness, inclement weather, unexpected costs, and transportation delays among them. In project management, risk is any potential event that can impact your project, positively or negatively.

A software project can be concerned with a large variety of risks. In order to be adept to systematically identify the significant risks which might affect a software project, it is essential to classify risks into different classes. The project manager can then check which risks from each class are relevant to the project.

Software risk management is a process whereby the project identifies and tracks threats to the success of the project. This process provides for mitigation strategies for potential problems and for early intervention with realized problems, lessening their impact to the project. Risk management is the system of identifying, addressing and eliminating these problems before they can damage the project.

"Tomorrow problems are today's risk." Hence, a clear definition of a "risk" is a problem that could cause some loss or threaten the progress of the project, but which has not happened yet.

What is a Project Risk?

Project risk is any potential issue that could negatively impact the successful completion of the projects. Risks could be due to internal or external factors. For instance, a key supplier going out of business and a key team member leaving your organization—both qualify as project risks. There can be multiple sources of risk (Figure 1).

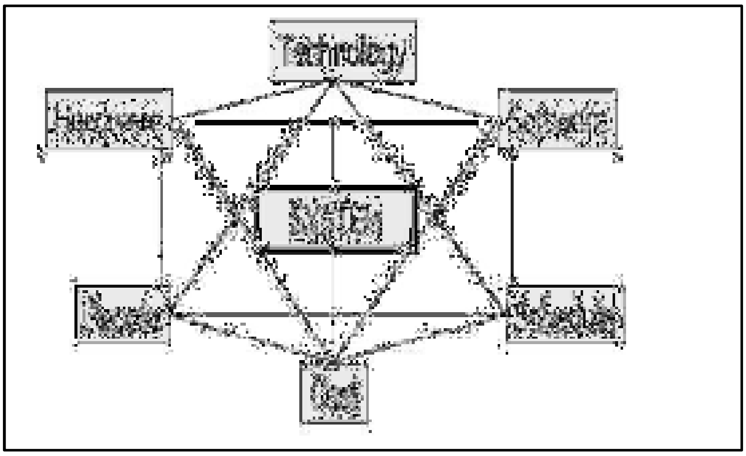


Figure 1: Sources of Project Risk

In risk management, a prioritization process is followed whereby the risks with the greatest loss and the greatest probability of occurring are handled first, and risks with lower probability of occurrence and lower loss are handled in descending order. In practice, the process can be very difficult, and balancing between risks with a high probability of occurrence but lower loss versus a risk with high loss but lower probability of occurrence can often be mishandled. Intangible risk management identifies a new type of risk that has a 100% probability of occurring but is ignored by the organization due to a lack of identification ability. For example, when deficient knowledge is applied to a situation, a knowledge risk materializes. Relationship risk appears when ineffective collaboration occurs. Process-engagement risk may be an issue when ineffective operational procedures are applied. These risks directly reduce the productivity of knowledge workers, decrease cost effectiveness, profitability, service, quality, reputation, brand value, and earnings quality. Intangible risk management allows risk management to create immediate value from the identification and reduction of risks that reduce productivity.

Risk management also faces difficulties allocating resources. This is the idea of opportunity cost. The resources spent on risk management could have been spent on more profitable activities. Again, ideal risk management minimizes spending while maximizing the reduction of the negative effects of risks.

Principles of Risk Management

1. Global perspective: In this, we review the bigger system description, design, and implementation. We look at the chance and the impact the risk is going to have.
2. Take a forward-looking view: Consider the threat which may appear in the future and create future plans for directing the next events.
3. Open communication: This is to allow the free flow of communication between the client and the team members so that they have certainty about the risks.

4. Integrated management: In this method risk management is made an integral part of project management.
5. Continuous process: In this phase, the risks are tracked continuously throughout the risk management paradigm.

8.1 Project Risk Management

Project risk management is the process of identifying, assessing, and responding to unexpected risks that might affect your project's goals and progress. The project risk management is a process that aims to reduce project risks that have already occurred, are occurring, or are likely to occur in the future. It focuses on risk reduction by identifying the root causes of risks and minimizing their impact, if not completely eliminating them.

Classification of Project Risks

There are three main classifications of risks which can affect a software project:

Project risks- Project risks concern differ forms of budgetary, schedule, personnel, resource, and customer-related problems. A vital project risk is schedule slippage. Since the software is intangible, it is very tough to monitor and control a software project. It is very tough to control something which cannot be identified. For any manufacturing program, such as the manufacturing of cars, the plan executive can recognize the product taking shape.

Technical risks- Technical risks concern potential method, implementation, interfacing, testing, and maintenance issue. It also consists of an ambiguous specification, incomplete specification, changing specification, technical uncertainty, and technical obsolescence. Most technical risks arise due to the development team's insufficient knowledge about the project.

Business risks- This type of risk contains risks of building an excellent product that no one needs, losing budgetary or personnel commitments, etc.

Other risk categories

Known risks: Those risks that can be uncovered after careful assessment of the project program, the business and technical environment in which the plan is being developed, and more reliable data sources (e.g., unrealistic delivery date).

Predictable risks: Those risks that are hypothesized from previous project experience (e.g., past turnover).

Unpredictable risks: Those risks that can and do occur but are extremely tough to identify in advance.

Common Types of Project Management Risks

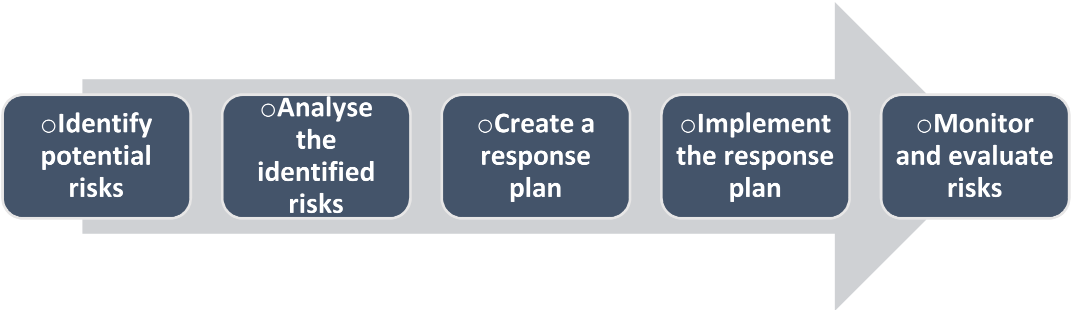
- Individual project risks: These are individual risk events that, if they occur, can affect the quality, cost, time, and/or scope of a project. Examples include not having enough resources for a job and having to deal with sick leave or employee time-off during peak season.
- Overall project risks: These risks refer to the impact of uncertainty on the overall project. Overall project risk comprises an aggregate of individual risks plus all other sources of project uncertainty. Examples of such uncertainties include natural calamities, wars, and changes in government policies.
- Variability risks: These risks are associated with fluctuations or inaccuracies in demand, supply, quality, price, etc., that can impact the project outcome. Examples include varying raw material prices and changing the supplier of a crucial product component.

- Ambiguity risks: These risks stem from the lack of clarity in project requirements that can lead to misinterpretations or mistakes. Examples include inaccurate requirements gathered from clients and different interpretations of the project scope among team members.

General Steps to Manage Project Risks

The following steps will help you competently reduce and control all potential project risks:

Identify Potential Risks- The first step is identifying all potential risks that could affect the project's timeline or goals. It includes closely analyzing the overall project plan and determining any potential issues that could arise. One way to ace this step is by scheduling brainstorming sessions with the project team and stakeholders. Once you identify the risks, put them into a risk register. This will help to track all the risks along with their details such as duration, impact, priority, and status.



Analyze the identified risks- Once you identify the risks, start analyzing them to understand how and to what extent they can impact your project. Focus on quantitative and qualitative risk analysis. Quantitative risk analysis assigns a numerical value to risk probability, while qualitative risk analysis is used to identify and assess risks that can't be quantified. Both help identify risks that need your immediate attention.

When assessing risks, consider three key factors: risk probability (likelihood of a risk event occurring), risk impact (consequences of a risk event occurring), and risk vulnerability (extent to which a risk event can be controlled). These will help you understand the overall project risk level and plan mitigation measures accordingly.

Create a response plan- Now that one has a better understanding of potential project risks, it's time to develop a response plan. The response plan should include how one will address each of the identified high-priority risks. The plan should also be achievable, practical, and tailored to fit the project's specific needs. The transfer, mitigation, avoidance, and acceptance are four different ways to respond to risks. Based on the risk tolerance, create a response plan to either transfer, mitigate, avoid, or accept potential project risks.

Implement the response plan- After developing a response plan, it's time to implement it. This will require close coordination between team members and stakeholders. Make sure everyone involved in the project is aware of the risks and knows what they need to do to mitigate them. To execute the plan effectively, designate someone to be in charge of each step so there is continuity and no confusion. As the project progresses, keep a close eye on the risks and make changes to the response plan as needed.

Monitor and evaluate risks- Risk management is not a one-time activity; it's an ongoing process that should be revisited regularly. And that's why one should never stop monitoring and evaluating project risks. Continuous monitoring will allow to track the progress of mitigation measures, ensure they are effective, and make necessary adjustments when required.

Importance of Project Risk Management

Risk exists in everything that we do. It is only through the effective management of risk that we can be assured that we are doing our reasonable best against risks of all kinds. Risk management is also used in the public sector to identify and mitigate risk to critical infrastructure. It can help to meet the objectives and improve performance by contributing to:

- Increased certainty and fewer surprises
- Better service delivery
- More effective management of change
- More efficient use of resources
- Better management at all levels through improved decision making
- Innovation
- Improved working environment
- Patient/Staff safety

8.2 Software Risk Management Steps

Figure 2 depicts the steps in the software risk management.

Risk Assessment

A risk assessment is a systematic process performed by a competent person which involves identifying, analyzing, and controlling hazards and risks present in a situation or a place. This decision-making tool aims to determine which measures should be put in place in order to eliminate or control those risks, as well as specify which of them should be prioritized according to the level of likeliness and impact they have on the business.

Risk assessment is one of the major components of a risk analysis. Risk analysis is a process with multiple steps that intends to identify and analyze all of the potential risks and issues that are detrimental to the business. This is an ongoing process that gets updated when necessary. These concepts are interconnected and can be used individually.

Risk communication is the process of exchanging information and opinion on risk with concerned parties. Risk management is the proactive control and evaluation of threats and risks to prevent accidents, uncertainties, and errors.

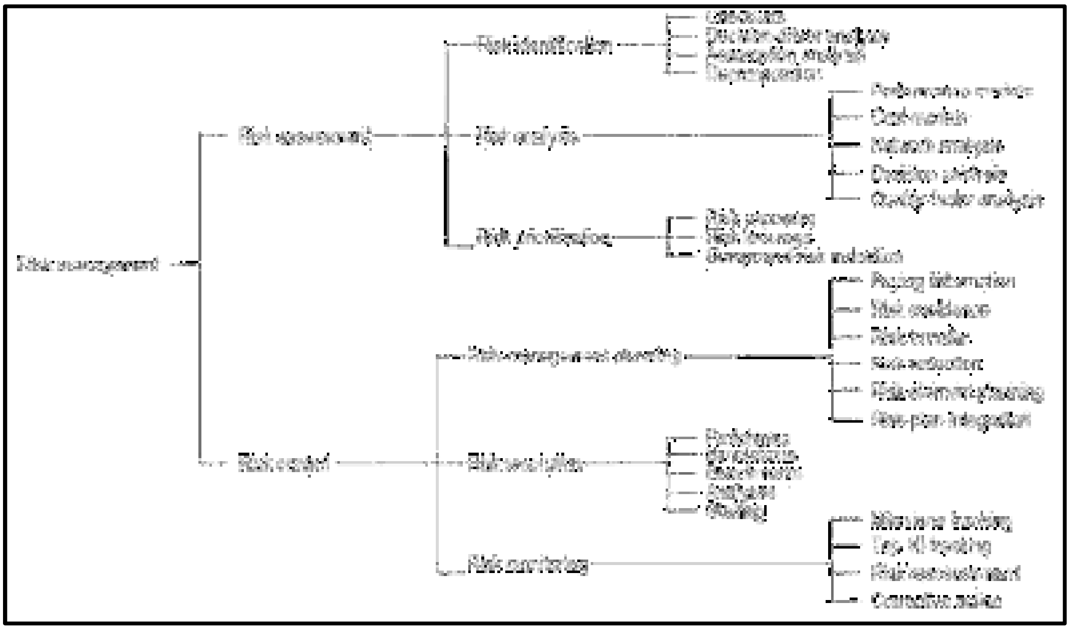


Figure 2: Software Risk Management Steps

A. Risk Identification

Risk identification requires knowledge of the organization, the market in which it operates, the legal, social, economic, political, and climatic environment in which it does its business, its financial strengths and weaknesses, its vulnerability to unplanned losses, the manufacturing processes, and the management systems and the business mechanism by which it operates. Any failure at this stage to identify risk may cause a major loss for the organization. Risk identification provides the foundation of risk management. The identification methods are formed by templates or the development of templates for identifying sources, problems, or events. There are several methods used for risk identification that include:

Assumption Analysis- It is evitable that when you start planning or outlining your project you will be making assumptions. Making assumptions within a project will always create risks and a way to help manage this is to list all the assumptions of each phase or stage of your project against a timeline. Then, think about the consequence of the assumptions and how they affect the other parts of the project. Try creating a high-level storyboard of the project showing risk and assumptions are associated, this can show the effect of decisions and should provide a better understanding about the risks in a program or project.

Checklist Analysis– Checklist Analysis is a type of technique generally used to identify or find risks and manage them. The checklist is basically developed by listing items, steps, or even tasks and is then further analyzed against criteria to just identify and determine if procedure is completed correctly or not. It is a list of risks that is just found to occur regularly in development of software project. They will normally consider: Quality experience, Formality of development, Novelty of application, Impact on business, Requirements standards, Software identification, Projects concurrency, Dependencies, Project duration, Flexibility of delivery, Planning estimates, Stability of suppliers, Range of sites etc.

Prompt Lists- Risks here will be identified by logical examination of each Program or Project aspect.

Brainstorming or SWOT Analysis– This technique provides and gives a free and open approach that usually encourages each and every one on the project team to participate. It also results in a greater sense of ownership of project risk, and the team is generally committed to managing risk for a given time period of project. It is a creative and unique technique to gather risks spontaneously by team members. The team members identify and determine risks in 'no wrong answer' environment. This technique also provides an opportunity for team members to always develop on each other's ideas.

SWOT Analysis– Strengths-Weaknesses-Opportunities-Threat (SWOT) is very technique and helpful for identifying risks within greater organization context. It is generally used as planning tool for analyzing business, its resources, and also its environment simply by looking at internal strengths and weaknesses and opportunities and threats in external environment. It is technique often used in formulation of strategy.

Facilitated Workshops- Within SWOT analysis, the risks are identified by looking at the Strengths (or perceived Strength), Weakness, Opportunity & Threats to the success of the project or program. This is usually done within a Workshop environment.

Casual Mapping– Causal mapping is method that builds or develops on reflection and review of failure factors in cause and effect of the diagrams. It is very useful for facilitating learning with an organization or system simply as method of project-post evaluation. It is also key tool for risk assessment.

Flowchart Method– This method allows for dynamic process to be diagrammatically represented in paper. This method is generally used to represent activities of process graphically and sequentially to simply identify the risk.

Interviews- Interviews conducted to identify risk will only be successful where there is:

- Good preparation.
- Clear objectives.
- A positive & supportive environment; Notes
- Proper time management.
- Use of open questions.

The results of interviews should be well documented.

B. Risk Analysis and Prioritization

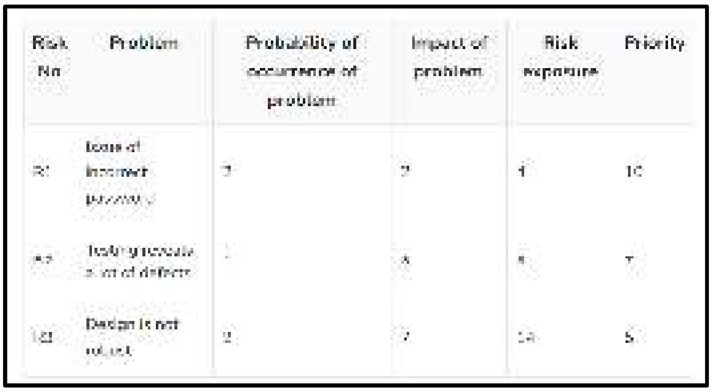
Risk Analysis is also called as Risk Estimation. It is a process that consists of the following steps:

- Identifying the problems causing risk in projects.
- Identifying the probability of occurrence of problem.
- Identifying the impact of problem.

During the risk analysis step of risk management, the frequency and consequences associated with each risk scenario are estimated and communicated with stakeholders. Stakeholders may have important knowledge of sources and patterns of exposure that analysts will need to integrate into a risk assessment.

Caution: However, the conflict is most likely to arise at this step as stakeholders are not typically involved in the risk estimation process, and the uncertainties and value assumptions associated with the methods may not be clearly communicated.

During the risk estimation stage, the stakeholder's knowledge and perceptions are assessed in light of receiving new information resulting from the risk estimates and the stakeholder analysis is updated. Third party review by third party experts and explicit communication of the methods, assumptions and uncertainties will contribute to credibility and trust in the technical analyses.



Risk No	Problem	Probability of occurrence of problem	Impact of problem	Risk exposure	Priority
R1	Loss of [illegible]	[illegible]	[illegible]	[illegible]	10
R2	Testing reveals a lot of defects	[illegible]	[illegible]	[illegible]	[illegible]
R3	Design is not robust	2	7	14	5

Figure 3: Risk Prioritization

Risk prioritization involves assigning values to step 2 and step 3 in the range of 1 to 10; calculating the risk exposure factor which is the product of values of step 2 and step 3 and then preparing a table consisting of all the values and order risk on the basis of risk exposure factor (Figure 3).

C. Risk Exposure

Quantifying the effects of a risk by multiplying the risk impact by the risk probability yields risk exposure.

Risk-exposure = Risk-impact x Risk-probability

For each risk, the risk exposure is defined as the probability of the undesirable outcome times the size of the loss involved.

Risk exposure helps us to list the risks in priority order, with the risks of most concern given the highest priority. Next, we must take steps to control the risks. The notion of control acknowledges that we may not be able to eliminate all risks. It is the responsibility of the project manager to ensure that team understands the project's exposure to risk. Gaining this understanding can be achieved through identifying categories of risk and then answering questions associated with each of these categories. The next section provides project managers with a set of questions to ask about their projects to help categorize risk.

Task: The notion of control acknowledges that we may not be able to eliminate all risks. Analyze.

There are several risk categories and questions involved for the same.

1. Business/Strategic

- o Do the project objectives fit into the organizations overall business strategy?
- o When is the project due to deliver?
- o What would be the result of late delivery?
- o What would be the result of limited success (functionality)?
- o What is the stability of the business area?

2. External Factors

- o Is the project exposed to requirements due to international interests (foreign legal
- o implications or foreign company involvement)?
- o Could there be political implications of the project failure?
- o Is this project a part of the larger program? If so, what constraints are set for the project by the program?

3. Procurement

- o Does the supplier have a reputation for delivery of high quality?
- o Is the contract sufficiently detailed to show what the supplier is going to provide?
- o Are the acceptance criteria clear to both the parties?
- o Is the contract legally binding/enforceable?

4. Organizational Factors

- o What consideration needs to be given to security of the project?
- o Does the project have wholehearted support from senior management?
- o What is the commitment of the user management?
- o Have training requirements been identified? Can these requirements be met?

5. Management

- o How clearly are the project objectives defined?
- o Will the project be run using well-documented approach to project management?
- o Does this approach cover aspects of quality management, risk management and development activities in sufficient depth?
- o How well does the project team understand chosen methodology?
- o What is the current state of project plans?
- o Is the completion of project dependent on completion of other projects?
- o Are the tasks in project plan interdependent?
- o Can a critical path through the project tasks be identified?
- o What is the availability of appropriate resources?
- o What are the skills and experience of project team?
- o Will people be available for training?
- o How many separate users are involved?
- o How much changes will there be for user’s operation or organization?

6. Technical

- o Is the specification clear, concise accurate and feasible?
- o How have the technical options been evaluated?
- o What is the knowledge of equipment (hardware/software)?
- o Does the experience of project manager cover a similar application?
- o Is this a new application?
- o What is the complexity of system?
- o How many sites will the system are implemented in?
- o Is the proposed equipment new/leading edge?
- o Who is responsible for defining system testing?

o Who is responsible for defining acceptance testing?

With risk identified, it is much easier to develop a plan to eliminate or manage risk.

Risk Control

A. Risk Avoidance and Mitigation

The purpose of this technique is to altogether eliminate the occurrence of risks. It is the method to avoid risks is to reduce the scope of projects by removing non-essential requirements.

B. Risk Management Plans

Risk Management Plan (RMP) presents the process for implementing proactive risk management as part of overall project management. The RMP describes techniques for identifying, analyzing, prioritizing & tracking risks; developing risk-handling methods; & planning for adequate resources to handle each risk, should they occur. The RMP also assigns specific risk management responsibilities & describes the documenting, monitoring & reporting processes to be followed.

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C. Risk Monitoring

The risk is monitored continuously by reevaluating the risks, the impact of risk, and the probability of occurrence of the risk. This ensures that:

- o Risk has been reduced.
- o New risks are discovered.
- o Impact and magnitude of risk are measured.

8.3 Software Risk Management Techniques

There are three main quantitative techniques:

- Decision Trees- Rather like flowchart diagrams these represent a method of looking at, for example, two options and making a decision. By analyzing the impact each decision will have, the risks of taking that decision can be forecast and used to anticipate problems or inform the direction the project takes. This technique is best suited to simpler situations. In complex scenarios they can become confusing and complicated.
- Influence Diagrams- This technique results in a diagram, which is similar to a project network diagram or Microsoft Project PERT charts. In this case each box will contain a variable or decision, which will have an influence on future progress. By analyzing the impact each variable will have, the risks of taking one path over another can be forecast and used anticipate problems or inform the direction the project takes.
- Monte Carlo Simulation (or 3-Point Estimation)- Looking at both best and worst case scenarios as well as most likely scenario and then planning what the impact of each is. This can be plotted against the Project Baseline and the Critical Path to show the consequence of risk and allow you to anticipate suitable response to risk.

8.4 Risk Management Plan

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Risk Management Plan defines how risks will be managed during the life cycle of the program. It is used to plan the way risks are handled within the program. The risk strategy and supporting plan must acknowledge actual and potential threats to the successful delivery of a project and determines the activities required to minimize or eliminate them. There are many approaches to project risk management planning, but essentially the risk management plan identifies the risks that can be defined at any stage of the project life cycle. The risk management plan evaluates identified risks and outlines mitigation actions. It needs to be capable of integration into or coordination with the project plan. The RMP should be periodically updated and expanded throughout the life cycle of the project, as the project increases in complexity and risks become more defined.

A risk management plan defines how your project's risk management process will be executed. That includes the funds, tools and approaches that will be used to perform risk identification, assessment, mitigation and monitoring activities. A risk management plan usually includes:

- Methodology: Define the tools and approaches that will be used to perform risk management activities such as risk assessment, risk analysis and risk mitigation strategies.
- Risk Register: A risk register is a chart where you can document all the risk identification information of your project.
- Risk Breakdown Structure: It's a chart that allows you to identify risk categories and the hierarchical structure of project risks.
- Risk Assessment Matrix: A risk assessment matrix allows you to analyze the likelihood and the impact of project risks so you can prioritize them.
- Risk Response Plan: A risk response plan is a project management document that explains the risk mitigation strategies that will be employed to manage your project risks.
- Roles and responsibilities: The risk management team members have responsibilities as risk owners. They need to monitor project risks and supervise their risk response actions.
- Funding: Have a section where you identify the funds required to perform your risk management activities.
- Timing: Includes a section to define the schedule for the risk management activities.

Risk Plan

The risk management plan should be a part of the overall project plan. The risk plan for smaller projects can be as simple as a risk management matrix. The complex projects require more thorough risk analysis and planning. For each risk outlined in the risk matrix one will have to create a thorough analysis for each. The main goal of creating the risk matrix is to prioritize the risks. One will never be able to eliminate all risk, but one can prioritize and document risks to attempt to mitigate or eliminate them. The risk management matrix will document the following items:

- Risk and Consequences- Brainstorm risks before you are beginning your project and continue adding to your risk management plan as the project moves throughout its life-cycle. What risks can be associated with this project? Will the risks affect the schedule, resourcing, or budget?
- Probability- the table should contain a probability of the risk occurring. This can be a percentage or a number.

- Impact- what is the impact to the project if the risk should occur? Build a scale appropriate for the project- smaller projects can use a simple impact of 1-5 (minimal to major) whereas larger projects may want a more formal scale.
- Priority- (Probability * Impact) will give an idea of the priority of the risk. Higher priority items should be mitigated and planned for before lower priority items.
- Mitigation Response- a brief overview of mitigation steps to eliminate or reduce the risk.

8.5 Risk Management Cycle

Every project is subject to constant change in its business and wider environment. The risk environment is constantly changing too. The project's priorities and relative importance of risks will shift and change. The assumptions about risk have to be regularly revisited and reconsidered, for example at each end stage assessment. The main steps through the risk management cycle are depicted in the Figure 4 below:

- Identify the risks
- Evaluate the risks
- Identify suitable responses to risk
- Select
- Plan and resource
- Monitor and report

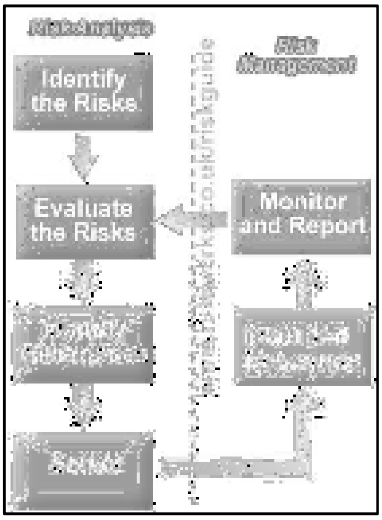

Figure 4: Risk Management Cycle

There are four stages of risk management planning. They are:

Risk Identification- In this stage, the risks are identified and named. The best approach is a workshop with business and IT people to carry out the identification. One can use a combination of brainstorming and reviewing of standard risk lists. There are different sorts of risk, and one needs to decide on a project-by-project basis what to do about each type.

Business risks are ongoing risks that are best handled by the business. An example is that if the project cannot meet end of financial year deadline, the business area may need to retain their existing accounting system for another year. The response is likely to be a contingency plan developed by the business, to use the existing system for another year. Generic risks are risks to all projects. For example, the risk that business user might not be available, and requirements may be incomplete. Each organization will develop standard responses to generic risks.

The risks should be defined in two parts. The first is the cause of the situation (Vendor not meeting deadline, Business users not available, etc.). The second part is the impact (Budget will be exceeded, Milestones not achieved, etc.).

Notes: Hence a risk might be defined as "The vendor not meeting deadline will mean that budget will be exceeded". If this format is used, it is easy to remove duplicates, and understand the risk.

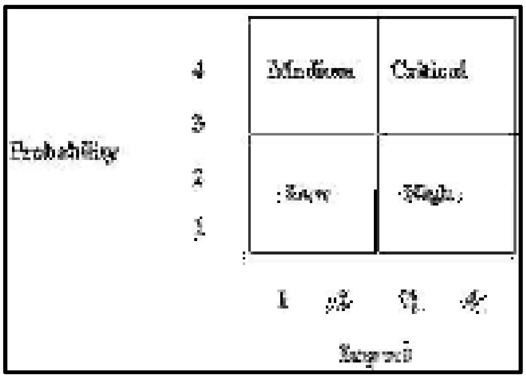

Figure 5: Risk Quantification Matrix

Risk Quantification- The risk needs to be quantified in two dimensions. The impact of the risk needs to be assessed. The probability of the risk occurring needs to be assessed. For simplicity, rate each on a 1 to 4 scale. The larger the number, the larger the impact or probability. By using a matrix, a priority can be established (Figure 5).

Notes: It is notable that if probability is high, and impact is low, it is a medium risk. On the other hand, if impact is high, and probability low, it is high priority.

Risk Monitoring- It is an ongoing risk management task that involves monitoring the success and status of the other risk management tasks. The typical responsibilities of risk monitoring are to determine if, any aspect of the risk analysis has changed and therefore should be repeated; any undesirable event defining a risk has actually occurred; the other risk tasks are being performed effectively and efficiently. The objectives of risk monitoring include:

- o Complete Conditions- Risk monitoring is typically complete when the following post conditions hold. The risk monitoring reports have all been:
  - ▪ Produced
  - ▪ Evaluated for quality
  - ▪ Updated based on the quality control evaluation
  - ▪ Approved
  - ▪ Published to its stakeholders
- o Steps in Risk Monitoring- The risk monitoring typically involves members of the endeavor's teams performing the following steps in an iterative, incremental, parallel, time boxed, and ongoing manner. These include:
  - ▪ Determine if any risks have changed.
  - ▪ Determine risk controls being used.
  - ▪ Determine the effectiveness of the risk control actions and techniques.
  - ▪ Develop the risk management plan.
- o Techniques in Risk Monitoring- Risk monitoring can typically be performed using the techniques that involve:
  - ▪ Assessment of current situation
  - ▪ Auditing of current situation
  - ▪ Cross Functional Teams to provide multiple viewpoints so that all aspects of risk management can be monitored.

- Inspecting of current development or usage tasks
- Interviews with stakeholders, domain experts, and members of the development and operations organizations.

o Work Products- Risk monitoring typically results in the production of all or part of the work products, a risk monitoring report.

Risk Mitigation- Risk mitigation is the process of understanding certain risks and threats, accepting that they exist, and taking the appropriate measures to reduce their effects in case they happen. It is a part of the risk management process and is necessary to prepare an organization for any threats to its operations and processes (Figure 6). Instead of eliminating threats, risk mitigation focuses on the unavoidable threats and reducing their impact.

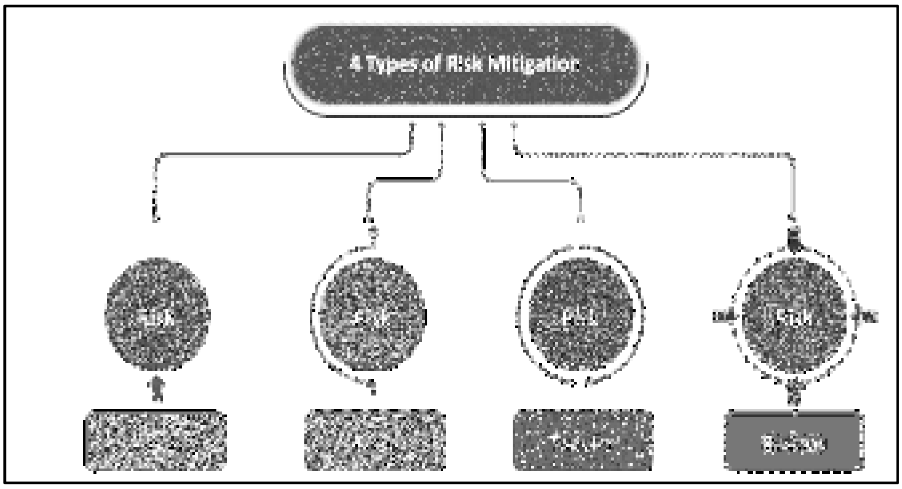

Figure 6: Risk Mitigation Types

Some of the common techniques used for risk mitigation include:

- o Risk acceptance- This involves accepting a certain risk and the threats it has for an organization for a certain period of time. The organization can focus on mitigating other risks and threats during this time.
- o Risk avoidance- This is the strategy that an organization uses when the consequences of certain risks are too high for them to mitigate the risk. In these cases, it might be best for an organization to take measures to eliminate and avoid the risk altogether.
- o Risk transfer- This involves transferring the risk allocation between different parties. For example, if an organization gets materials or products from a third party before distributing them, they can put all the risk for those certain materials in the hands of the third party instead.
- o Risk reduce- This involves keeping a close eye on different processes and teams to assess risks as they happen. From there, measures can be taken to minimize the effect of these risks.

8.6 Metrics of Risk Management

There are many situations a business may face and prepare for using a risk management plan. Risk management can help a business maintain its success or improve its operations by preventing or handling risks that may or may not occur. To know if the risk management plan is effective, one can use key performance indicators to measure certain aspects of risk.

Importance of Risk Management Metrics

Typically, risk management approaches allow to actively manage risk within a defined area of the business, like a project. However, this kind of risk management doesn’t tell how good the business is at identifying and managing risk overall. It doesn't flag up areas where people managing risk might be struggling, and it doesn't help to identify where the risk management processes might need a little work. One needs to look at and track how risk is managed to do that. This is where risk management metrics come into play. One can better understand risk exposure for a project, a program or the business overall if one has a sense of whether risk in the business is being effectively managed. The risk managers are not only responsible for protecting and securing their organizations, but they also have to provide evidence that their risk management programs are actually effective at managing risk.

Risk Metrics and key risk indicators are an important way to measure effectiveness. This is because risk managers must prove they are meeting the expectations of not only regulators, examiners, and their board of directors, but also their customers, investors, fellow employees, and communities.

Metrics of Risk Management

- Number of risks identified- This is a relatively easy measure. One can track number of risks identified per project or program. There is no 'right answer' to how many risks a project should have identified. It completely depends on the type of project. A project may have carried out many times before will be low risk. A project with multiple areas of complexity using a methodology that is new to the team will inherently be riskier. However, this measure is useful for comparing projects where the PMO can apply some basic principles. If you know that two projects are similar in many respects (like duration, priority, complexity) then one can assume they would have around the same number of risks. If one project manager has identified 90 risks and the other project manager has identified 19, one would be justified in comparing how robustly they are doing risk analysis on the project.
- Number of risks that occurred- One can also track the number of risks that materialize and turn into 'real-life' issues on the project. Hopefully, there aren't that many. However, this measure can also tell you that risk analysis is being done thoroughly. For example, if lots of risks are tracked that then turn into issues, one can give the team credit for spotting that these things might cause problems. If lots of risks are tracked but none turn into issues, this could be that the team are tracking the wrong things– issues pop up out of nowhere and never make it on to the risk log.
- Number of risks that occurred more than once- This can be a sign that lessons aren't being learned. If a risk occurs multiple times, across the same project or several projects, it can show that teams aren't learning from the past experience.
- Predicted risk severity compared to actual severity- When the risk occurs, and becomes an issue, one'll be able to see how much of an impact it had on the project. Comparing predicted severity to actual severity can be a bit of a professional guess, but it's worth giving it a go. It's interesting to see whether the risk mitigating plans had the impact expected in reducing the risk. One can look at whether residual risk was adequately identified and managed too.
- Number of risks that were not identified- How can anyone track something one doesn't is going to happen? There has to be a way to track issues that occur that should have been flagged as a risk but weren't. One can look at the issues on the issue log that could have been foreseen but have bypassed the risk stage.
- Cost of risk management- One can track actual spent on risk management activities against forecasted spend. This is a really interesting one for future projects because it can help one estimate the cost of risk on new projects.
- Number of risks closed- Track how many risks passed by without happening, whether one has taken any active measures to manage them or not. This can be a counterbalance to the number of risks identified. If one identifies, one can work out the key risks facing the project. This measure is also a sign that active risk management is happening during the project. A large

number of identified risks and no closed risks shows that risk analysis was carried out at the start of the project and then not followed up throughout the project lifecycle.

8.7 Project Evaluation Review Technique (PERT)

Project Evaluation Review Technique, or PERT, is used to identify the time it takes to finish a particular task or activity. It is a system that helps in the proper scheduling and coordination of all tasks throughout a project. It also helps in keeping track of the progress, or lack thereof, of the overall project. In the 1950s, the Project Evaluation Review Technique was developed by the US Navy to manage the Polaris submarine missile program of their Special Projects Office.

PERT is a procedure through which activities of a project are represented in its appropriate sequence and timing. It is a scheduling technique used to schedule, organize and integrate tasks within a project. PERT is basically a mechanism for management planning and control which provides blueprint for a particular project. All the primary elements or events of a project have been finally identified by the PERT. The main characteristics of PERT are as following:

- It serves as a base for obtaining the important facts for implementing the decision-making.
- It forms the basis for all the planning activities.
- PERT helps management in deciding the best possible resource utilization method.
- PERT take advantage by using time network analysis technique.
- PERT presents the structure for reporting information.
- It helps the management in identifying the essential elements for the completion of the project within time.

Advantages of PERT

- Estimation of completion time of project is given by the PERT.
- It supports the identification of the activities with slack time.
- The start and dates of the activities of a specific project is determined.
- It helps project manager in identifying the critical path activities.
- PERT makes well organized diagram for the representation of large amount of data.

Disadvantages of PERT

- The complexity of PERT is more which leads to the problem in implementation.
- The estimation of activity time are subjective in PERT which is a major disadvantage.
- Maintenance of PERT is also expensive and complex.
- The actual distribution of may be different from the PERT beta distribution which causes wrong assumptions.
- It underestimates the expected project completion time as there is chances that other paths can become the critical path if their related activities are deferred.

8.8 PERT Chart

In this technique, a PERT Chart is made which represent a schedule for all the specified tasks in the project. The reporting levels of the tasks or events in the PERT Charts is somewhat same as defined in the work breakdown structure (WBS). PERT chart is a visual representation of a project's timeline and breaks down individual tasks (Figure 7). These charts are similar to Gantt charts but, are structured differently. The diagram consists of a few steps to get you from a project start date to end date. To create a PERT chart, a project management team should follow these steps:

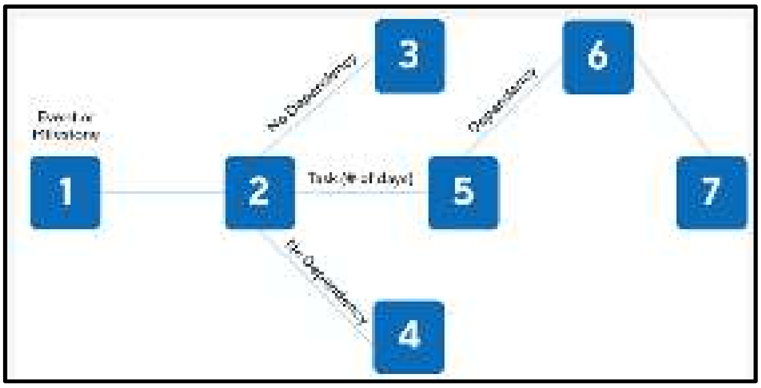

Figure 7: PERT Chart Example

Step 1: Identify all of the project's activities- First, define all of the major phases, milestones, and tasks needed to complete the project.

Step 2: Identify dependencies- If one determines some tasks or activities have dependencies, one will want to depict those tasks with directional arrows. This will ensure the team knows the sequence they need to tackle each task.

Step 3: Draw the chart- The next step is to take the events and milestones (numbered nodes) one has identified and draw them out. Then write out the tasks and activities that the team must complete between each node, using directional arrows or divergent arrows accordingly.

Step 4: Establish timelines for all activities- One should now set a timeframe when the team will need to complete those tasks along with all arrows.

8.9 PERT Chart vs Gantt Chart

- o Gantt charts are bar graphs; PERT charts are free-form- Gantt charts are drawn as bar graphs along a timeline. They represent the tasks and phases of a project with horizontal bars, each drawn to a length representing its estimated timeframe. A PERT chart, by contrast, can be drawn as a free-form diagram. Project managers create PERT charts by drawing boxes or circles ("nodes") representing events or milestones and connecting them via arrows, representing the tasks that must be completed between each milestone and the amount of time the team will have to complete each task.
- o PERT charts illustrate dependencies; Gantt charts do not- One disadvantage of using a Gantt chart to track a project is that it does not indicate task dependencies. Each bar on the graph stands alone. This makes it difficult for project managers to know how much one missed deadline could affect other chart tasks. PERT charts solve this challenge with the use of directional arrows. These directional (or "concurrent") arrows indicate that a series of tasks must be completed in sequence because they have interdependencies. On the other hand, diverging arrows indicate functions that can be completed parallel or out of order because they do not have dependencies.

Summary

- Software risk management is a process whereby the project identifies and tracks threats to the success of the project. This process provides for mitigation strategies for potential problems and for early intervention with realized problems, lessening their impact to the project.
- Risk management is the system of identifying, addressing and eliminating these problems before they can damage the project.

- Risks could be due to internal or external factors.
- Project Evaluation Review Technique, or PERT, is used to identify the time it takes to finish a particular task or activity. It is a system that helps in the proper scheduling and coordination of all tasks throughout a project.
- Quantifying the effects of a risk by multiplying the risk impact by the risk probability yields risk exposure.
- An ideal risk management minimizes spending while maximizing the reduction of the negative effects of risks.
- Risk monitoring is an ongoing risk management task that involves monitoring the success and status of the other risk management tasks.

Keywords

Project Risk: Project risk is any potential issue that could negatively impact the successful completion of the projects.

Project Risk Management: The project risk management is a process that aims to reduce project risks that have already occurred, are occurring, or are likely to occur in the future. It focuses on risk reduction by identifying the root causes of risks and minimizing their impact, if not completely eliminating them.

Project risks: Project risks concern differ forms of budgetary, schedule, personnel, resource, and customer-related problems.

Technical risks: Technical risks concern potential method, implementation, interfacing, testing, and maintenance issue.

Predictable risks: Those risks that are hypothesized from previous project experience (e.g., past turnover).

Unpredictable risks: Those risks that can and do occur but are extremely tough to identify in advance.

Response Plan: The response plan should include how one will address each of the identified high-priority risks. The plan should also be achievable, practical, and tailored to fit the project's specific needs.

Self Assessment

1. Which of the following method can be used for Risk Identification?

A. Assumption Analysis
B. Checklist Analysis
C. Brainstorming
D. All the above.

2. _______________ charts represent the tasks and phases of a project with horizontal bars, each drawn to a length representing its estimated timeframe.

A. Gantt
B. Critical
C. Counter
D. PERT

3. In risk management, a prioritization process is followed whereby the risks with the greatest loss and the greatest probability of occurring are handled first, and risks with lower probability of occurrence and lower loss are handled in descending order.

A. True

B. False

4. ____________ risks are associated with fluctuations or inaccuracies in demand, supply, quality, price, etc., that can impact the project outcome.

A. Ambiguity risks

B. Variability risks

C. Individual project risks

D. Overall project risks

5. PERT charts are bar graphs while the Gantt charts are free-form.

A. True

B. False

6. The statement accurately describing project risk management is/are:

A. It is the process of identifying, assessing, and responding to unexpected risks that might affect your project's goals and progress.

B. It is a process that aims to reduce project risks that have already occurred, are occurring, or are likely to occur in the future.

C. It focuses on risk reduction by identifying the root causes of risks and minimizing their impact, if not completely eliminating them.

D. All the above.

7. ______________ is a process whereby the project identifies and tracks threats to the success of the project.

A. Threat management

B. Workflow management

C. Software risk management

D. Role management

8. _________________ defines how risks will be managed during the life cycle of the program.

A. Accuracy Risk Plan

B. Risk Management Plan

C. Software Risk Analysis Plan

D. Software Estimation Plan

9. ___________________ is also called as Risk Estimation.

A. Risk monitoring

B. Risk programming

C. Risk analysis

D. Risk coding

10. Which of the statement (s)below aptly explains the Risk Management Plan (RMP)?

A. RMP presents the process for implementing proactive risk management as part of overall project management.
B. RMP describes techniques for identifying, analysing, prioritizing & tracking risks; developing risk-handling methods; & planning for adequate resources to handle each risk, should they occur.
C. RMP assigns specific risk management responsibilities & describes the documenting, monitoring & reporting processes to be followed.
D. All the above.

11. ________________ is a systematic process performed by a competent person which involves identifying, analysing, and controlling hazards and risks present in a situation or a place.
A. Risk assessment
B. Risk modelling
C. Risk attribution
D. Risk definition

12. During the risk estimation stage, the stakeholder's knowledge and perceptions are assessed in light of receiving new information resulting from the risk estimates and the stakeholder analysis is updated.
A. True
B. False

13. ____________ risks stem from the lack of clarity in project requirements that can lead to misinterpretations or mistakes.
A. Variability risks
B. Individual project risks
C. Ambiguity risks
D. Overall project risks

14. PERT stands for,
A. Project Execution Review Technique
B. Project Execution Report Topic
C. Project Evaluation Reporting Technique
D. Project Evaluation Review Technique

15. Quantifying the effects of a risk by multiplying the risk impact by the risk probability yields risk exposure.
A. True
B. False

Answers for Self Assessment

1.	D	2.	A	3.	A	4.	B	5.	B
6.	D	7.	C	8.	B	9.	C	10.	D

11. A	12. A	13. C	14. D	15. A

Review Questions

1. Differentiate PERT chart and Gantt chart?
2. Discuss in detail about Software risk management.
3. Describe the importance and concept of PERT?
4. What is the significance of using a risk plan?
5. What is a project risk? Explain the categories of risks associated with a project.
6. Briefly explain the Project Evaluation Review Technique (PERT).
7. How is the project risk management important?
8. What are the different steps in software risk management?
9. Discuss the general steps to manage the project risks.
10. What are the different techniques used for software risk management?

Further Readings

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Web Links

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https://youtu.be/EwOHSnxmbVI

Unit 09: Resource Allocation

CONTENTS

Objectives

After studying this unit, you will be able to:

- learn the basics and importance of resource allocation in project management.
- identify the resource requirements.
- understand the resource schedule & cost schedule.
- Know about the scheduling of the resources and the scheduling sequence.

Introduction

Resource allocation in project management deals with finding and assigning the right resources to the right tasks at the right time. It is the most efficient and profitable way of scheduling and assigning available resources to tasks. Allocating the right resources at the right time could be the difference between project success and failure.

Resource allocation is a process in project management that helps project managers identify the right resources and assign them to project tasks in order to meet project objectives. The project resources can be material, equipment, financial, or human resources. Typically, resource allocation is done during the early stages of a project's lifecycle. Specifically, it's a step in resource planning, which, in turn, is a step in the project planning phase in project management.

One of the essential components of an effective project management (PM) process is resource allocation. According to Wellington's research (2019), it is the second largest project management challenge among surveyed organizations. Assigning the right resources to the proper projects isn't as easy as one might think. The process requires preliminary preparation, specific knowledge, and experience. Robust allocation processes affect the successful project realization.

Types of Resources in a Project

Globally, resources can be human and non-human. In project management, these are divided into 5 groups:

- Labor: These are various professionals, employees, and team members with different skills needed to complete a project successfully. These people make any plan's backbone.
- Equipment: It includes necessary tools for project completion, from software or hardware to hammer or drill, depending on a company's specifics.
- Facilities: It is all about an environment for work and project realization such as offices, open space, meeting rooms, etc.
- Materials: In other words, it is the stuff needed to produce outputs, from pens and paper to raw material for house building.
- Budget: Probably, the most important type that allows buying all we listed above.

A project manager needs to consider the following factors during resource allocation:

- Skills: the skills that can help achieve the project objectives.
- Capacity: the number of theoretical hours a resource can work during the project schedule.
- Availability: the number of available resource hours, after excluding time off and culture hours from capacity.
- Utilization: the number of productive hours a resource can put in, typically 80% of available hours.

Who is responsible for allocating resources in project management?

A project manager is responsible for resource allocation in project management. In larger organizations, resource managers are responsible for allocating resources from the resource pool. While the project manager creates and assigns tasks, the resource manager is accountable for allocating resources to ensure the project's success.

Before a project manager resource planning and allocation, they must:

- Get a sign-off on the project scope.
- Identify all critical project tasks using Work Breakdown Structure (WBS).
- Create a project schedule and a project timeline.

During resource allocation, the project manager must work closely with:

- project stakeholders, including the customers and the project team members.
- other project managers, in cases where multiple projects share the same resources.
- identified resources to determine if their capacity and availability are in line with project objectives.

Large organizations often have dedicated resource management teams. In such cases, the project manager needs to work closely with resource managers to ensure that resource requirements are met.

9.1 Importance of Resource Allocation in Project Management

It is difficult to overestimate the importance of resource allocation and leveling in project management. It affects all working processes and helps to avoid missed deadlines and meet business objectives.

- Efficient resource utilization- Assigning resources the right way ensures that limited resources are used in the best possible way to achieve the project's goals. It helps make the most effective use of the team's capacity among different projects and tasks.
- Mitigate resource risks- Proper allocation of resources helps identify resource constraints that can cause project delays. It enables managers to anticipate potential risks and take remedial measures. Thus, improving the chances of project success.
- Reduces scheduling conflicts- Time off and shared resources across multiple projects often result in scheduling conflicts. Planned resource scheduling ensures that the project timelines don't conflict with resource availability. In addition, it takes care to minimize resource dependencies while ensuring that the project stays on track.
- Improved cost management- Deliberate resource allocation helps project managers track progress, and manage resource costs, which leads to better cost management. As a result, it reduces the possibility of the project budget going overboard.
- Better project outcomes- Effective resource management leads to fewer project failures. When the right resources are assigned to the right tasks, it results in better project outcomes. As a result, project goals are met within the timeline and budget.
- Improved project team productivity- If done right, resource assignment ensures optimum resources are allocated and avoid overallocation. This, in turn, prevents overwork, stress, and burnout. As a result, team productivity improves.

Resource allocation helps:

- Forecast and avoid possible difficulties and scarcity of people, money, materials, etc.
- Prevent employees' burnout.
- Inform others about your team's plans and workload.
- Meet deadlines.
- Avoid extra spending.

9.2 Resource Allocation Strategies

A resource allocation strategy is a method by which a project manager ensures the right resources are assigned to a project and its tasks. Three popular resource allocation strategies include:

Critical Path Method (CPM)- Using this resource allocation strategy, a project manager identifies tasks that cannot be delayed without delaying the project schedule. Then the project manager prioritizes the best available resources for these critical tasks. The biggest advantage of CPM is that it ensures the project's time constraints are met. However, it does not allow multi-tasking. As a result, while time constraints are met, resources need to be allocated for a longer duration than necessary.

Critical Chain Method (CCM)- The Critical Chain Method is a newer resource allocation technique. It focuses on resource constraints instead of time constraints like in CPM. Considering resource availability and constraints, a buffer time is added to the initial project estimate. This allows project teams enough time to complete the project on time. Some managers use CCM along with CPM.

Resource leveling and smoothing- Things don't always go according to the resource allocation plan—An emergency means a team member is no longer available.

- A task takes much longer than estimated. Or something else happens that throws your project timeline off. In such situations, a project manager can do little else but change the initial project plans.
- In resource leveling, a project manager changes the project schedule, including the start and end dates, to account for resource availability.
- However, that's not possible with all projects. In such cases, the project manager uses resource smoothing—They change the resource schedule and allocation plan, or in extreme cases, bring in more resources.

9.3 Steps to Allocate Project Resources Effectively

The project resource allocation process involves identifying and assigning the necessary resources to complete a project successfully. It is a plan that is developed with the aim of making the most of the available resources at disposal in a project, which makes it a critical resource planning activity. This is mostly a short-term plan set in place to achieve goals in the future.

Here are the steps involved:

- Define the Project scope- Before allocating resources or managing them, one has to determine the scope of the project to be working on. Is it a big or small project, long or short? Once the questions have been answered, then one can make the right decision on what resources one'll need and how many of them are necessary to complete the project. The clearer the project scope is, the better will be able to figure out how to allocate the resources. Take the time to get the full picture of the project prior to doing any resource allocation.
- Estimate what project resources will be needed- Once the scope has been known, the objective and tasks for the project needed to be on time and within the budget approved, now is the time to get the resources together. An estimation needs to be done regarding the resources needed, including people, equipment, materials, and anything else needed to complete the project tasks. It needs to analyzed which resources are already within the organization and which others will be required to be purchased or rented. All the resources are required before allocation. So, make a list using the criteria above and then make sure it fits within the project budget.
- Assess the current resource utilization & resource availability- This involves an identification and assessment of the resources required for the project that are available within the organization. However, some existing resources might be being used for other projects, so it's important to identify which resources the organization has but also which of those are being utilized.
- Create a resource allocation plan- Take the information gained from the above steps to put together a resource allocation plan. Outline the list of resources needed for the project as well as the cost and quantity of each. When finished, circle back to the project scope to make sure the plan aligns with it.
- Keep track of the project resources- It is important to be always aware of the state of the resources. For example, what's the schedule for the team, are any taking vacation time, are they sick, etc.? Also, what's the duration of the lease for the site or equipment? These are important questions to ask when scheduling resources.
- Use resource allocation reports- The reports relating to the resources allocated can be generated. One can generate all sorts of reports to give a full picture of the project and how it's progressing, which helps to balance the resources. For example, resource reports give an overview of the team's workload and whether they're over-tasked or idle. Task reports keep us updated and variance reports help to determine whether the project is proceeding as planned. The latter gives vital information, such as if the project is behind schedule and requires redistribution of the work to get back on track.

9.4 Resource Allocation Tools

Resource Allocation Matrix: A resource allocation matrix is an overview of the needed project resources. It helps to identify any potential bottlenecks or imbalances ahead of time. Typically, the matrix includes the names and roles of each team member, their availability, and their skills and tasks on the project. It acts as a visual representation of the resources mapped against project tasks and activities.

Resource Breakdown Structure: This resource allocation tool is a hierarchical chart of the resources needed to execute the project and it includes everything from the people needed for the project to what anyone will be spending the money on. An RBS can include materials, equipment, people, project management tools and more.

Gantt Charts: Gantt charts provide an easy way to map the required project tasks and note dependencies. Once the tasks have been identified, one can assign them on the Gantt chart and see how long each team member has spent working on each task.

Workload Charts: These charts visually represent the resource allocation for the project team, department or entire company. Use it to quickly determine how the human resource management is aligning with the planned resource allocation.

Challenges of Resource Allocation

We live in an age of technology and constant changes. A good manager should be able to adapt to market changes to achieve better results. Resource allocation is one of the essential parts of PM, and at the same time, it is the hardest thing to optimize and automate. Nowadays, many professionals are engaged in several projects and sometimes play several roles in them. This trend makes management processes even more complex.

Changes in a project- Every manager should keep in mind that changes can occur in every moment of project delivery. So, it is always better to have a flexible resource allocation plan.

A lack of qualified resources- It is important to ensure the employees possess the required skills to work on the project and in a company in general. Otherwise, the allocation procedure will become just a waste of time.

Poor capacity planning and measuring- Before starting work, define the capacity of your resources. In other words, determine available resources (no matter human or not) to deliver the project within budget and in a timely manner.

Changes in resource availability- Resource allocation is not a static process. It will be helpful if one won’t forget about sick days, delivery delays, etc., which can cause scenario changes.

Not assessed risks- Here we are talking about not only humans but about all types of resources listed earlier. A manager should assess every possible risk: from extra costs and unforeseen events to equipment changes and the learning process of new software.

Task delays- Tasks can be connected with dependencies. So, if one step in the project is delayed, it can cause a domino effect and affect the timing of other tasks.

Working with international teams/remotely- If anyone works in a remote or distributed team, one has probably faced difficulties in a workflow because of colleagues’ different time zones and locations. A good manager should always predict such things to avoid miscommunications and delays.

9.5 Identifying Resource Requirements

One of the essential components of an effective project management (PM) process is resource allocation. Assigning the right resources to the proper projects isn’t as easy as you can think. The process requires preliminary preparation, specific knowledge, and experience. Robust allocation processes affect successful project realization.

As you plan for application compatibility testing, keep in mind the future state of your computing environment. Are you planning to upgrade some of your software to versions that fully use new Windows features? Are you planning to implement new standard desktop configurations or use Terminal Services? Issues such as these determine the resources that are required and the applications that are to be tested as a suite.

You can facilitate testing by setting up a lab where testers can conduct their tests. In such a lab, you can always have the necessary tools and equipment available. If you do not have the budget for a separate lab, you might share a lab with another project or with training. If you share a lab, try to choose one that has compatible scheduling and equipment requirements.

In the lab, set up the test computers for dual or triple startup so that testers can quickly access the mode they need to install and test their applications. If your test lab is large, you might decide to assign a lab manager. Because the skills required to run a lab and to manage testing are so different, consider selecting different people for the two roles. While the lab manager needs to have strong technical skills, the testing manager needs to have strong managerial and communication skills.

Resources are the means we use to achieve project objectives. The primary resource is obviously people with applicable skills and competencies. The other main grouping of resources we need includes capital, facilities, equipment, material, and information. There is usually a gap between the investment reach of a project and the project demands as depicted in the Figure 1 below.

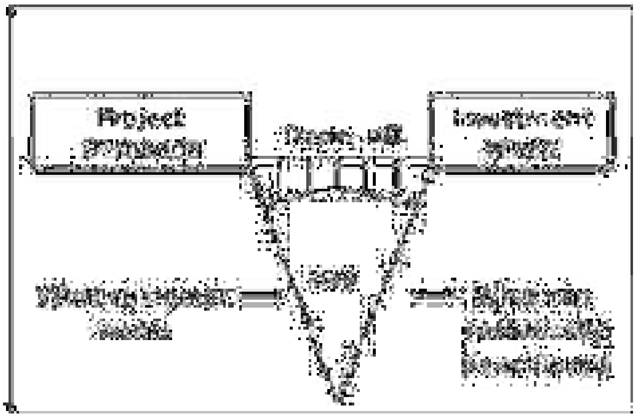

Figure 1: Gap depicting Investment Reach of a Project & Project Demands

In order to ensure a cost-effective application of the required resources we must perform a proper needs analysis in order to define the project goals and objectives. The project's baseline that must be resourced will be known after a requirement specification has been completed. The WBS is the base document for determining resource requirements.

Task: The requirement specification will spell out the real requirements to achieve through the specific project. Explain.

Inputs to Resource Planning

The WBS identifies the project elements that will need resources. It is therefore the primary input to resource planning. The historical information as to what types of resources were required for similar work on previous projects is valuable input. In many instances there are industry standards available that can be consulted. The scope statement contains the project justification and the project objectives which should be considered. A resource pool description is another useful input. It constitutes knowledge of what resources (people, equipment, and material) are potentially available.

Resource Estimation

Resource estimation is a structured prediction of the cost and other resources required to execute a task. One of the primary functions of the process is to establish a control basis. Therefore, the more accurate the estimation, the more reliable the control system becomes.

The required accuracy and effort going into resource estimation can be influenced by the element of uncertainty and risk involved because of technical complexity and novelty of the project. The expected price basis of the contract could make resource estimation a critical factor. The higher the risk the more important it becomes to have a realistic estimation, which implies a more detailed process.

The amount of effort that it will take to complete a task is also important. Effort is determined by the time it will take to complete a task. Once the effort that's required for a project is understood, one can assign resources to determine how long the project will take and estimate human resources and other resource costs. A properly documented resource plan will specify the exact quantities of human resources, equipment and materials needed to complete your project.

Resource Acquisition

Resource acquisition refers to the process of physically securing the necessary inputs. All resources required have to be paid for in some way or another. The financing of a project therefore plays an essential role in the acquisition process.

The acquisition process must be managed properly to take care of possible seasonal shortages, labor disputes, equipment breakdowns, competing demands, delayed deliveries and other things that may go wrong. The project plan may have to be modified to accommodate or work around supply problems.

Resource Levelling

Resource levelling is the process that ensures resource demand does not exceed resource availability and vice versa. The first step is usually to move non-critical tasks with float to a later date. If there is rescheduling of a task on the critical path, it would influence the completion dates of successive tasks. One can check to see whether it will have an influence on meeting the project deadline.

Human Resource Planning

There is the use of a Responsibility Assignment Matrix (RAM) to allocate roles and responsibilities. The WBS is the primary document for doing this. List the project activities on the left-hand side of the matrix and role-players on top of the matrix. List a brief description of the work to be done in the matrix cells. After completion of the RAM, one will know exactly who will do what on the project and what their respective roles are. In the case of a large project, one can then draw an organization chart for the project. Once the staff have been assigned, one can plan for briefings, coaching, training and all the activities regarding the management of the project teams and staff.

Resource Allocation

The different types and quantities of resources must be allocated to the project as needed to perform the activities. A schedule for this must be maintained to ensure that the allocation process takes place on time and in the right quantities. The delivery of resources is a very important point. During contracting, one must know exactly where resources will be originated and where it will be delivered to.

9.6 Resource Schedule

It helps to identify all of the resources required to complete the project successfully. Using the resource plan, one will be able to identify the quantity of labor, equipment and materials needed to deliver the project. One can then create a resource schedule, which enables to plan the consumption of each type of resource, so that one can analyze that there are enough resources to complete the project. The resource planning template will help to identify the:

- Types of labor required for the project.
- Roles and key responsibilities for each labor type.
- Number of people required to fill each role.
- Items of equipment to be used and their purposes.
- Types and quantities of equipment needed.
- Total amount of materials needed.

The resource plan template will also help to:

- Plan the dates for using or consuming these resources.
- Identify the amount of resource required per project activity.
- Create a detailed resource utilization schedule.

9.7 Cost Schedule

Cost planning ensures value for money and responsible management of public money of a capital project's finances, including the requirements set out in the code of practice, for example, for the building and construction industry.

Utilizing all the cost planning estimates templates (CPA, CPB, CPC1, CPC2, CPD), guarantees that a project can be costed as accurately as possible, as well as assist in the determining of the economic building lifespan and all future redevelopments that may occur and their estimated costing. Cost planning is to allow for options to be analyzed and may be required to determine best value for money by assessing recurrent costs over the life of the facility, as well as the capital cost. The cost planning and analysis may include a comprehensive cost-benefit analysis or cost-effectiveness analysis for the preferred option.

Throughout the life of a project, project objectives, client requirements or social, economic and environmental conditions may change. This can affect the budget and costs of the identified delivery options. If there is significant change to the service plan, asset and property configurations or similar, that impact on the preferred option(s), consideration should be given to reworking the options analysis process.

The project managers use the cost plans to exercise financial monitoring and control. It is intended that the Total End Cost budget elements be assessed and modified on an individual project basis as set out in the section allowances and are dependent upon the risks assessed at each phase of the project.

9.8 Scheduling Resources

Resource scheduling deals with assigning resources to project tasks and scheduling these tasks in a way that optimizes the use of resource availability and skills. The resource scheduling in project management is a process by which a project manager assigns capable and available resources to a scheduled task.

Scheduled tasks have specific start and end dates. Project managers need to meet resource demand during these dates by looking at resource capabilities and availability. To schedule resources, managers must balance two goals:

- Assign the most capable resources to a task. The most efficient resources will help to get the project tasks done on time, without sacrificing quality.
- Assign only the available resources. This helps avoid scheduling conflicts with other assignments and time off.

There are the four major stages of the resource scheduling process:

1. Resource definition
2. Resource allocation
3. Resource aggregation
4. Resource leveling

Resource definition involves identifying the critical resources that need to be planned and managed for the successful completion of the project. In a multi-project environment as projects are competing for scarce resources, resource allocation addresses the problem of the optimum use and timing of the assignment of these resources to the various project activities. Resource aggregation involves determining the aggregate resources that will be needed, period by period, to complete all project activities. Having identified the necessary resource requirements, the last stage in the process is resource leveling. In this stage, there are attempts to ensure that the demand for resources does not exceed availability. Specifically, demand for resources is smoothed to ensure that the peaks and valleys are reduced.

1. Resource Definition

Project Constraints

The primary impact of project constraints is the likelihood of delaying the completion of the project. There are three types of project constraints: technological, resource and physical. The technological constraints relate to the sequence in which individual project activities must be completed. For example, in constructing a house, pouring the foundation must occur before building the frame.

Resource constraints relate to the lack of adequate resources which may force parallel activities to be performed in sequence. The consequence of such a change in network relationships is delay in the completion date of the project. The physical constraints are caused by contractual or environmental conditions.

In general, from a scheduling perspective, projects can be classified as either time constrained or resource constrained. A project is classified as time constrained in situations where the critical path is delayed, and the addition of resources can bring the project back on schedule and the project completed by the required date. However, the additional resource usage should be no more than what is absolutely necessary. The primary focus, for purposes of scheduling, in time constrained projects is resource utilization.

On the other hand, a project is resource constrained if the level of resource availability cannot be exceeded. In those situations where resources are inadequate, project delays are acceptable, but the delay should be minimal. The focus of scheduling in these situations is to prioritize and allocate the resources in such a manner that there is minimal project delay.

Resource Constraints

The most important resources that project managers have to plan and manage on a day-to-day basis are people, machines, materials, and working capital. Obviously, if these resources are available in abundance, then the project could be accelerated to achieve shorter project duration. On the other hand, if these resources are severely limited, then the result more likely will be a delay in the project completion time. Depending on the type of resources, the costs of providing an abundance of such resources to accelerate project completion time can be very high. However, if the resources are readily available and excess premiums are not incurred to use them on the project, then project cost should be low, as some project costs are resource related while others are likely to be time dependent. In general, projects with a shorter duration are less expensive. The longer the duration of the project, the higher will be overall project cost due to the increase in fixed costs such as overheads.

For any particular project, the decision to place the project on the curve between the point of least duration with its associated higher resource requirements and a point of increased duration with its associated lower resource requirements depends on the particular parameters of the project.

When a project plan is first devised it is likely that the plan will identify peaks of resource requirements. However, given the finite nature of resource availability, it may be impractical to meet such peak resource needs. Ideally, there should be an even demand for resources over the entire project duration, with a smooth increase at the beginning of a project and a smooth decrease at the end. Given the limited nature of resources, thoughtful consideration should be given to the project resource requirements; the project plan should be refined when necessary, so that it is practical.

2. Resource Allocation

Resource allocation, also called resource loading, is concerned with assigning the required number of those resources identified in the previous step to each activity identified in the plan. More than one type of resource may be attributed to a specific activity. From a practical standpoint, resource allocation does not have to follow a constant pattern; some activities may initially require fewer resources but may require more of the same resources during the later stages of the project.

At this stage, the impact of any resource allocation decision is not known, and we cannot yet answer questions such as:

- Is lack of resources for this particular activity having an adverse effect on the duration of the whole project? Such an activity is more likely to be on the critical path.
- By excessive use of resources are we completing this activity more quickly than necessary in terms of the overall project duration? Such an activity is not likely to be on the critical path.

These questions will be answered later in the resource modeling process, specifically during the resource leveling and smoothing stage.

3. Resource Aggregation

Resource aggregation, or resource loading, is simply the summation, on a period-by-period basis, of the resources required to complete all activities based on the resource allocation carried out in the previous stage. The results are usually shown graphically as a histogram. Such aggregation may be done on an hourly, daily, or weekly basis, depending on the time unit used to allocate resources. When a bar chart is used as the planning tool, the resource aggregation is fairly simple and straightforward.

For a given bar chart, there is a unique resource unit aggregation chart which can be drawn underneath the bar chart. However, a separate graph will be required for each resource unit. An example is shown in the chart below (Figure 2), where, for a particular resource, the required resource units for each time period are annotated on the bar chart. The total number of resource units for each time period can then be summed up and a resource aggregation or load chart can be produced.

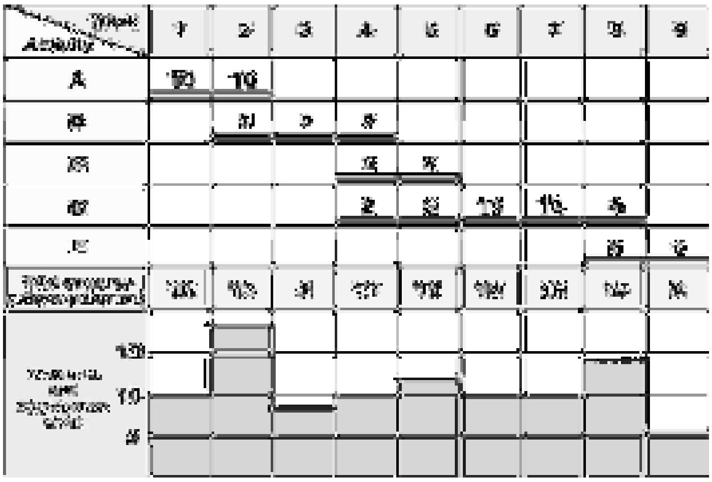

Figure 2: Resource Unit Aggregation Chart Derived from a Bar

However, when a network is used for planning, the resource aggregation procedure is not so simple or straightforward. As the network is not drawn to a timescale, there is not a direct link between the network and the demand for resources. Therefore, a schedule must be prepared which tabulates activities in terms of time.

4. Resource Leveling and Resource Smoothing

Having established the resource requirements through resource allocation and aggregation, the next phase of the planning and resource management process—resource leveling. Resource leveling is the process that ensures resource demand does not exceed resource availability. The ideal scenario would be a buildup of resource usage at the beginning of the project and a reduction at the end of the project. However, the approach to resource leveling will also depend on whether resources are dedicated to a particular project or shared across several projects and whether there is a need to keep all resources fully utilized.

Resource leveling can be accomplished more easily if resource requirements to complete an activity are expressed in terms of hours or days required. The definition of resource requirements using such units of measure can help us determine if an activity should be completed in a short time through the use of many resources or over a longer period of time through the use of fewer resources. Generally, there are two approaches to leveling and smoothing the resources required:

- Time-limited resource considerations: In this case emphasis will be placed on completing the project within a specified time. This time will usually have been determined by network analysis. Adjustments in the timing of any activity, and the resources required at a given time, must be undertaken within the float (slack) available.

- Resource-limited resource considerations: In this case the project must be completed with the resources available even if this means extending the project duration. If the total resource demand exceeds the resource availability at any time, then some of the activities must be delayed until there is sufficient resource availability.

Resource smoothing is part of the resource leveling process. In itself, resource smoothing is the process that, notwithstanding any constraints imposed during the leveling process, attempts to determine a resource requirement that is "smooth" and where peaks and troughs are eliminated.

For example, even if 7 units of a given resource are available at any one time, utilizing 5 of these units each week is preferable to 4 one week, 7 the next, 2 the next and so on. Even if there is no limit to the amount of any one resource available, it is still desirable that resource usage is as smooth as possible. Given that the resource requirements of those activities on the critical path are fixed, some order or priority needs to be established for selecting which activity and which particular resource associated with this activity should be given priority in the smoothing process.

In determining which activity should be given priority, a subjective judgment should be made about the type of resource (or resources) associated with each activity; priority should be given to the activities whose resources are considered to be most important.

Did You Know?

What is a useful device for prioritizing?

A useful device for prioritizing is to consider the ratio of total work content/total float remaining and give priority to activities with the highest value of this ratio.

Solving the resource scheduling problem for optimal solutions is extremely complex, particularly for large project networks with many different resource types. However, several heuristics are available to solve such problems. These heuristics allocate resources to activities to minimize project delay based on certain priority rules. The two most commonly used heuristics are the serial and the parallel methods.

In the serial method of resource allocation, activities are sorted into a list and resources are allocated to each of these activities one at a time until resources are allocated to all activities. In the parallel method, however, resources are allocated on a period-by-period basis rather than each activity. In this method only those activities whose preceding activities have been completed will be considered. If two or more activities compete for the same resources, then allocation of resources is based on certain prescribed priority rules.

9.9 Computerized Resource Scheduling

All the better-quality computer packages for project management, besides network analysis, also feature the ability to schedule activities considering the resource constraints. Thus, for most people engaged in project management today, a computerized approach is preferred. While a full description of the way in which current packages perform resource scheduling, these packages commonly use the serial scheduling and parallel scheduling algorithms.

Given the nature of the resource constraints, each method may produce a feasible schedule; however, the schedules need not necessarily be the same. Furthermore, if the same problem is solved by two different project management packages, different schedules may be generated.

Benefits of Resource Scheduling

The process of scheduling resources before the project begins provides the following benefits:

- If the project delay is unacceptable, it allows sufficient time for considering alternatives such as cost-time trade-offs and changing of priorities.
- Provides information to prepare time-phased work package budgets with dates.

- o Enables project managers to determine the amount of flexibility they have over certain resources.

9.10 Scheduling Sequence

You use the scheduling sequence to specify in which sequence the system executes the scheduling or rescheduling of an operation group or order group. You can set up the sequence using various criteria, for example:

- o Order priority
- o Resource
- o Product number

The scheduling sequence is relevant for:

- o Manual scheduling and rescheduling of operations and order groups using drag and drop.
- o Scheduling and rescheduling of operations and order groups using the planning function Reschedule.
- o Scheduling with detailed scheduling heuristics.

The scheduling sequence is not relevant for scheduling an order. The scheduling sequence is valid for all detailed scheduling strategies in a strategy profile.

Summary

- The resource scheduling in project management is a process by which a project manager assigns capable and available resources to a scheduled task.
- Scheduled tasks have specific start and end dates. Project managers need to meet resource demand during these dates by looking at resource capabilities and availability.
- Resource allocation is the most efficient and profitable way of scheduling and assigning available resources to tasks. Allocating the right resources at the right time could be the difference between project success and failure.
- Resource allocation is a process in project management that helps project managers identify the right resources and assign them to project tasks in order to meet project objectives.
- Resource aggregation, or resource loading, is simply the summation, on a period-by-period basis, of the resources required to complete all activities based on the resource allocation carried out in the previous stage.
- Resource levelling is the process that ensures resource demand does not exceed resource availability.
- Resource smoothing is the process that, notwithstanding any constraints imposed during the levelling process, attempts to determine a resource requirement that is "smooth" and where peaks and troughs are eliminated.
- In the serial method of resource allocation, activities are sorted into a list and resources are allocated to each of these activities one at a time until resources are allocated to all activities. In the parallel method, however, resources are allocated on a period-by-period basis rather than each activity.
- Resource constraints relate to the lack of adequate resources which may force parallel activities to be performed in sequence while the physical constraints are caused by contractual or environmental conditions.

Keywords

Resource scheduling: Resource scheduling deals with assigning resources to project tasks and scheduling these tasks in a way that optimizes the use of resource availability and skills.

Resource allocation: Resource allocation in project management deals with finding and assigning the right resources to the right tasks at the right time.

Resource levelling: Resource levelling is the process that ensures resource demand does not exceed resource availability.

Resource loading: Resource aggregation, or resource loading, is simply the summation, on a period-by-period basis, of the resources required to complete all activities based on the resource allocation carried out in the previous stage.

Technological constraints: The technological constraints relate to the sequence in which individual project activities must be completed.

Resource constraints: Resource constraints relate to the lack of adequate resources which may force parallel activities to be performed in sequence. The consequence of such a change in network relationships is the delay in the completion date of the project.

Physical constraints: The physical constraints are caused by contractual or environmental conditions.

Self Assessment

1. Which of the following statement(s) is/are True for resource allocation?

A. Resource allocation is the most efficient and profitable way of scheduling and assigning available resources to tasks.

B. Allocating the right resources at the right time could be the difference between project success and failure.

C. Resource allocation is a process in project management that helps project managers identify the right resources and assign them to project tasks in order to meet project objectives.

D. All the above.

2. Resource constraints relate to the lack of adequate resources which may force parallel activities to be performed in sequence while the physical constraints are caused by contractual or environmental conditions.

A. True

B. False

3. The primary impact of project constraints is the likelihood of delaying the completion of the project. There are three types of project constraints. One of them is

A. Physical

B. Logical

C. Impactful

D. Working

4. Resource loading is also called as

A. Resource setting

B. Resource plan

C. Resource aggregation

D. Resource according

5. The constraints caused by contractual or environmental conditions are __________ constraints.

A. Technical
B. Resource
C. Physical
D. Dispersed

6. ____________ involves identifying the critical resources that need to be planned and managed for the successful completion of the project.
A. Criticality Index
B. Resource definition
C. Resource margin
D. Resource matter

7. Resource _________is a process in project management that helps project managers identify the right resources and assign them to project tasks in order to meet project objectives.
A. acquisition
B. accomplishment
C. allocation
D. advertisement

8. Which of the following is NOT an example of project resources?
A. Labor
B. Facilities
C. Budget
D. Project scope

9. Using the resource plan, one will be able to identify the quantity of labor, equipment and materials needed to deliver the project.
A. True
B. False

10. The effort in resource estimation is indicated by:
A. Effort is determined by the time it will take to complete a task.
B. Once the effort that's required for a project is understood, one can assign resources to determine how long the project will take.
C. The effort involves estimating the human resources and other resource costs.
D. All the above.
11. The required accuracy and effort going into resource estimation can be influenced by the element of uncertainty and risk involved because of technical complexity and novelty of the project.
A. True
B. False

12. CCM stands for
A. Critical Chain Method
B. Critical Cost Method
C. Critical Computation Method
D. Complete Chain Method

13. _____________ is a structured prediction of the cost and other resources required to execute a task.

A. Resource prediction
B. Resource estimation
C. Resource structuring
D. Resource costing

14. _____________ refers to the process of physically securing the necessary inputs.
A. Resource prediction
B. Resource estimation
C. Resource acquisition
D. Resource workgroup

15. Using the resource plan, one will be able to identify the quantity of labor, equipment and materials needed to deliver the project.
A. True
B. False

Answers for Self Assessment

1.	D	2.	A	3.	A	4.	C	5.	C
6.	B	7.	C	8.	D	9.	A	10.	D
11.	A	12.	A	13.	B	14.	C	15.	A

Review Questions

1. Discuss the concept of scheduling resources and its benefits.
2. How significantly resource allocation impacts a project?
3. Explain the process of scheduling the resources.
4. Write a short note on:
   (a) Scheduling sequence
   (b) Cost schedule
5. What do you understand by project and resource constraints in resource definition?
6. How is the identification of resource requirements done?
7. List the different challenges in resource allocation.
8. Which different resource allocation tools can be used?
9. What are the various steps to allocate the project resources effectively?
10. What are the different resource allocation strategies? Explain.

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What is Resource Scheduling? | Visual Planning (visual-planning.com)

https://youtu.be/4j_UR9q21iw

https://youtu.be/7AJ73qxZtsI

Unit 10: Monitoring and Control

CONTENTS

Objectives

After studying this unit, you will be able to:

- understand project monitoring and control in detail.
- know about creation of frameworks in project monitoring & control.
- understand the progress visualization and change control in detail.
- learn about the progress reporting system and graphical reporting tools.
- explore the importance of the project status meetings and the challenges in them.

Introduction

At this point, you have put considerable effort into building and getting approval for a project plan that describes in great detail how you will accomplish the goal of the project. The project work has begun, and you want to make sure that it is progressing as planned. To do this, you will institute a number of reports that are designed to tell exactly how well the project is doing with respect to the plan and how to correct variances from this plan. The question to consider is the extent to which you want to maintain control through the reports you require.

Project monitoring and control is an important part of any successful project. It involves assessing the progress of a project, recognizing deviations from the plan, and taking corrective action to ensure that it stays on track. This process helps to identify potential risks early on and allows for better decision-making that can help avoid costly delays or budget overruns. Project monitoring and control is a crucial phase in the project management lifecycle. It involves tracking, reviewing, and regulating the progress of a project to meet its objectives and performance targets. This process helps ensure that a project stays on schedule and within budget while meeting the quality standards set out at the beginning.

The monitoring aspect involves regularly keeping track of the project's progress by comparing actual performance with planned performance. This includes monitoring timelines, costs, quality, risks, and other important project metrics. On the other hand, the control aspect involves adjusting the project plan if the monitoring process identifies any deviations from the plan. This could involve reassigning resources, adjusting timelines, or changing processes to get the project back on track. Together, the project monitoring and control help ensure that a project is successful and delivers the expected results. At the same time, it helps to reduce the risk of a project running into costly delays or budget overruns.

10.1 Project Monitoring

Project monitoring is the act of overseeing all key performance indicators. Once the project execution phase begins, the managers have to juggle multiple moving parts. Thus, effective project monitoring requires diligent observation of the project's progress.

Project managers accomplish this via various systems. For example, they apply a four-stage process to reach the project objectives. The first two revolve around initiation and planning. As the team starts working on the tasks, the monitoring and control phase commences. Therefore, the project monitoring process is a daily recurring task. It allows the leaders to track the momentum of the project team. Hence, brands often implement project-monitoring software for all future projects.

Project monitoring is an essential tool for staying on budget. It provides the necessary data for making informed decisions and sticking to the primary purpose. As such, it lends a helping hand when fulfilling all measurable objectives. At the same time, it produces a new status report for upkeeping quality control. The status of a project is subject to change very quickly because unexpected risks can surface at any moment and new opportunities may be discovered.

Project leaders will develop a reporting format that meets the needs of the stakeholders and quite likely includes a combination of the above types. The experienced project leaders know that project success is much more than delivering on time, on budget, and within the defined scope and quality parameters.

However, this is not enough. A project that fulfills those parameters while failing to address the organizational need that led to its initiation would be considered unsuccessful. This is an extremely important concept to understand as it widens the lens of what project leaders monitor and how they respond to change. This leads to an important distinction– qualitative versus quantitative monitoring.

Qualitative and Quantitative Monitoring

Qualitative monitoring, as its name implies, involves measuring quality rather than quantity. Quantitative monitoring uses metrics and indexes to assess project performance. In the context of project management, qualitative monitoring addresses the following questions:

- Is the team delivering on the intended scope in order to fulfill the project's objectives and organizational needs?
- Is the quality of the deliverables meeting stakeholder expectations?
- Are stakeholders engaged?
- Are project communications effective?
- Are the expectations outlined in procurement contracts being adhered to by vendors?
- Are risks and opportunities being effectively managed by the team?
- Has the team become high-performing and are individual team members meeting performance expectations?
- Are resources being effectively managed and available as expected?

Scope Monitoring and Control

The approach taken to monitor and control scope depends on the development methodology used. The predictive/waterfall approach involves a sequential definition of requirements and scope, which then leads to solution development. This approach is commonly utilized when the organization has a clear vision of the project's end outcome. Given this, monitoring and controlling scope occurs with the premise that scope change is not expected. The validating scope involves formal acceptance of the completed project deliverables by the project sponsor and their assigned designates.

Acceptance often requires deliverable reviews where the quality of the work is inspected before sign-off is provided. It is possible that changes will be required. These changes can be a result of poor quality (which leads to re-work), or new requirements intended to improve the organizational value of the project's outcomes. New requirements are carefully met.

A scope change may mean those resources, timelines, and budgets are now insufficient to deliver on the increased scope. Controlling scope in this situation requires the project team to assess the impact of the new requirement on all the project's constraints. If necessary, the team will seek approval for additional funding, time, and/or resources to pursue the new requirement. It is important for project leaders to reserve judgement on scope changes until the impact and benefits are clearly understood.

The term "scope creep" refers to the poorly controlled expansion of scope over time. This means that the scope expands, perhaps unintentionally, without an understanding of its impact on the project's other constraints, such as time and budget. Therefore, utilizing an integrated approach for change management is a critical success factor for projects using the predictive/waterfall approach.

Quality Monitoring and Control

Quality is about ensuring the expectations of the project sponsor have been met. This involves ensuring the expectations of the end-user community are well understood. High quality is achieved by planning for it (proactive) rather than by reacting to problems after they are identified (reactive).

Standards are chosen and processes are established to achieve those standards in the planning phase.

Project quality focuses on the end deliverables that reflect the purpose of the project. The project leader is responsible for developing a quality management plan that defines the quality expectations and ensuring the specifications and expectations are met.

In the execution phase, the project team attempts to prevent quality issues from occurring with the use of quality management techniques, such as checklists, assessments, and lean six-sigma tools (Lean six-sigma tools are focused on creating efficient and effective processes that involve error-proofing methods).

In the monitoring and control phase, the project team is reviewing the project deliverables to ensure they are ready for review and sign-off. Ideally, this review leads to deliverable acceptance. However, the team may encounter problems that they are unable to prevent. When this occurs, the team's objective is to determine how to fix these problems.

Stakeholder Management

Project teams cannot control stakeholders. However, they can significantly influence their level of engagement. During the planning phase of a complex project, the stakeholder register may have been created. A stakeholder register is an effective tool for keeping track of a project's stakeholders, their relative interest in the project, and their level of power/influence over the project's outcomes. The register provides an effective starting place for determining how to engage stakeholders. The emphasis is on keeping high interest, high power/influence stakeholders very informed of the project's progress. During the monitoring and control phase, the project team is looking for new stakeholders and is monitoring the engagement level of existing stakeholders.

Communication Management

Communication is one of the most effective ways to keep stakeholders engaged. In order for this communication to be effective, it must be developed and delivered in ways that consider stakeholder roles and communication preferences. During the planning phase, a communication plan would be created to guide the project team's communication efforts throughout the project.

Procurement Management

Monitoring procurement includes ensuring the vendors' performance meets the agreed-upon, often contractual, requirements. The complexity of the project determines the number and type of vendors procured. This, in turn, determines the nature of the monitored activities. For instance, projects that only require supplies to be purchased externally will have much simpler vendor management processes than projects that had to outsource the completion of some of the work to external consultants. The key tools and techniques that may be used in procurement management include inspections, audits, formal change control methods, vendor-produced performance reports, payment systems, and contract administration.

Risk Management

Monitoring and controlling risks involves implementing the risk management plan identifying during the planning phase. A key aspect of this plan is often the risk register, which helps the team keep track of the project risks, triggers (early warning signs), and risk responses. The risk responses can be implemented in any phase of the project as long as documentation is kept up to date.

Resource Management

Projects require labor and non-labor resources in order to produce the desired outcomes. During monitoring and controlling, the project leader is assessing the effectiveness of both types of resources. With respect to the project team, efficient project leaders continuously assess the performance of the team and its members. A project leader must sometimes make the difficult decision to replace team members when they are not able to perform as expected or the ensuing conflicts cannot be resolved.

Conflict management skills are important in this regard. Proactive conflict management requires the project leader to continuously monitor stress levels in the team in an attempt to anticipate the likelihood of rising conflict.

Monitoring resource utilization levels in the project schedule and staying connected to project team members are also critical activities that the project leader must perform. Lastly, many projects require people with different skills at different times. The project leaders should be actively monitoring when these skills will be required and ensuring people join/transition off the project at the appropriate times.

Monitoring and controlling is about integrating all the teams while assuring that work is being completed at a steady rate to keep the project on track. This phase is vital to the overall success of the project. Thus, requiring additional, highly skilled resources, which is a key consideration during the planning phase. Qualitative monitoring is also very important to the overall success of the project. Earned value management (EVM) is a key technique used in this type of monitoring.

10.2 Monitoring and Control Methodology

Monitoring and controlling involves regularly measuring the progress on a project to ensure it continues meeting objectives and addressing current organizational needs. It involves determining what corrective action is required, when it must occur, and who must do it.

Monitoring should begin in the planning phase because it is easy to get off track with planning efforts. When the predictive/waterfall development methodology is used, the team is monitoring performance against the timeline, budget, scope, and quality objectives for the entire project. When an adaptive approach is used, progress within the iteration is assessed.

It is important to note that it is much easier to monitor the project success on small projects. Due to far fewer team members, stakeholders, and complexities to consider, the project's progress is more easily observed.

However, on higher complexity projects that require many people, who are often spread out over different locations, the project leaders are unable to use simple observation to assess the progress. In these instances, it is important to have more robust tools and techniques that monitor the success of the full project team.

The project team evaluates its performance against the plans that have been developed. Every project requires a monitoring and control system. This system considers the following:

- What information is needed and how should it be collected?
- When (and with what frequency) should this information be collected?

- o Who should collect and analyze this information?
- o How should this information be represented from a reporting perspective?
- o Who should prepare the report?
- o Who should receive the reports?

Commonly collected information includes the status of the project budget and the project schedule. The work completed to date, what has yet to be completed, and the likelihood of completing the project on time and on budget are of particular interest. In addition, it is important to identify the risks and issues that require attention.

Whenever possible, information technology should be used to collect and analyze the information and distribute the reports.

Different organizations require different roles to collect and analyze the project information. In organizations with a project management office (PMO), they may be accountable for progress reporting in an "end-to-end" way, meaning they would be involved from information collection all the way to report distribution. Organizational culture influences who and how progress monitoring is performed.

One of the common methods used to monitor progress is team meetings. Team meetings are highly collaborative and serve many purposes, including information sharing and team development. Depending on the nature of the project, these meetings may be focused exclusively on sharing the status of tasks underway. It is also possible for status discussions to lead to team planning. The individuals who participate in these meetings vary depending on many factors, such as development methodology in use, organizational culture, project complexity, and status of the overall project. The project teams typically develop different reports for different stakeholders. Stakeholders who have a high interest and high power/influence will receive more information, more frequently. Depending on the priority and duration of the project, the reporting frequency could be daily, weekly, monthly, or quarterly. There are three different types of project reports:

- o Status reports– where the project stands at a specific point in time.
- o Progress reports– what the project team has accomplished during a certain period.
- o Forecasts– future project status based on current project status and known trends.

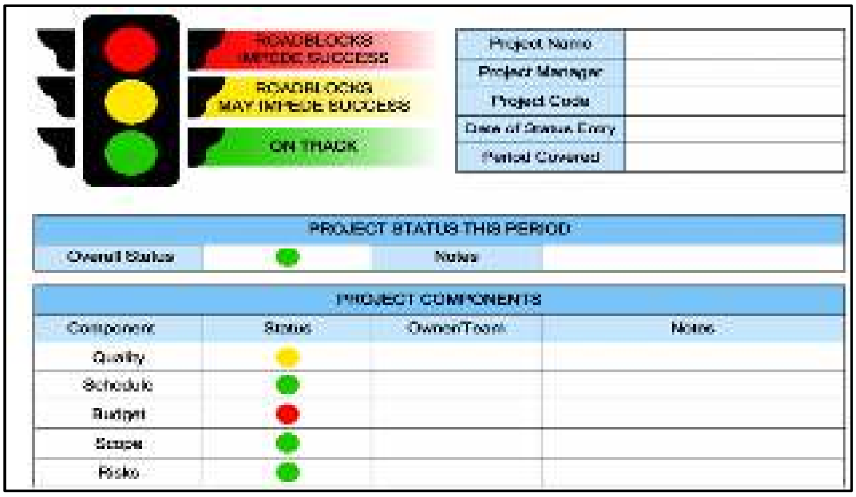

Figure 1: Project Status Report Utilizing Stoplight Symbology

Figure 1 represents a common and simple approach to sharing project status is the stoplight. Red means the project will not accomplish its objective(s). Yellow means the project may not accomplish the objective(s). Green means the project is on track to accomplish its objectives.

Benefits of Project Monitoring & Control

The main purpose of project monitoring and control is to ensure that the project stays on course. Monitoring and control are essential components of project management, and they are critical to completing the project on schedule and according to the original plan. This allows teams to leverage opportunities, promptly address problems, and make changes as needed.

Monitoring and Controlling are processes needed to track, review, and regulate the progress and performance of the project. It also identifies any areas where changes to the project management method are required and initiates the required changes.

A myriad of project changes can diminish the monitoring in project management efforts. Yet, the project's success level rests on monitoring and controlling. That means that project planning has a very limited range of appliances. Afterward, it is all about boosting project performance. Here are a few ways to accomplish that:

- Learning from past mistakes is key for conducting evaluations.
- Regularly update the resource plan.
- Acknowledge all important milestones and inform the beneficiaries.
- Focus on project monitoring and control during each project stage.
- Refrain from expanding the project scope.
- Ensure all departments remain on the same page regarding the project's execution.
- Rely on flexible policies to improve the status reports.
- Consider making project changes for better resource management.

The project monitoring tools are an essential part. Pinpointing the current status can get tricky, and the managers often need to dig deeper. Yet, continuous monitoring produces all of the project-related details. This allows managers to change courses if needed. The project lifecycle can morph and divert from the expected result. Therefore, you should always aim to submit the project deliverables on time. To do so, frequently compare the project progress with the planning phase.

The important aspects indicating the importance of project monitoring and control include:

- Ensures project stays on track- Project Monitoring and Control allow project managers to ensure the project follows its intended path. Regular monitoring helps identify any deviations from the plan early, allowing corrective actions to be taken before they become major issues.
- Optimizes resource allocation- By regularly tracking resource usage, project managers can ensure that resources are used efficiently and effectively. If resources are underused or overused, adjustments can be made to optimize their allocation.
- Improves risk management- Monitoring and control processes help in identifying potential risks and issues early. This early identification allows for timely mitigation strategies, reducing the impact of these risks on the project.
- Optimizes resource allocation- By regularly tracking resource usage, project managers can ensure that resources are used efficiently and effectively. If resources are underused or overused, adjustments can be made to optimize their allocation.
- Improves risk management- Monitoring and control processes help in identifying potential risks and issues early. This early identification allows for timely mitigation strategies, reducing the impact of these risks on the project.

Understanding Project Monitoring and Project Control: The Distinct Roles

Project monitoring and control are two integral yet distinct aspects of project management. They work in tandem but serve different purposes. The project monitoring is primarily about gathering, analyzing, and reporting data related to the project's progress. It provides an overarching perspective on the project's trajectory, enabling project managers to understand how things are unfolding. Moreover, it ensures that pertinent information is communicated effectively to all stakeholders.

Conversely, project control ensures the project adheres to its planned schedule and objectives. It employs strategies and actions based on the insights derived from the project monitoring phase.

Project control uses the data provided by project monitoring to adjust, correct, and steer the project toward its successful completion.

Project Monitoring and Control Process

The process of project monitoring and control ensures that the project is completed according to the original plan, within the designated budget, and within the scheduled timeline while also carrying out the tasks properly. This process involves identifying issues and implementing solutions to prevent them from affecting the project's success. The essential steps involved in the project monitoring and control process involve:

Step 1: Monitoring Key Performance Indicators (KPIs)

This step involves tracking the project's KPIs, quantifiable measures used to gauge the project's performance over time. KPIs may include project completion percentage, budget variance, and quality metrics.

Step 2: Monitoring Requests

Project managers need to keep track of all requests that come in during the project lifecycle. This includes change requests, additional resource requests, or adjustments in timelines. These requests must be evaluated and addressed promptly to ensure smooth project progression.

Step 3: Monitoring Project Scope

One of the critical aspects of project management is ensuring that the project stays within its defined scope. Regular monitoring can help identify any scope creep (uncontrolled changes or continuous growth in a project's scope) early and take necessary actions to prevent it.

Step 4: Risk Identification

Project monitoring also involves identifying potential risks or issues that could derail the project. By proactively identifying these risks, project managers can develop mitigation strategies to minimize their impact.

Step 5: Communication

Communication is key in project monitoring and control. Regular updates about the project's status, any identified risks, and changes in the plan need to be communicated to all stakeholders. This ensures everyone is on the same page and can contribute effectively towards the project's success.

10.3 Creating Frameworks

Considering that the Project Management Plan (PMP) is the baseline for the project. As a project manager, one will need access to work performance information, performance reports, and change requests. This information will need to be at your fingertips as inputs to yield project performance indicators. After analyzing and reviewing the information, it is time to decide whether corrective or preventative actions are needed. The four inputs to monitoring and controlling project work are:

1. Project Management Plan: The project management plan is the main source of information about how the project will be executed, monitored, and controlled. It is the plan, with all additional subsidiary plans as needed.
2. Work Performance information: Work performance information is the information about project activities. This includes status information about progress, deliverables, expenses, and quality assurance validations.
3. Rejected Change Requests: Reject change requests can be enlightening when reviewed in the context of determining how the progress of the project is fairing.
4. Tools & Techniques: There are standardized tools and techniques for monitoring and controlling project work. These tools and techniques are:

- o Expert Judgment: On the basis of current project information and experience with similar projects, project managers and team members can use expert judgment to make decisions, such as whether to take corrective or preventive actions.
- o Earned Value Technique (EVT): Earned Value Technique (EVT) provides project managers with a means of calculating current project schedule and cost performance. Project managers can then use this information to forecast future schedule and cost performance.
- o Project Management Methodology: The organizational project management methodology provides project managers with detailed guidance and procedures to enable effective monitoring and control through each stage of a project.
- o Project Management Information System (PMIS): A PMIS allows for monitoring and controlling parameters such as cost and resource usage. A PMIS can also enable project managers to calculate and manage earned value information, as well as request and update project information automatically.

The outputs of monitoring and controlling project work are:

- o Recommended Corrective Actions: These are based on project work performance information. By comparing this information to the project plan, the project manager or team uses expert judgment to put forward ideas to remedy problems that have arisen.
- o Recommended Preventive Actions: These are based on project work performance information. By comparing this information to the project plan, the project manager or team uses expert judgment to suggest ways of avoiding project risks.
- o Forecasts: Based on work performance information received during the Monitor and Control Project Work process, forecasts allow the prediction of successful or unsuccessful project outcomes.
- o Recommended Defect Repairs: These are an output of monitoring and controlling project work. This output recommends the remedial work necessary when a product does not meet quality requirements.
- o Requested Changes: These are revised actions that are necessary for meeting project objectives. The requests are often made by the project manager or members of the project team as a way of improving methods or overcoming problems.

Project Monitoring & Control Solution Framework

A project monitoring & control solution framework offers an overview of the steps involved in each IT project, although the level of detail required for each step will depend on the complexity and criticality of the individual project (Figure 2). For smaller, less critical projects, for example, all steps in the first two columns may be completed in a two hour meeting followed by an email summary. For the larger projects, multiple meetings and revisions may be required to fully define the project requirements and scope.

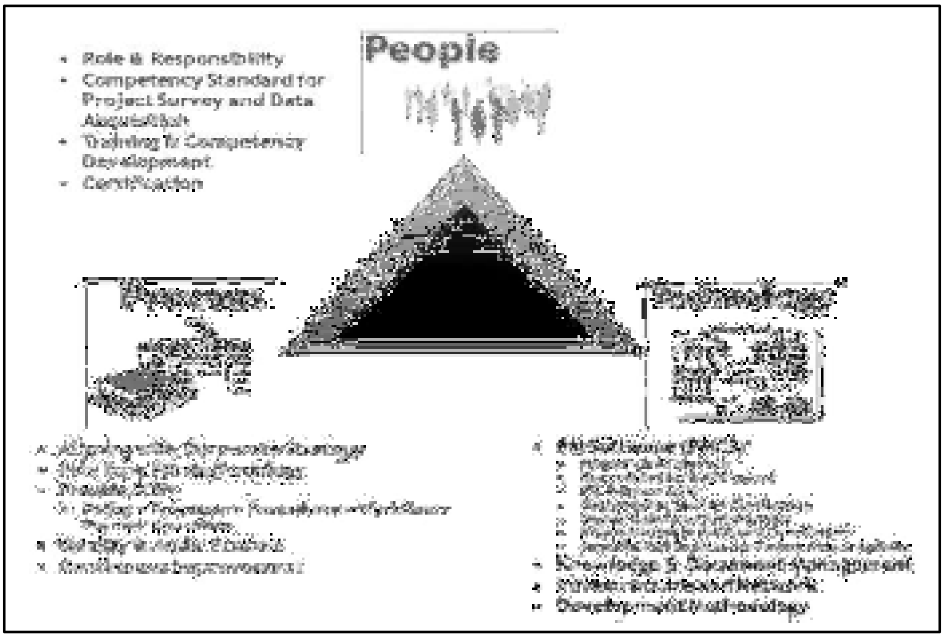

Figure 2: Project Monitoring & Control Solution Framework

10.4 Progress Visualization

Project management is an extremely "data rich" business activity. At any given time, project management practitioners are capturing, manipulating, transforming, and communicating hundreds of individual project data points. These data points include labor estimates, capital and operational expenses, task lists, performance metrics, calendars, cost-benefit analysis worksheets, risk profiles, trending data, and a seemingly countless number of other project-related artifacts.

As the speed of business continues to increase, and as focus on an ever-growing number of data points is needed to keep business and project execution in control, new and innovative tools and techniques are required to help busy executives make efficient and effective decisions on where to invest money and resources. Visualization of data and complex processes has proven valuable in serving those needs.

A project manager's world is already full of data visualizations, designed to transform complex and voluminous data into simple, effective communication tools. The traditional visualizations such as Gantt charts, work breakdown structures, Kanban boards, process diagrams, project team calendars, project stakeholder organization charts, and the like are beneficial in their own way, but they don't tell the collective story of overall project status and/or performance.

Complicating the matter, busy executive sponsors and key project stakeholders no longer have the luxury of time for lengthy project status reports or weekly status briefings. The decisions must be made in the moment, with whatever facts are available at the time. Because of this, traditional project management discipline that relies on complex processes and document-heavy approaches are rapidly being left behind in favor of more agile-based methods.

Lengthy, paper-based project artifacts take significant time and effort to both generate and consume. Research has also shown that information presented in text-based formats is ineffective and inefficient. In fact, several supporting statistics exploring this concept indicate that, in order for information to be conveyed most efficiently, it needs to be visual.

These facts have led to the creation of a new niche within the project management community known as "Visual Project Management." When it comes to improving project communication and collaboration, as well as envisioning processes and workflows, the visual project management has emerged as one of the best new methods for leading and managing projects. The key benefit of this new approach is speed, as critical project information can be produced, replicated, and digested in more effective and efficient ways.

Benefits of Progress Visualization

- Easy to see information because it is in a single consistent format.
- Project staff are forced to review progress on a period basis.
- Little work involved to generate a report.
- Periods can be set to match company requirements.

The visual project management provides additional distinct benefits to the project managers, team members, and, most importantly, key stakeholders. This includes:

- The status of project planning, execution, monitoring, and control activities are available in a single, at-a-glance, and easy to understand view.
- Improves clarity, visibility, and understanding of the scope and overall operational plan of the project effort.
- Resource allocation levels across the project, or multiple projects, are clearly visible.
- Impacts of changes to the scope, plan, priority, or resource allocations are available in real-time.
- Information is delivered in such a way that anyone can consume it at a time, place, and manner that is most convenient to them.

Visual Project Management

In today's time-compressed and lean business culture, busy executive sponsors and key project stakeholders simply do not have the luxury of time to digest a verbose, three-page project status report on a weekly basis. Likewise, their double-booked calendars can no longer support attending status briefing meetings that simply regurgitate information that is otherwise available in alternative formats. The project decision-makers must constantly make conscious decisions when to be engaged versus when to simply monitor progress. Based on this new reality, managing project-based work in a “business as usual” fashion is no longer a feasible or acceptable option.

Time-honored, structured processes and document-laden approaches to managing projects are rapidly being left behind in favor of more agile-based methodologies. Established waterfall and command-and-control structures no longer address the new, innovative manner in which work is now being conducted and managed. The agile movement wasn't started with the desire to eliminate traditional work organization tactics or project management methodology, but to make them more balanced, less rigid, lighter in documentation, and more fluid in planning.

In fact, agile approaches to managing projects have started to become entrenched within even the most conservative industries like financial services, insurance, and healthcare. Self-managed teams are beginning to replace hierarchical management structures. The focus shift on “doing the right thing,” as compared to “doing the thing right,” has pushed both traditional and agile methods forward in a positive way.

Cross-pollination from a number of different methodologies has led to an impressive diversity of custom approaches dedicated to finding the most efficient and effective way of getting the work done. One of many new customized approaches gaining traction in project management circles today is a concept that presents project-related information in a visual, often graphical, form to improve clarity, visibility, and understanding of the scope and operation of the effort.

The “Visual Project Management” approach serves as an additional tool for project management professionals to provide:

- At-a-glance views of project status,
- Real-time project status tracking,
- Real-time issue management and resolution status, and
- Data-rich environments for better decision making.

The visual project management offers information delivered in such a way that anyone can consume it at a time, place, and manner that is convenient to them. Traditionally, project information distribution has been based on "push" methods of communication. In push-based communication, the sender, or project manager, decides the "who, how, what, and when" regarding project information flow. This information is typically delivered in the form of emails, status reports, project status meetings, conference calls, and in some cases, instant or text-based messaging. The recipient doesn't really get a choice regarding whether they receive the communication or not; nor do they have a say in what format it is delivered.

Alternatively, more and more information is being made available electronically, to be digested when the recipient has the time to review it. In this "pull-based" form of communication, information is simply posted to a common location, akin to a bulletin board or document library. The recipient chooses what information they want to receive and when they want to access it. Most importantly, it creates an opportunity for the project manager and the project stakeholders to have a conversation about what information and specific data points are most important to them. Then, leveraging any number of visual thinking tools, the project manager can design the format that most clearly and efficiently serves the stakeholders needs.

Data Visualization Concept

Data visualization refers to the technique of communicating complex data or information by converting it into a visual object or graphical representation in order to aid in visual processing and comprehension. The effective visualization makes data more understandable and usable for analysis and communication. The graphical displays should:

- Show the data.
- Induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production or something else.
- Avoid distorting what the data have to say.
- Present many numbers in a small space.
- Make large data sets coherent.
- Encourage the eye to compare different pieces of data.
- Reveal the data at several levels of detail, from a broad overview to the fine structure.
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration.
- Be closely integrated with the statistical and verbal descriptions of a data set.

Data visualization has become an active area of research, teaching, and development. The scholars and practitioners in the field have even begun to branch out into a number of specialty areas that have application within the project management profession:

- Informational graphics are graphical visual representations of information, data, or knowledge intended to present complex information quickly and clearly. They can improve cognition by utilizing graphics to enhance the human visual system's ability to see patterns and trends.
- Visual literacy is the ability to interpret, negotiate, and make meaning from information presented in the form of an image, extending the meaning of literacy, which commonly signifies interpretation of written or printed text. Visual literacy is based on the idea that pictures can be "read" and that meaning can be communicated through a process of reading pictorial information.
- Exploratory data analysis is an approach in statistical modeling for analyzing data sets to summarize their main characteristics, often with visual methods. The common tools used in data visualization are- Charts, Diagrams, Drawings, Graphs, Ideograms, Pictograms, Data Plots, Schematics, Tables, Technical Drawings or Illustrations, and Maps or Cartograms.

  The results generated by the use of these tools serve as feedback for conducting certain analytical tasks, such as depicting cause and effect, discovering the ratio of one data set against another, showing trends or cycles, revealing anomalies or rare events in repeatable processes, discovering correlations between two or more sets of data, and/or ranking categories of data.

One of the reasons that the conversion of data into graphical renderings is such a key contributor to understanding complex processes and concepts stems from the fact that the human mind is naturally designed to process information more easily in the form of pictures. This concept is also known as Visual Thinking.

Visual thinking, as an area of academic focus, is the consolidation of study in neuroscience, art, storytelling, information design, visual perception, color theory, shape/pattern recognition, and graphic design. It is a discipline that leverages a myriad of tools to bring ideas and concepts developed in the mind, out into the external world for further examination and testing. It seeks to bring clarity to complex concepts and brings truth to the adage that "a picture is worth a thousand words." Seeing is believing…seeing is, indeed, understanding!

Many organizations underestimate the strategic importance and bottom line impact that visual thinking can bring to the workplace. Tactical, facilitated visual thinking activities can bring significant positive impact within any business function and have even experienced a renaissance as of late from a number of different organizational sources:

Strategic Management

- Vision and Mission Development
- Scenario Planning
- What If? Analysis
- Organizational/Strategic Road Map Development

Product Management

- New Product Development
- Target Market Assessments
- Product Lifecycle Management
- Product Road Map Development
- Product Documentation
- Prototyping

Marketing and Communications

- Sales and Marketing Campaign Management
- Customer "Day In The Life" (DITL) Analysis
- Customer Use Case Development

Finance

- Forecasting and Backcasting Analysis
- Risk Analysis and Mitigation Planning
- Financial Modeling

Project Management

- End User, Business and/or System Requirements
- Project Timeline and Road Map Development
- Project Communications Management

Visual Thinking Tools that Support Project Management

The use of visual thinking tools enhances understanding of complex projects and supports management of high volumes of disparate data points. Visual thinking tools (Figure 3) also facilitate conceptual and idea-development processes, as well as fostering a common language for conversations and discussions among the members of the project team. While only a small sample of the available list of visual thinking tools can be applied in project management practice, some of them have the most direct, day-to-day practicality and impact including:

- Mind Mapping;
- Process Mapping;
- Storyboarding;
- Root Cause Analysis;
- Charting, Diagramming, and Graphing;
- Drawing and Sketching; and
- Wireframes and Use Cases.

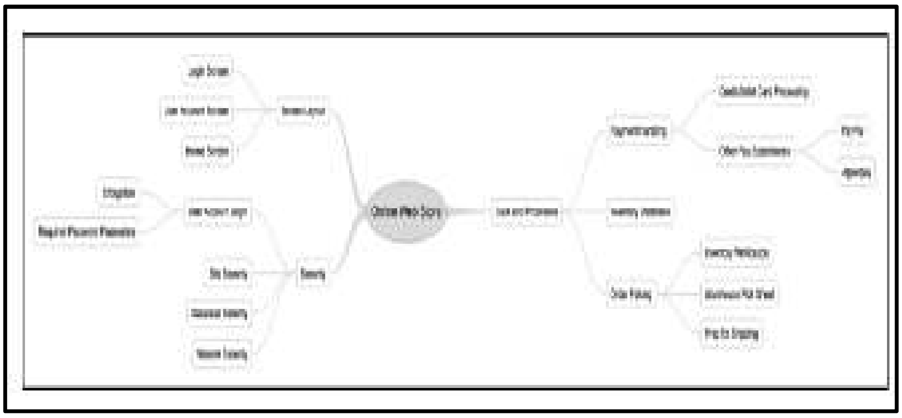

Figure 3: Sample Mind Map

Visualizing Progress by Progress Report

Having collected data about project progress, a manager needs some way of presenting that data to greatest effect. There can be some methods of presenting a picture of the project and its future. Some of these methods (such as Gantt charts) provide a static picture, a single snapshot, whereas others (such as time-line charts) try to show how the project has progressed and changed through time.

To generate a project status report for the project, the project manager need only add a few comments and the project management report will be produced automatically showing:

- Milestones in the last period, and if they are completed
- Milestones due next period
- Action items not completed by their due date
- Action items due to be completed in the next period
- The commentary prepared by the project manager.

Progress Report

A progress report documents the project and shows how far it has progressed in comparison to where the project plan expected it to be. It serves as a snapshot of the project's progress within a specific period of time. The progress report provides an overview of all the activities and tasks that have occurred over the reported period of time. It highlights milestones and other performance metrics, including risks, issues, changes, etc.

The progress report template saves time and lessens the effort of reporting. All the information collected is already laid out in the document. All you need to do is add the specific details as they relate to the project. The progress report is also a tool to communicate to the stakeholders and clients that the project is moving forward as planned. In a sense, it's a persuasive tool to appease any anxiety or concerns they have over the project's progress. Ideally, the progress report shows that the project is going as planned and will deliver as expected. Of course, if this is not the case, then the progress report will explain the reason for the delays and what is being done to rectify these issues.

The Gantt charts

One of the simplest and oldest techniques for tracking project progress is the Gantt chart. This is essentially an activity bar chart indicating scheduled activity dates. Henry Gantt (1861-1919) was an industrial engineer interested in the efficient organization of work.

Cost Monitoring

Having accurate project estimates and a robust project budget is necessary to deliver within the project budget. Both Estimate Costs and Determine Budget are project planning processes.

Without keeping an eye on the actual costs while the project is being implemented, the project will most likely never be delivered on-budget. There are several techniques as stated in the PMBOK used to monitor and control the cost of a project:

- Earned Value Management- Earned Value Management (EVM) is a mathematical method by which you can measure the actual performance of a project.
- Forecasting- EVM provides formulae to forecast the future performance of a project. The forecast is based on the current actual performance. As a project manager, having the ability to tell whether your project will be delivered on-time and on-budget is critical.
- To-Complete Performance Index (TCPI)- If the project is delayed or over-budget, you can use TCPI to determine the project performance required to complete the project as budgeted or estimated. TCPI also leverages the EVM formulae.
- Variance Analysis- Variance analysis is the comparison of expected project performance to the actual cost performance. This analysis helps you understand the causes of variance, if any. Preventative and corrective actions are determined based on the variance analysis.

- Performance Reviews- Performance reviews in projects are required to check the health of a project. This usually involves Cost and Schedule as the main parameters to assess.

Visualizing Progress Tools

There are many digital platforms one can use to employ the visual project management tools. The project managers need to choose one that suits the team's needs and is easy for everyone to use. The 5 best visual project management software that is best on the market include:

1. Kissflow Project: Kissflow Project takes a unique approach to kanban boards, adding divisions in each column for "in progress", "on hold", and "done" sections.
2. Asana- Asana allows users to create templates for use on similar projects in the future. It's good for all-size businesses but not ideal for freelancers. Some users feel Asana's interface is overly simple and the system is too rigid, but Asana offers Gantt charts, calendars, and kanban boards.
3. Monday.com- Monday.com has Gantt charts, calendars, and work breakdown structures. Some users feel the interface gets too cluttered when multiple assignments or comments are on a single board, but overall, the user experience is intuitive and simple.
4. Wrike- Wrike offers Gantt charts, calendars, and kanban boards. It's a flexible platform and lets the user decide how to visualize their projects effectively. Wrike allows users to prioritize certain tasks over others and easily integrate with other external applications.
5. Zoho Sprints- Zoho Sprints is an agile project management tool featuring scrum boards. It integrates with Zoho Projects, which features Gantt charts, Kanban boards, and other customizable functions. It has many integrations, though not as many as some of its competitors, and it isn't robust enough for large enterprises.

10.5 Progress Reporting System

To make sure that the project proceeds according to plan, one needs to establish a reporting system that keeps informed of the many variables that describe how the project is proceeding as compared to the plan. A reporting system has the following characteristics:

- Provides timely, complete, and accurate status information.
- Doesn't add so much overhead time as to be counterproductive.
- Is readily acceptable to the project team and senior management.
- Warns of pending problems in time to act.
- Is easily understood by those who have a need to know.
- Most project management software tools allow you to customize their standard reports to meet even the most specific needs.

The following is a list of what should actually be reported:

- Determine a set period of time and day of week by which by which all updated information is to be submitted.
- Report actual work accomplished during this period.
- Record historical and re-estimate remaining (in-progress work only).
- Actual start and finish dates of activities started or completed during the report period.
- Record days of duration accomplished of so far working re-estimated duration as reflected in the time-to-completion number.
- Report resource effort (hours/day) spent and remaining (in-progress work only).

Did you Know?

What is Frequency of Gathering and Reporting Project Progress?

A logical frequency for reporting project progress is once a week, usually on Friday afternoon. There are some projects, such as refurbishing a large jet airliner, where progress is recorded after each shift, three times a day.

Types of Project Status Reports

There are five types of project status reports:

- Current Period Reports: These reports cover only the most recently completed period. They report the progress on those activities that were open or scheduled for work during the period. Reports might highlight activities completed and variance between scheduled and actual completion dates.
- Cumulative Reports: These reports contain the history of the project from the beginning to the end of the current report period. They are more informative than the current period reports because they show trends in project progress.
- Exception reports: Exception reports report variances from plan. These reports are typically designed for senior management to read and interpret quickly.
- Stoplight reports: Stoplight reports are a variation that can be used on any of the previous report types. Here stickers of the different colors are put on the top right of the first page of the project status report. The purpose of the different color of stickers are as follows:

  (a) Green sticker: It means the project is on schedule and everything seems to be moving as planned. This sticker will signal to senior managers that everything is progressing according to plan, and they need not even read the attached report.

  (b) Yellow sticker: It means that the project has encountered a problem or there is a schedule slippage. That is a signal to the upper management that the project is not moving along as scheduled but that you have a get-well plan in place.

(c) Red stickers: It means that a project is out of control. Red reports are to be avoided at all costs because they mean that the project has encountered a problem, and you don't have a get-well plan or even a recommendation for upper management.

o Variance reports: Variance reports do exactly what their name suggests—they report differences between what was planned and what happened. There are two types of variances: positive and negative variances.

- Positive Variances- Positive variances are deviations from plan that indicate that an ahead-of-schedule situation has occurred or that an actual cost was less than a planned cost. This type of variance is good news to the project manager. Positive variances can allow for rescheduling to bring the project to completion early, under budget, or both. Resources can be reallocated from ahead-of-schedule projects to behind-schedule projects.

Task: Project variance reports can be used to report project as well as activity variances. Explain.

- Negative Variances- Negative variances are deviations from plan that indicate that a behind-schedule situation has occurred or that an actual cost was greater than a planned cost. Negative cost variances can result from uncontrollable factors such as cost increases from suppliers or unexpected equipment malfunctions. Some negative variances can result from inefficiencies or error.

Progress Report

Tracking project progress is necessary to ensure the project is moving in the right direction. A project progress report is a key tool to help achieve this objective. A project progress report removes the overwhelming task of surfing through data to get meaningful project information and provide information that matters to stakeholders. These days, most organizations use automation to generate progress status reports, as all project management software programs provide this facility. This has drastically reduced data collection time and report generation time.

A project progress report is a formal project management document that provides project status and progress, compares it with the planned progress, and presents the result to stakeholders. It helps sync project information among stakeholders. Progress reports are part of performance reports. This document shows stakeholders how close the team is to achieve the project objectives. It summarizes the work and provides an at-a-glance update on project activities. The areas covered in a progress report include the following:

- The project's current status
- The achieved milestones
- Roles of team members
- Cost and schedule performance
- Influencing factors in achieving project goals

Notes: The progress report can be submitted daily, weekly, monthly, quarterly, bi-annually, or annually. This frequency is defined in the project plan.

Here's what one can expect to find in a typical progress report:

- Project Overview: A brief summary of the project's objectives and scope.
- Current Status: A snapshot of where the project stands regarding completed tasks, milestones reached, and overall progress.
- Challenges and Issues: Any technical difficulties, resource constraints, or personnel issues.
- Next Steps: The immediate tasks and goals on the horizon and how the team plans to tackle them.
- Progress Report Format: The layout of the report can vary depending on the organization's preferences or industry standards.

Writing a progress report creates a valuable document that keeps everyone informed and aligned by breaking it down into manageable sections and using clear, concise language.

Importance of Progress Report

Progress reports play a vital role in project management, serving as a communication tool to keep stakeholders updated. The following points indicate the importance of progress reports:

- Transparency and accountability: Progress reports eliminate ambiguity and promote transparency. By regularly sharing project updates with stakeholders, the project team is held accountable for their work. This accountability ensures everyone is on track to meet the project milestones and objectives.
- Identify potential issues early: Progress reports help identify potential problems before they escalate. Team members can spot bottlenecks, delays, and other issues by examining project data and analyzing the progress report. The early detection enables the team to take prompt action and prevent these issues from derailing the project.
- Effective decision making: Armed with accurate and timely information from progress reports, project managers and stakeholders can make informed decisions. When a project progresses

smoothly, management can allocate resources more efficiently or plan for future phases. On the other hand, if a project encounters challenges, swift decisions can be made to reallocate resources or change course.

- Maintaining momentum: A progress report's important aspect is maintaining momentum. When team members see their progress documented and shared, it fosters a sense of accomplishment and motivation. This positive reinforcement encourages teams to keep pushing forward and maintain their productivity.
- Improved communication and collaboration: Progress reports facilitate better communication and collaboration among team members. By sharing updates and insights, the entire team stays informed, reducing the chances of miscommunication or misunderstandings. Moreover, progress reports provide a platform for team members to ask questions, provide feedback, and offer support.

Writing a Progress Report

Step 1: Define the Purpose

The first step in writing a progress report is understanding its purpose. Progress reports inform stakeholders about the project's status, including what has been accomplished, any challenges encountered, and future planning. This allows project managers to keep everyone in the loop and make informed decisions.

Step 2: Know Your Audience

Determine who will read the progress report. Is it for higher-ups, clients, or team members? Tailor the language, tone, and level of detail accordingly.

Step 3: Set the Timeframe

Decide the reporting period – weekly, monthly, or quarterly. Choose a timeframe that best suits your project's pace and stakeholder expectations.

Step 4: Collect Information

Gather data on tasks completed, team members involved, and any obstacles faced. Consult previous progress reports, project documentation, and team members for accurate information.

Step 5: Organize Content

Break down the report into logical sections. Here’s what we suggest:

- Summary: A brief overview of the report's contents.
- Completed Tasks: List tasks accomplished during the reporting period.
- In-Progress Tasks: Describe ongoing tasks and their current status.
- Upcoming Tasks: Outline tasks scheduled for the next reporting period.
- Challenges: Discuss any obstacles encountered and how they were addressed.
- Key Metrics: Highlight key project performance indicators and progress towards goals.
- Future Planning: Discuss plans for the next reporting period and any adjustments needed.

Step 6: Write the Summary

Craft a concise summary that provides a snapshot of the report. Mention key achievements, challenges, and plans for the future. Keep it brief but informative.

Step 7: Detail Completed Tasks

List all tasks completed during the reporting period. Include the following information:

- Task description
- Team members involved

- Start and end dates
- Any relevant metrics (e.g., hours spent, budget used)

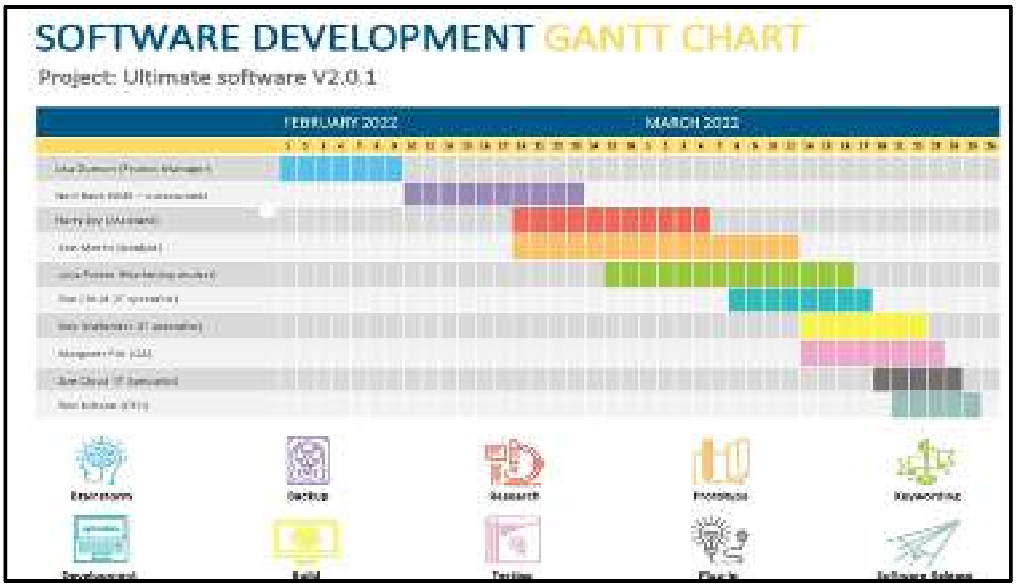

Figure 4: Gantt Chart Depiction

10.6 Graphical Reporting Tools

Usually, the senior managers have only a few minutes of uninterrupted time to digest your report. Having to read several pages only to find out that the project is on schedule is frustrating and a waste of valuable time. For this it is better to present them the report in the form of graphics. There can be graphical representations like the Gantt charts and Milestone Trend Charts for this purpose (Figure 4 and Figure 5).

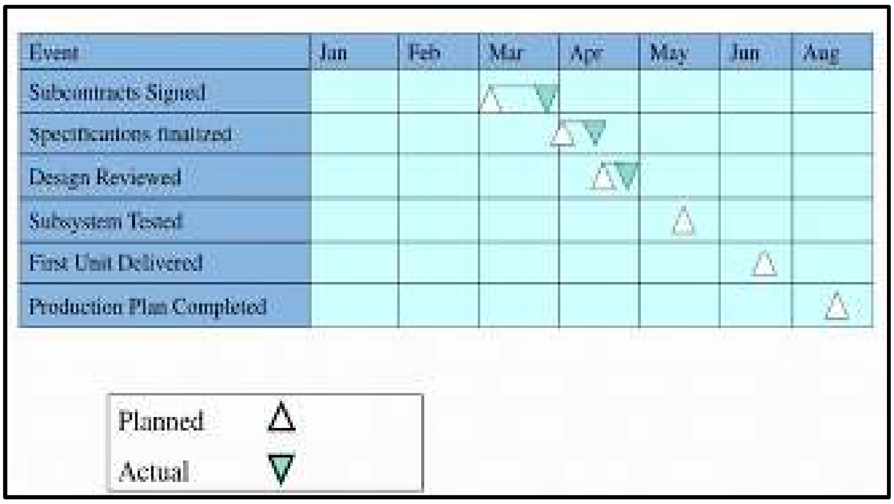

Figure 5: Milestone Trend Chart

Using the WBS to Report Project Status

Work Breakdown Structure (WBS) shows the hierarchical structure of the work to be done, it can be used for status reporting, too (Figure 6). In its simplest form, each activity box can be shaded to reflect completion percentages. As lower-level activities are completed, the summary activities above them can be shaded to represent percent complete data. Senior managers will appreciate knowing that major parts of the project are complete. Unfortunately, the WBS does not contain scheduling or sequencing information. To the extent that this adds to the value of the report, narrative data or brief tabular data might be added to the report.

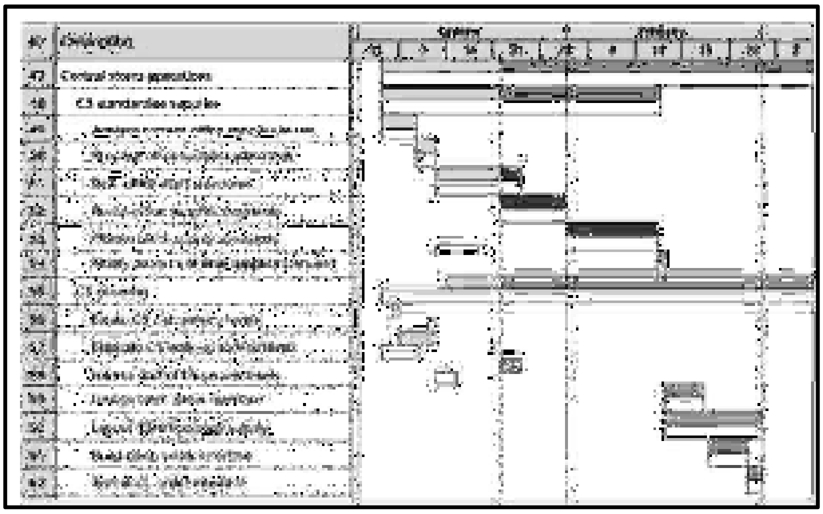

Figure 6: Status Reporting with the WBS

10.7 Change Control

When developing and maintaining a product, changes are inevitable. People make mistakes, customers need changes, and the environment in which the product operates evolves. In addition, the people constantly develop their knowledge of the problem and their ability to solve it. In software development, it’s generally said that the solution of a problem will create new problems. In other words, we get wiser all the time. The purpose of change control is to be fully in control of all change requests for a product and of all implemented changes. For any configuration item, it must be possible to identify changes in it relative to its predecessor. Any change should be traceable to the item where the change was implemented

Within Quality Management Systems (QMS) and IT systems, change control is a process—either formal or informal—used to ensure that changes to a product or system are introduced in a controlled and coordinated manner. It reduces the possibility that unnecessary changes will be introduced to a system without forethought, introducing faults into the system or undoing changes made by other users of software. The goals of a change control procedure usually include minimal disruption to services, reduction in back-out activities, and cost-effective utilization of resources involved in implementing change.

According to the Project Management Institute, change control is a "process whereby modifications to documents, deliverables, or baselines associated with the project are identified, documented, approved, or rejected." Change control is a methodology used to manage any change requests that impact the baseline of your project. It’s a way to capture that change from the point where it’s been identified through every step of the project cycle. That includes evaluating the request and then approving, rejecting or deferring it.

Change control refers to the systematic process of managing any modifications or adjustments made to a project, system, product, or service. This ensures that all proposed changes undergo a structured evaluation, approval, implementation, and documentation process. The change control aims to maintain the integrity and consistency of a system or project by ensuring that changes are introduced in a controlled and coordinated way, minimizing potential risks and unintended negative consequences.

Change control ensures that every change is justified, beneficial, and aligned with the overarching objectives and requirements. The purpose of this process is to make sure that you’re not changing things in the project that don’t need to be changed. The last thing you want to do is disrupt the project for no good reason, wasting valuable time and resources. Any changes that are approved are then documented. The change control process is part of the larger change management plan.

Key Elements of Change Control

There are some key elements that build a change control framework for project management that include:

- Change control board: A change control board is a group of representatives from the project team that regularly meet to approve or disapprove change requests. If they approve a change request, it can turn into a change order.
- Change requests: A change request is a formal petition for change in a project. It's a document that explains what the changes are to be made and the main reasons why they should be implemented. Change requests can either be submitted by internal or external project stakeholders.
- Change orders: Once the change control board has approved a change request, a change order is signed by the board and the clients or stakeholders. This is an agreement from both parties to change the conditions that were first drafted in the original contract.
- Change log: A change log is a change management tool that's used to document all the changes made to a project plan or any contracts. It's a must-have tool for any project manager.

Change Request

A change request is declarative, that is, it states what needs to be accomplished, but leaves out how the change should be carried out. The important elements of a change request are an ID, the customer (ID), the deadline (if applicable), an indication whether the change is required or optional, the change type (often chosen from a domain-specific ontology) and a change abstract, which is a piece of narrative. The change requests typically originate from one of five sources:

- o problem reports that identify bugs that must be fixed, which forms the most common source
- o system enhancement requests from users
- o events in the development of other systems
- o changes in underlying structure and or standards (example, in software development this could be a new operating system)
- o demands from senior management.

A change request is usually the trigger that starts the process of change control. The change request can originate from stakeholders asking for new features, the need to repair something that proves faulty during the execution phase, upgrades or any number of other causes. Whatever or wherever the change comes from, change control determines its value and how to feasibly implement it.

Change Control Process

The change control process is depicted in Figure 7.

1. Initiate change request

In this stage, there is a clear need for change due to business process inefficiencies, technological advancements, and evolving customer needs. These types of change requests come from various areas of an organization– a project team member, leadership, or a customer. This requires organizations to have open communication channels to hear the voice of the customer (VoC) and insights from various team members and departments. There must be a detailed change proposal describing the change and how it would benefit the company to initiate a change request. The initiator must outline the reasons for the change on the change request form, which is further added to the changelog. Some examples of what to include in the change request are:

- o Project name
- o Date
- o Request description
- o Requested by

- o Change owner
- o Priority
- o Impact of change
- o Deadline
- o Comments

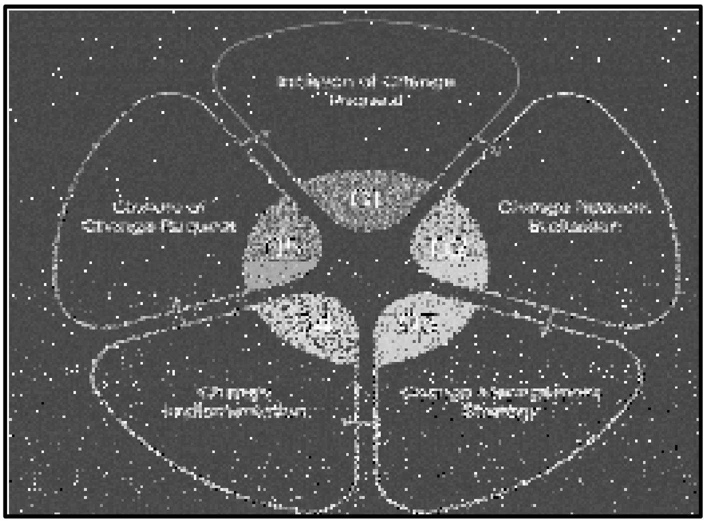

Figure 7: Change Control Process

2. Evaluate the change request

In the second phase, the change request is assessed to evaluate the resource requirement, budgeting, and impact on the company. This step also comprises risk evaluation and any behavioral modifications required for the change to succeed. Finally, the process moves to the next step if the change is approved. If rejected, the reasons are documented and communicated to the stakeholders and client.

- o If a change request is not legitimate, you must deny or cancel it as a project manager.
- o Then, you need to determine the resources required for the change request analysis.
- o After that, quickly evaluate the potential outcomes, and revise the request form as needed.
- o At this point, rejected requests for modifications should be put on hold.

3. Develop a change management strategy

The third stage includes detailed planning for a change initiative. Change leaders build a clear & concise strategy, including timelines, resources, pilot testing, and how to minimize the impact of change. A few action items for a successful organizational change include:

- o Identify clear milestones
- o Create a change communication plan
- o Clearly define the roles & responsibilities using the RACI matrix
- o Decrease change resistance by conducting change management exercises.

4. Implement change

In this step of the change control process, a company begins to disrupt the status quo and initiates the change action plan. It’s crucial to ensure that the change implementation occurs in phases and not at once.

5. Close change request

Review the implemented change to mark it as a success or failure. Once the change initiator signs off the document for closure, the process is finalized and closed for future reference.

Implementing an Effective Change Control Process

Implementing an effective change control process can be a game-changer for organizations, driving efficiency and ensuring that changes are well-executed and aligned with business objectives. However, the journey to successful implementation comes with challenges. To navigate these complexities and ensure a smooth transition, consider the following tips that have proven beneficial for many organizations embarking on this path.

Engage all relevant stakeholders

Stakeholder engagement is the cornerstone of any change initiative. Involving those directly or indirectly affected by a change ensures that multiple perspectives are considered. This engagement fosters a sense of ownership and inclusion, which is critical to the success of the change control process. The stakeholders also often provide valuable insights that might otherwise be overlooked. Their feedback can identify frustrating roadblocks, enhance the efficiency of the process, and drive a more unified approach to implementing changes.

Maintain clear documentation

Having a comprehensive documentation system serves as a historical record of all changes made, which ensures transparency, clarity, and traceability. This documentation becomes an essential resource for any team member who needs to understand the rationale, methodology, and outcomes of previous changes. A well-maintained process documentation also provides a framework for future changes, ensuring consistency and reducing the likelihood of errors. It facilitates knowledge sharing, making it easier for new team members to get up to speed and contribute to ongoing change initiatives.

Establish a Change Control Board (CCB)

A change control board (CCB) is responsible for overseeing the change control process. By bringing together a diverse group of experts and decision-makers, the CCB ensures that changes are evaluated holistically, considering various organizational perspectives. The CCB has a dual role of ensuring that changes align with the organizational objectives while also acting as a gatekeeper to allow only well-planned and essential changes to proceed. This centralized decision-making structure ensures that changes are strategic, beneficial, and well-coordinated.

Prioritize changes

It's not uncommon for organizations to have limited resources, making it crucial to prioritize changes based on urgency, impact, and feasibility. By ranking changes, organizations ensure that the most critical and beneficial changes are addressed first. A structured prioritization process also fosters better decision-making and reduces the risk of changes that might not yield significant benefits. It clarifies the change control process and ensures alignment with broader organizational goals.

Implement standardized procedures

Standardized procedures bring consistency and predictability to the change control process. They outline a clear roadmap for initiating, evaluating, and implementing changes, ensuring that all team members have a common understanding of the steps involved. Having standard operating procedures (SOPs) in place also reduces the risk of errors and oversights. They act as a safety net, ensuring that all changes—regardless of their size or complexity—are handled with the same level of diligence and care.

Provide training and raise awareness

Change control is most effective when everyone involved understands its intricacies. Change management training sessions empower stakeholders with the knowledge and tools they need to navigate the change control process efficiently, ensuring they play an active, informed role.

Communicate regularly about change status

Communication connects all elements of a change control process. Organizations can foster transparency and trust by keeping stakeholders updated about the status of changes. The regular communication also provides an opportunity for feedback, allowing for real-time adjustments and refinements. It ensures everyone is aligned and working towards a common goal, making the entire change control process more cohesive and collaborative.

Maintain flexibility within the process

Flexibility with the change control process is crucial—it ensures a structured approach to managing change and room to adapt when necessary. Being rigid can lead to inefficiencies, missed opportunities, or even failures in implementation. Flexibility allows for better responsiveness to a project's evolving needs and realities, ensuring that the change control process remains effective and relevant.

Incorporate a risk assessment

Organizations can identify, evaluate, and mitigate potential threats associated with proposed changes by incorporating a risk assessment stage within the change control process. A thorough risk assessment not only safeguards against potential pitfalls, but also instills confidence in stakeholders. Knowing that risks have been considered and planned for ensures a more streamlined implementation, reducing uncertainties and enhancing the overall robustness of the change control process.

Conduct post-implementation reviews

Once a change has been implemented, it's crucial to evaluate its effectiveness and the overall efficiency of the change control process. Conducting post-implementation reviews allows organizations to assess what went well and where there might be room for improvement.

Carry out regular audits

Change control processes, like all organizational procedures, benefit from regular audits. These audits dive deep into the workings of the process, ensuring that it's being followed correctly and identifying areas where it could be improved.

Change Control Process Example

Let's take a look at a hypothetical change in a project and go through the five steps that are part of the change control process. Take something as simple as painting a house.

- The client proposes a color change from the agreed-upon white to light green.
- The change is made during a meeting with the construction project manager, who creates a change proposal to capture the change.
- The construction team then looks into what impact the color change will have on the project. Did they already purchase the white paint, is the green paint more expensive, etc.?
- After researching its impact, the project manager will decide. If going forward will impact the budget, then the client will be consulted.
- Once everyone agrees, the change is made. The new paint is purchased and applied to the construction.
- The client approves the paint job and any cost change, which brings this change control process to a close.

Benefits of a well-executed Change Control

During a change implementation project, the change control process provides several crucial benefits, including:

- Improved productivity- Research suggests that an average employee is only productive for three working hours a day. One of the major reasons for this behavior is unclear deliverables or a poorly managed execution process. Change control often rectifies this issue by reducing employee confusion on project deliverables, helping to improve overall employee productivity.
- Collaborative teamwork- The change control process streamlines the implementation by documenting all the project details in a centralized location. It also helps provide clear team

communication, allowing cross-functional teams to collaborate seamlessly on a change initiative.

- o Effective change communication- Transparency in change management communication is critical to prepare your workforce for an upcoming change and to accept that change at both an individual & company-wide level. Effective change communication will allow you to deal head-on with various barriers to change and reduce internal resistance.
- o Decreased cost of change- The change control process effectively reduces risks associated with a change initiative and minimizes the risk of change failure. The streamlined approach results in resource optimization and decreased project costs.
- o Enhanced compliance and traceability- A change control process ensures that all changes adhere to certain standards and guidelines. By documenting each step of the process, organizations have a clear audit trail. This not only helps in demonstrating compliance during audits, but also provides a historical reference for future change initiatives.
- o Reduced risks and unintended consequences- An effective change control process involves assessing and mitigating risks. Companies can avoid unwanted and unintended consequences by anticipating potential challenges and developing plans to address them. This proactive approach promotes business continuity and ensures that changes have a positive impact instead of causing disruption.
- o Continuous improvement and feedback integration- One of the most significant benefits of a change control process is its cyclical nature. After changes are implemented, feedback is gathered and analyzed to ensure organizations are always evolving, refining, and improving their processes, systems, and strategies.

10.8 Project Status Meeting

The project status report meeting is when team members provide data that the project manager uses to review where the project is over a specific period of time. This isn't only to keep the project manager informed but also serves to hold the project team accountable. The project manager needs to talk about what was accomplished and what's still pending, as well as upcoming milestones. He/ She intends to review the budget, assess risk and schedule upcoming meetings to make sure everything discussed has been resolved. To keep close track of progress on the project, the project manager needs to have information from his or her team on a timely basis. This information will be given during a project status meeting.

Notes: At a minimum, you need to have a status meeting at least once a week.

On some of the major projects, daily status meetings are a norm for the first few weeks, and then as the need for daily information wasn't as critical. Depending upon criticality, there can be meetings twice a week and finally, to weekly status.

Status review meetings are regularly scheduled events to exchange information about the project. On most projects, status review meetings will be held at various frequencies and on different levels. For example, the project management team can meet weekly by itself and monthly with the customer. Indeed, virtually all project managers are familiar with the status meeting. This is one tool that the project manager uses to "check in" on the project.

Purpose of Project Status Meetings

Typically, the project manager wants to assess the status of each of the following elements during a project status meeting:

- o Task updates.
- o Schedule status update (Are we behind or ahead of schedule?).

- o Budget status update (Are we under or over budget?).
- o Quality/scope status update (Are we maintaining desired scope/quality levels?).
- o Current or anticipated issues (e.g., changes, risks, resource issues, client satisfaction issues, vendor issues, etc.).
- o Next steps.

Because the project manager should be able to report up-to-date information to project sponsors or clients at any time, it's imperative for the project manager to conduct status meetings regularly. The frequency of these status meetings will vary depending on several factors, including (but not limited to) the following:

- Project complexity.
- Number of team members.
- Level of information required by project sponsor, clients, and others.
- Project manager's level of task involvement.

Effective status meetings not only benefit the project manager, by providing timely task updates, but also benefit the entire team, by providing a venue for recognizing milestone achievements, sharing information, and bringing problems/issues to the team.

Managing Project Status Meetings

While the format of the status review meetings should be flexible, as the project needs dictate, certain items are part of every status meeting. One can proceed in a top-down fashion:

- o The project champion reports any changes that may have a bearing on the future of the project.
- o The customer reports any changes that may have a bearing on the future of the project.
- o The project manager reports on the overall health of the project and the impact of earlier problems, changes, and corrective actions as they impact at the project level.
- o Activity managers' report on the health of activities open or scheduled open for work since the last status meeting.
- o Activity managers of future activities report on any changes since the last meeting that might impact project status.
- o The project manager reviews the status of open problems from the last status meeting.
- o Attendees identify new problems and assign responsibility for their resolution.
- o The project champion, customer, or project manager, as appropriate, offers closing comments.
- o The project manager announces the time and place of the next meeting and adjourns the meeting.

Minutes are part of the formal project documentation and are taken at each meeting, circulated for comment, revised as appropriate, distributed, and filed in the project notebook. Because there is little discussion, the minutes contain any handouts from the meeting and list the items assigned for the next meeting.

Notes: The minutes should also contain the list of attendees, a summary of comments made and assigned responsibilities.

Common Project Status Meeting Dysfunctions

Interestingly, project status meetings that fail invariably seem to possess similar dysfunctions. The common project status meeting dysfunctions include:

- Poorly developed agendas– Often, project managers simply assemble team members to meet without developing/circulating a clearly defined agenda including topics, timings, and topic owners. When status meetings have no agenda or one that is incomplete or unclear, the meeting lacks a framework or roadmap. Without this roadmap, the meeting easily runs off course and time is often wasted. In addition, if team members don't receive a clear agenda prior to the meeting, they often come to the session unprepared. Because the entire purpose of a project status meeting is to obtain status on tasks, identify issues, and so forth, it is imperative that team members gather specific data prior to the meeting and come prepared to answer certain key questions. Without specific predefined goals, the session wanders aimlessly.
- Ill-prepared team members– Unfortunately, some team members feel that all they need to do for a status meeting is show up and participate. When this happens, the entire team wastes valuable time. Invariably, when a team member is unable to provide feedback on an issue because of not being prepared, the team typically wastes time speculating about it and someone is tasked with following up after the meeting and reporting back at the next meeting.
- Poor time management– One of the biggest frustrations team members have with project meetings is that they often drone on too long (without much getting accomplished). When time isn't managed well, additional meetings are often required, which decreases team member morale and often rushes decisions. All of these can negatively impact not just the project timeline but also the quality of the project's product or service. When time isn't managed appropriately during status meetings, team members often become tempted to skip the meeting because they suspect it will be a waste of time and their time will be better spent other ways. Once team members start missing status meetings, their overall effectiveness begins to fundamentally break down.
- Allowing discussions to veer off topic– This is an extremely common dysfunction during project status meetings. When participants spend more and more time on topics outside the scope of the meeting, less and less time is available for intended topics. This often means that the intended agenda topics are rushed or not addressed at all, resulting in poor quality decisions, delays, communication breakdowns, and the like.
- Not getting balanced input from team members– One of the most difficult tasks any project manager has is dealing with different personalities on the team. More aggressive personalities can tend to dominate project meetings while more passive types tend to contribute much less to discussions and tend to be much less vocal about their opinions on a given issue. When certain team members dominate while others sit passively (without providing critical input on an issue), the quality of the team's decisions suffers. Another major problem with this particular dysfunction is that the project manager often develops a skewed view of important project issues because one or two people may voice very strong opinions. Those opinions may not be representative of the group at all, but without balanced input from the group, he/she may leave the project status meeting with an inaccurate perspective of the team's views on a particular issue.
- Ineffective handling of action items– One of the important parts of any project meeting is effective handling of action items. Action items are the vehicle project managers use to assign follow up tasks after the meeting. When that process is ineffective, those follow-up tasks suffer. It becomes much easier for team members to complain that they didn't know about the action item, they didn't understand it, or they didn't have time to complete it. When action items aren't completed in a timely manner, project progress is stalled.

Techniques to Enhance Project Status Meeting Effectiveness

Seasoned facilitators use specific techniques to avoid common meeting management pitfalls. In particular, project managers should implement the BLISS strategy to enhance the effectiveness of their project status meetings.

B- Be Efficient

L- Look Back – Look Forward

I- Insist on Accountability

S- Simplify the Agenda

S- Stay Focused

Be Efficient: Meeting efficiency refers to accomplishing as much as possible in the shortest amount of time with the smallest number of people participating in the meeting. Running efficient meetings is important because it respects everyone's time and provides team members more time to focus on task completion, encourages team members to participate in project meetings, and builds goodwill for the project manager. To run efficient project status meetings, project managers can employ several specific techniques:

- Assign time-intensive tasks as homework—don't waste meeting time reading reports, reviewing materials, and so forth.
- Only invite those team members truly necessary for the meeting—if you want to include other team members but they're not required, designate them as optional attendees.
- Assign a timekeeper to let the team know when five minutes remain in each section of the agenda.
- Prepare a standard "status update form" for all task leaders to complete prior to the meeting.
- Consider shorter, more frequent status meetings.
- Use facilitation techniques like simultaneous documentation to develop ideas very quickly (e.g., having attendees spend two to three minutes individually writing down ideas at the same time before initiating a group discussion).
- Use round robin (going around the room to get feedback from each attendee) and other facilitation techniques to balance participation and minimize dominators.

Look Back–Look Forward: Look back – look forward refers to reviewing the previous immediate timeframe and the immediately upcoming timeframe as well (e.g., +/- 2 weeks). During a status meeting, "looking back and looking forward" encourages the team to focus on a current snapshot of the project and zero in on issues relevant to the current period. This approach provides a brief historical view that offers context for the "current state" project discussion. The brief review also affords important opportunities to recognize team members for recent accomplishments. To implement the "look back-look forward" technique, consider the following:

- Produce a project schedule that focuses on the immediately preceding and upcoming time periods.
- Highlight key milestones/accomplishments on the project schedule.
- Summarize key events leading to the current state.
- Ask task leaders and team members to anticipate risks/issues likely during the upcoming time period.

Insist on Accountability: The project managers rely on subject matter expert team members to complete tasks in a timely manner. Throughout the course of the project, additional items will arise requiring follow-up by various team members. Team members must be accountable for tasks that they take on if the project is to reach its objectives within the parameters set. Consider these techniques to encourage that dedication to accountability in the team:

- Write all action items with a task owner and due date on a flip chart in real time during the meeting.

- Ask action item owners to suggest due dates (do not mandate due dates)—negotiate dates if needed.
- Maintain a database of action items that task owners are responsible for updating.
- Begin all status meetings with a review of previous action items.
- Consider using electronic tools to provide automatic reminders of action items.
- Discuss importance/consequences for missing action items during project kickoff.

Simplify the Agenda: The agenda is your roadmap for the meeting. It should include not just topics but also timings, topic owners, and possibly even facilitation techniques for each section. A well-developed agenda helps the project manager keep the team on track, makes preparation easier for team members, reduces meeting time, and provides a sense of focus for the meeting.

Stay Focused: One of the biggest dilemmas project managers face during project status meetings is keeping focused on the topic at hand. Everyone seems to have their favorite soap box issue that they'd love to discuss extensively, whether it's on the agenda or not! These tangents not only take the group off topic but also tend to take up critical time during the meeting and cause meetings to run late. Another problem with tangents is that they tend to cause the meeting to bounce from topic to topic without facilitating true resolution of the intended topic at hand.

Summary

- Project management is an extremely "data rich" business activity. At any given time, project management practitioners are capturing, manipulating, transforming, and communicating hundreds of individual project data points.
- Project Management Plan (PMP) is the baseline for the project. As a project manager, one will need access to work performance information, performance reports, and change requests.
- Monitoring and control are essential components of project management, and they are critical to completing the project on schedule and according to the original plan. This allows teams to leverage opportunities, promptly address problems, and make changes as needed.
- A project monitoring and control solution framework offers an overview of the steps involved in each IT project, although the level of detail required for each step will depend on the complexity and criticality of the individual project.
- The project monitoring is primarily about gathering, analyzing, and reporting data related to the project's progress. Project control ensures the project adheres to its planned schedule and objectives. It employs strategies and actions based on the insights derived from the project monitoring phase.
- Data visualization has become an active area of research, teaching, and development. It is the technique of communicating complex data or information by converting it into a visual object or graphical representation in order to aid in visual processing and comprehension.
- Visual literacy is based on the idea that pictures can be "read" and that meaning can be communicated through a process of reading pictorial information.
- Exploratory data analysis is an approach in statistical modeling for analyzing data sets to summarize their main characteristics, often with visual methods.

Keywords

Progress report: A progress report documents the project and shows how far it has progressed in comparison to where the project plan expected it to be.

Visual thinking: Visual thinking, as an area of academic focus, is the consolidation of study in neuroscience, art, storytelling, information design, visual perception, color theory, shape/pattern recognition, and graphic design.

Visual literacy: Visual literacy is the ability to interpret, negotiate, and make meaning from information presented in the form of an image, extending the meaning of literacy, which commonly signifies interpretation of written or printed text.

Earned Value Technique: Earned Value Technique (EVT) provides project managers with a means of calculating current project schedule and cost performance.

Project Management Plan: The project management plan is the main source of information about how the project will be executed, monitored, and controlled. It is the plan, with all additional subsidiary plans as needed.

Project monitoring: The project monitoring is primarily about gathering, analyzing, and reporting data related to the project's progress.

Project control: Project control ensures the project adheres to its planned schedule and objectives. It uses the data provided by project monitoring to adjust, correct, and steer the project toward its successful completion.

Self Assessment

1. __________ is a technique that provides project managers with a means of calculating current project schedule and cost performance.

A. Project technique
B. Early value technique
C. Earned value technique
D. Benefit technique

2. _____________ refers to the technique of communicating complex data or information by converting it into a visual object or graphical representation in order to aid in visual processing and comprehension.

A. Data representation
B. Data depiction
C. Data visualization
D. Data showcasing

3. EVT stands for

A. Earned Value Technique
B. Earlier Visual Technique
C. Earned Value Template
D. Earlier Visual Template

4. _______________ graphics are graphical visual representations of information, data, or knowledge intended to present complex information quickly and clearly.

A. Informational
B. Rotational
C. Virtual
D. Notational

5. __________________ is a discipline that leverages a myriad of tools to bring ideas and concepts developed in the mind, out into the external world for further examination and testing.

A. Domain thinking

B. Visual thinking
C. Virtual thinking
D. Proportion thinking

6. The statement appropriately reflecting about progress report is
A. It documents the project and shows how far it has progressed in comparison to where the project plan expected it to be.
B. It serves as a snapshot of the project's progress within a specific period of time.
C. It provides an overview of all the activities and tasks that have occurred over the reported period of time.
D. All the above.

7. The project managers should implement the BLISS strategy to enhance the effectiveness of their project status meetings.
A. True
B. False

8. ________________ report milestones and other performance metrics, including risks, issues, changes, etc.
A. Software
B. Analysis
C. Progress
D. Domain

9. _____________ involves identifying potential risks or issues that could derail the project. By proactively identifying these risks, project managers can develop mitigation strategies to minimize their impact.
A. Project monitoring
B. Project analysis
C. Work breakdown analysis
D. Progress identification

10. The process of project monitoring and control ensures that the project is completed according to the ___________________ while also carrying out the tasks properly.
A. original plan
B. within the designated budget
C. within the scheduled timeline
D. all the above.

11. Visual literacy is the ability to interpret, negotiate, and make meaning from information presented in the form of an image, extending the meaning of literacy, which commonly signifies interpretation of written or printed text.
A. True
B. False

12. A ____________ is declarative, that is, it states what needs to be accomplished, but leaves out how the change should be carried out.

A. change request
B. change log
C. change board
D. change state

13. The statement that is TRUE for project control is

A. It ensures the project adheres to its planned schedule and objectives.
B. It employs strategies and actions based on the insights derived from the project monitoring phase.
C. It uses the data provided by project monitoring to adjust, correct, and steer the project toward its successful completion.
D. All the above.

14. The __________________ is primarily about gathering, analyzing, and reporting data related to the project's progress and ensures that pertinent information is communicated effectively to all stakeholders.

A. progress virtualization
B. project monitoring
C. status visualization
D. software development

15. Based on work performance information received during the Monitor and Control Project Work process, forecasts allow the prediction of successful or unsuccessful project outcomes.

A. True
B. False

Answers for Self Assessment

1.	C	2.	C	3.	A	4.	A	5.	B
6.	D	7.	A	8.	C	9.	A	10.	D
11.	A	12.	A	13.	D	14.	B	15.	A

Review Questions

1. How change control benefits effective project management?
2. Discuss about change control in detail.
3. What is the significance of using graphical reporting tools?
4. Explain the change control process.
5. Elaborate on how progress visualizations aid in effective project management.
6. Compare Qualitative and Quantitative Monitoring.
7. Discuss the steps for writing a progress report.
8. Discuss the project monitoring and control process.

9. What is a progress report? Discuss the importance of developing a progress report.
10. Write a short note on:
    (a) Change request
    (b) Progress report

Further Readings

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Guide to Project Monitoring & Control | Smartsheet

What Is Data Visualization? | Microsoft Power BI

Top 16 Project Charts to Visualize Projects [2023] • Asana

5 Visualization Techniques to Help You Reach Your Goals (betterup.com)

What Is a Change Control Process? (with Example Change Log) [2023] • Asana

What are the common tools and frameworks for change control? (linkedin.com)

What is Data Visualization and Why is It Important? - GeeksforGeeks

Unit 11: Software Quality

CONTENTS

Objectives

After studying this unit, you will be able to:

- know about the software quality and various factors contributing to the quality of a software.
- learn about the ISO9126 software quality model.
- understand the measurement of the software quality.
- explore the product quality and product quality management.
- analyze the external standards and quality assurance plans in detail.

Introduction

Traditionally, a high-quality product is outlined in terms of its fitness of purpose. That is, a high-quality product will specifically be what the users need to try. For code merchandise, the fitness of purpose is typically taken in terms of satisfaction of the wants arranged down within the SRS document. though "fitness of purpose" could be a satisfactory definition of quality for several merchandise like an automobile, a table fan, a grinding machine, etc.– for code merchandise, "fitness of purpose" isn't a completely satisfactory definition of quality.

Software quality products are defined in terms of its fitness of purpose. That is, a quality product does precisely what the users want it to do. For software products, the fitness of use is generally explained in terms of satisfaction of the requirements laid down in the SRS document. Although, "fitness of purpose" is a satisfactory interpretation of quality for many devices such as a car, a table fan, a grinding machine, etc. for software products, "fitness of purpose" is not a wholly satisfactory definition of quality.

11.1 Definition of Software Quality

The quality of software can be defined as the ability of the software to function as per user requirement. When it comes to software products it must satisfy all the functionalities written down in the SRS document.

- ISO: Software quality is "capability of a software product to conform to requirements." while for others it can be synonymous with customer- or value-creation or even defect level.
- ASQ: ASQ uses the following definition: Software quality describes the desirable attributes of software products. There are two main approaches that exist: defect management and quality attributes.
- NIST: Software Assurance (SA) covers both the property and the process to achieve it:
- Confidence that software is free from vulnerabilities, either intentionally designed into the software or accidentally inserted at any time during its life cycle and that the software functions in the intended manner. The planned and systematic set of activities ensures that software life cycle processes and products conform to requirements, standards, and procedures.
- PMI: The Project Management Institute's PMBOK Guide "Software Extension" defines not "Software quality" itself, but Software Quality Assurance (SQA) as "a continuous process that audits other software processes to ensure that those processes are being followed (includes for example a software quality management plan)." whereas Software Quality Control (SCQ) means "taking care of applying methods, tools, techniques to ensure satisfaction of the work products towards quality requirements for a software under development or modification."

Software quality is defined as a field of study and practice that describes the desirable attributes of software products. The software quality refers to two related but distinct notions:

- Software's functional quality reflects how well it complies with or conforms to a given design, based on functional requirements or specifications. That attribute can also be described as the fitness for purpose of a piece of software or how it compares to competitors in the marketplace as a worthwhile product. It is the degree to which the correct software was produced. The functional quality is typically assessed dynamically but it is also possible to use static tests (such as software reviews).
- Software structural quality refers to how it meets non-functional requirements that support the delivery of the functional requirements, such as robustness or maintainability. It has a lot more to do with the degree to which the software works as needed. Many aspects of structural quality can be evaluated only statically through the analysis of the software inner structure, its source code, at the unit level, and at the system level (sometimes referred to as end-to-end testing), which is in effect how its architecture adheres to sound principles of software architecture. However, some structural qualities, such as usability, can be assessed only dynamically (users or others acting on their behalf interact with the software or, at least, some prototype or partial

implementation). Other aspects, such as reliability, might involve not only the software but also the underlying hardware, therefore, it can be assessed both statically and dynamically.

There are two main approaches to software quality: defect management and quality attributes.

Defect Management: A software defect can be regarded as any failure to address end-user requirements. Common defects include missed or misunderstood requirements and errors in design, functional logic, data relationships, process timing, validity checking, and coding errors. The software defect management approach is based on counting and managing defects. Defects are commonly categorized by severity, and the numbers in each category are used for planning. More mature software development organizations use tools, such as defect leakage matrices (for counting the numbers of defects that pass-through development phases prior to detection) and control charts, to measure and improve development process capability.

Quality Attributes: This approach to software quality is best exemplified by fixed quality models, such as ISO/IEC 25010:2011. This standard describes a hierarchy of eight quality characteristics, each composed of sub-characteristics:

- Functional suitability
- Reliability
- Operability
- Performance efficiency
- Security
- Compatibility
- Maintainability
- Transferability

The high-quality associates many quality factors for a software. The key aspects that conclude software quality include,

Good design: It's always important to have a good and aesthetic design to please the users.

Reliability: Be it any software it should be able to perform the functionality impeccably without issues. A software has smart reusability if completely different modules of the merchandise will simply be reused to develop new merchandise. The software is more reliable if it has fewer failures. Since software engineers do not deliberately plan for their software to fail, reliability depends on the number and type of mistakes they make. Designers can improve reliability by ensuring the software is easy to implement and change, by testing it thoroughly, and also by ensuring that if failures occur, the system can handle them or can recover easily.

Durability: Durability means the ability of the software to work without any issue for a long period of time.

Consistency: Software should be able to perform consistently over platform and devices.

Maintainability: A software is reparable, if errors may be simply corrected as and once, they show up, new functions may be simply added to the merchandise, and therefore the functionalities of the merchandise may be simply changed, etc. Bugs associated with any software should be able to capture and fix quickly and news tasks and enhancement must be added without any trouble.

Value for money: The customer and companies who make use of software should feel that the money spent on it has not being wasted.

Portability: A software is claimed to be transportable, if it may be simply created to figure in several package environments, in several machines, with alternative code merchandise, etc.

Usability: Software has smart usability if completely different classes of users (that is, knowledgeable and novice users) will simply invoke the functions of the merchandise.

Correctness: Software is correct if completely different needs as laid out in the SRS document are properly enforced.

Efficiency: The more efficient software is, the less it uses CPU-time, memory, disk space, network bandwidth, and other resources. This is important to customers in order to reduce their costs of running the software, although with today's powerful computers, CPU time, memory and disk usage are less of a concern than in years gone by.

How do we achieve Software quality?

Achieving quality will ensure maximum profit for your software business. But the biggest hurdle is to achieve quality and here are some of the ways:

- Define characteristics that define quality for a product.
- Decide how to measure each of that quality characteristic.
- Set standards for each quality characteristic.
- Do quality control with respect to the standards.
- Find out the reasons that are hindering quality.
- Make necessary improvements.

11.2 Software Quality Management

A quality management system is the principal method used by organizations to ensure that the products they develop have the desired quality. A quality system consists of the following:

- Managerial Structure and Individual Responsibilities: A quality system is the responsibility of the organization as a whole. However, every organization has a sever quality department to perform various quality system activities. The quality system of an arrangement should have the support of the top management. Without help for the quality system at a high level in a company, some members of staff will take the quality system seriously.
- Quality System Activities: The quality system activities encompass the following:
  - Auditing of projects
  - Review of the quality system
  - Development of standards, methods, and guidelines, etc.
  - Production of documents for the top management summarizing the effectiveness of the quality system in the organization.

Evolution of Quality Management System

Quality systems have increasingly evolved over the last five decades. Initially, the usual function of quality systems was to produce quality products and inspect the finished products to remove defective devices. Since that time, quality systems of organizations have undergone four steps of evolution. The first product inspection task gave method to quality control (QC) (Figure 1).

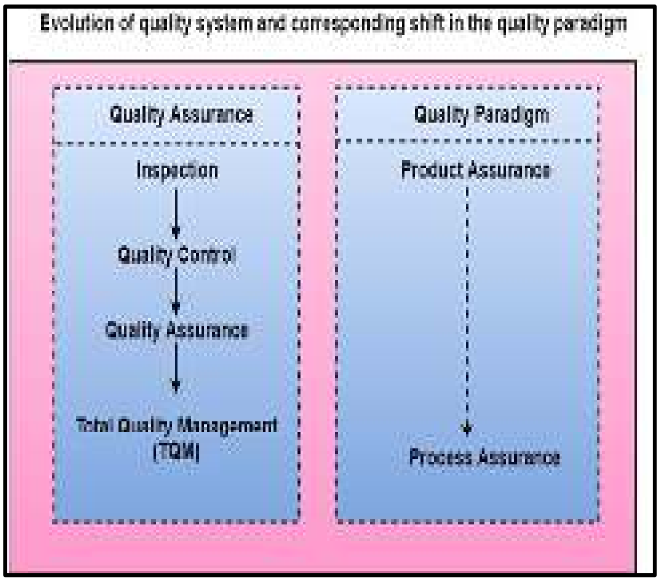

Figure 1: Evolution of Quality Management System

Quality control targets not only detecting the defective devices and removing them but also on determining the causes behind the defects. Thus, quality control aims at correcting the reasons for bugs and not just rejecting the products. The next breakthrough in quality methods was the development of quality assurance methods. The primary premise of modern quality assurance is that if an organization's processes are proper and are followed rigorously, then the products are obligated to be of good quality. The new quality functions include guidance for recognizing, defining, analyzing, and improving the production process.

11.3 International Standards Organization (ISO)

ISO (International Standards Organization) is a group or consortium of 63 countries established to plan and fosters standardization. ISO declared its 9000 series of standards in 1987. It serves as a reference for the contract between independent parties. The ISO 9000 standard determines the guidelines for maintaining a quality system. The ISO standard mainly addresses operational methods and organizational methods such as responsibilities, reporting, etc. ISO 9000 defines a set of guidelines for the production process and is not directly concerned about the product itself.

Types of ISO 9000 Quality Standards

The ISO 9000 series of standards assumes that if a proper stage is followed for production, then good quality products are bound to follow automatically. The types of industries to which the various ISO standards apply are as follows.

- **ISO 9001:** This standard applies to the organizations engaged in design, development, production, and servicing of goods. This is the standard that applies to most software development organizations.
- **ISO 9002:** This standard applies to those organizations which do not design products but are only involved in production. Examples of these category industries include steel and car manufacturing industries that buy the product and plants designs from external sources and are engaged in only manufacturing those products. Therefore, ISO 9002 does not apply to software development organizations.
- **ISO 9003:** This standard applies to organizations that are involved only in the installation and testing of the products. For example, gas companies.

How to get ISO 9000 Certification?

An organization determines to obtain ISO 9000 certification applies to ISO registrar office for registration. The process consists of the following stages (Figure 2):

- Application: Once an organization decides to go for ISO certification, it applies to the registrar for registration.
- Pre-Assessment: During this stage, the registrar makes a rough assessment of the organization.
- Document review and Adequacy of Audit: During this stage, the registrar reviews the document submitted by the organization and suggests an improvement.

Figure 2: ISO Certifications

- Compliance Audit: During this stage, the registrar checks whether the organization has compiled the suggestion made by it during the review or not.
- Registration: The registrar awards the ISO certification after the successful completion of all the phases.
- Continued Inspection: The registrar continued to monitor the organization time by time.

11.4 Software Product Quality Model

Software quality models are a standardized way of measuring a software product. With the increasing trend in the software industry, new applications are planned and developed every day. This eventually gives rise to the need to reassure us that the product so built meets at least the expected standards. The software quality models were proposed to measure the quality of any software model. There are widely accepted models when it comes to measuring software quality. Following are few models that explains what kind of quality criteria is to be followed:

Mc Call's Model: McCall Model is the first quality model developed, which defines a layout of the various aspects that define the product's quality. It defines the product quality in the following manner – Product Revision, Product Operation, Product Transition. Product revision deals with maintainability, flexibility and testability, product operation is about correctness, reliability, efficiency, and integrity.

Boehm Model: This model describes how easily and reliably a software product can be used. This model actually elaborates the aspects of McCall model in detail. It begins with the characteristics that resort to higher level requirements. The model's general utility is divided into various factors-portability, efficiency, and human engineering, which are the refinement of factors like portability and utility. Further maintainability is refined into testability, understandability, and modifiability.

FURPS Model: This model categorizes requirements into functional and non-functional requirements. The term FURPS is an acronym for Functional requirement (F) which relies on expected input and output, and in non-functional requirements (U) stands for Usability which includes human factors, aesthetic, documentation of user material of training, (R) stands for reliability(frequency and severity of failure, time among failure), (P) stands for Performance that includes functional requirements, and finally (S) stands for supportability that includes backup, requirement of design and implementation etc.

Ghezzi Model: This model states that the internal qualities of a software help the software developers to attain a collaborative result both in terms of external and internal qualities of a software. The overall qualities can be accuracy, flexibility, integrity, maintainability, portability, reliability, re-usability, and usability.

IEEE Model: It is a standard which defines various specifications for software maintenance, thus providing a quality model. This model gives a variety of measurement techniques for various qualitative factors like efficiency, functionality, maintainability, portability, reliability, and usability.

Dromey's Quality Model: This model emphasizes evaluating one software's quality with another. It helps to find defects if any, and also to point out the factors that caused such defects. This model is designed on the basis of the relationship that exists between software properties and its quality attributes.

SATC's Model: SATC is an acronym for Software Assurance Technology Centre. Its objective is to improve software quality by defining a metrics program which helps to meet the basic needs with least expenditure. This model tests a quality model by evaluating the results of the metrics used, and also on the basis of discussions based on the project. This model defines a set of goals and process attributes based on the structure of ISO 9126-1 quality model.

ISO 9126-1 Quality Model: This model has two primary categories– internal and external quality attributes and quality in use attributes. The internal quality attributes are the properties of the system the evaluation of which can be done without executing it whereas the external quality attributes are those that are evaluated by observing the system during execution.

Capability Maturity Model: One of the most important quality models of software quality maintenance. The model lays down a very simple approach to define the quality standards. It has five levels namely – initial, repeatable, defined, managed, optimizing. At the initial level, the company is quite small, and it solely depends on an individual how he handles the company. The repeatable level states that at least the basic requirements or techniques have been established and the organization has attained a certain level of success. By the next level that is defined, the company has already established a set of standards for smooth functioning of a software project/process. At the managed level, an organization monitors its own activities through data collection and analysis. At the fifth level, that is the optimizing level, constant improvement of the prevailing process becomes a priority, a lot of innovative approaches are applied towards the qualitative enhancement.

Importance of Software Product Quality Model

With the growing number of customers' demand for software systems, the expectations for quality have also grown in terms of how reliable a software product will be. As we know, a software application is quite complex in nature, hence the task of verifying whether a specific functionality has been implemented or not becomes quite difficult. Therefore, the software developers often divide the tasks into the form of deliverables, that is, defining a benchmark to mark the completion of one specific task.

If the errors in some of the previous phases are not rectified on time, then it may lead to that error being carried over to the next consecutive phases, which may have a serious problem in the later stages of the project.

11.5 ISO9126 Quality Model

ISO9126 is a worldwide standard for the evaluation of software. The standard is split into four parts: quality model; external metrics; internal metrics; and quality in use metrics. ISO 9126 Part one, referred to as ISO 9126–1 is an extension of previous work done by McCall (1977), Boehm (1978), FURPS and others in defining a set of software quality characteristics.

ISO9126-1 symbolizes the latest research into characterizing software for the purposes of software quality control, software quality assurance and software process improvement (SPI). The ISO 9126-1 software quality model recognizes 6 main quality characteristics:

Functionality: Functionality is the essential purpose of any product or service. For certain items this is relatively easy to define, for example a ship's anchor has the function of holding a ship at a given location. The more functions a product has, for example, an ATM machine, then the more complicated it becomes to define its functionality. For software a list of functions can be specified, that is, a sales order processing system should be able to record the customer information so that it can be used to reference a sales order.

Did you Know?

What is the sales order system?

A sales order system should also provide the following functions:

Record sales order product, price and quantity.

Calculate total price.

Calculate appropriate sales tax.

Calculate date available to ship, based on inventory.

Generate purchase orders when stock falls below a given threshold.

Functionality is expressed as a totality of essential functions that the software product provides. It is also important to note that the presence or absence of these functions in a software product can be verified as either existing or not, in that it is a Boolean (either a yes or no answer). The other software characteristics listed (that is, usability) are only present to some degree, that is, not a simple on or off. Many people get confused between overall process functionality (in which software plays a part) and software functionality. This is partly due to the fact that Data Flow Diagrams (DFDs) and other modeling tools can depict process functionality (as a set of data in\data out conversions) and software functionality.

Following the functionality, there are five other software attributes that characterize the usefulness of the software in a given environment. Each of the characteristics can only be measured (and are assumed to exist) when the functionality of a given system is present. In this way, for example, a system cannot possess usability characteristics if the system does not function correctly.

Reliability: Once a software system is functioning, as specified, and delivered the reliability feature describes the capability of the system to maintain its service provision under defined conditions for defined periods of time. One aspect of this characteristic is fault tolerance, that is the ability of a system to withstand component failure. For example, if the network goes down for 20 seconds, then comes back, the system should be able to recover and continue functioning.

Usability- Usability only exists with regard to functionality and refers to the simplicity of use for a given function. For example, a function of an ATM machine is to dispense cash as requested. Placing common amounts on the screen for selection, that is, $20.00, $40.00, $100.00 etc., does not impact the function of the ATM but addresses the usability of the function. The ability to learn how to use a system (learn ability) is also a major sub characteristic of usability.

Efficiency: Efficiency is concerned with the system resources used when providing the necessary functionality. The amount of disk space, memory, network etc. provides a good indication of this characteristic. As with a number of these characteristics, there are overlaps. For example, the usability of a system is influenced by the system's performance, in that if a system takes three hours to respond the system would not be easy to use although the essential issue is a performance or efficiency characteristic.

Maintainability: The capability to recognize and fix a fault within a software component is what the maintainability characteristic addresses. In other software quality models this characteristic is referenced as supportability. Maintainability is impacted by code readability or complexity as well as modularization. Anything that helps with identifying the cause of a fault and then fixing the fault is the concern of maintainability. Also, the ability to verify (or test) a system, that is, testability, is one of the sub characteristics of maintainability.

Portability: This characteristic refers to how well the software can accept changes in its environment or with its requirements. The sub characteristics of this includes adaptability. Object oriented design and implementation practices can contribute to the extent to which this characteristic is present in a given system.

ISO9126 Observations

For the most part, the overall structure of ISO 9126–1 is similar to past models, McCall (1977) and Boehm (1978), although there are a couple of notable differences. Compliance comes under the functionality characteristic. This can be attributed to government initiatives like SOX. In many requirements specifications all characteristics, that are specified, that are not pure functional requirements are specified as Non-Functional requirements. It is interesting to note, with ISO 9126, that compliance is seen as a functional characteristic.

Using the ISO 9126 (or any other quality model) for derivation of system requirements brings clarity of definition of purpose and operating capability. For example, a rules engine approach to compliance would enable greater adaptability, should the compliance rules change. The functionality for compliance could be implemented in other ways but these other implementation methods may not produce as strong an adaptability characteristic as a rule, or some other component based, architecture.

Also, a designer typically will need to make tradeoffs between two or more characteristics when designing the system. Consider highly modularized code, this code is usually easy to maintain, that is, has a good changeability characteristic, but may not perform as well (for cpu resource, as unstructured program code). On a similar vein a normalized database may not perform as well as a not normalized database. These tradeoffs need to be identified, so that informed design decisions can be made.

Although ISO 9126–1 is the latest proposal for a useful quality model, of software characteristics, it is unlikely to be the last. One thing is certain, the requirements (including compliance) and operating environment of software will be continually changing and with this change will come the continuing search to find useful characteristics that facilitate measurement and control of the software production process.

11.6 Measurement of Software

A measurement is a manifestation of the size, quantity, amount, or dimension of a particular attribute of a product or process. Software measurement is a titrate impute of a characteristic of a software product or the software process. It is an authority within software engineering. The software measurement process is defined and governed by ISO Standard.

Software Measurement Principles

The software measurement process can be characterized by five activities-

- Formulation: The derivation of software measures and metrics appropriate for the representation of the software that is being considered.
- Collection: The mechanism used to accumulate data required to derive the formulated metrics.
- Analysis: The computation of metrics and the application of mathematical tools.
- Interpretation: The evaluation of metrics resulting in insight into the quality of the representation.
- Feedback: Recommendation derived from the interpretation of product metrics transmitted to the software team.

Classification of Software Measurement

There are 2 types of software measurement:

- Direct Measurement: In direct measurement, the product, process, or thing is measured directly using a standard scale.
- Indirect Measurement: In indirect measurement, the quantity or quality to be measured is measured using related parameters, that is, by use of reference.

Need for Software Measurement

Software is measured to:

- Create the quality of the current product or process.
- Anticipate future qualities of the product or process.
- Enhance the quality of a product or process.
- Regulate the state of the project in relation to budget and schedule.
- Enable data-driven decision-making in project planning and control.
- Identify bottlenecks and areas for improvement to drive process improvement activities.
- Ensure that industry standards and regulations are followed.
- Give software products and processes a quantitative basis for evaluation.
- Enable the ongoing improvement of software development practices.

11.7 Software Metrics

In any software project, you can go on building the code but at some point, you need to take a break and check if the work you are doing is right, if the process you followed is correct and so on. Metrics help you in exactly that.

Metrics are pointers or numbers which help you understand the attributes of a product, (like its complexity, its size, it's quality etc.), the attributes of the process (which can be used to improve the quality and speed of development) and the attributes of the project (which includes the number of resources, costs, productivity, and timeline among others), popularly known as the three P's. There are 3 types of software metrics:

- Product Metrics: Product metrics are used to evaluate the state of the product, tracing risks and undercover prospective problem areas. The ability of the team to control quality is evaluated. Examples include lines of code, cyclomatic complexity, code coverage, defect density, and code maintainability index.
- Process Metrics: Process metrics pay particular attention to enhancing the long-term process of the team or organization. Examples include effort variance, schedule variance, defect injection rate, and lead time.
- Project Metrics: The project matrix describes the project characteristic and execution process. Examples include effort estimation accuracy, schedule deviation, cost variance, and productivity.
  - Number of software developer
  - Staffing patterns over the life cycle of software
  - Cost and schedule
  - Productivity

11.8 Software Quality Metrics

Software quality metrics are an indicator of the health of the product, process, and project. Good metrics with accurate data can help in,

- Developing a strategy and giving the right direction to the process/project
- Recognizing the areas of focus
- Making strategic decisions
- Driving performance and many others.

Important Software Quality Metrics

For any metrics to truly serve the purpose, there are 2 parts. One is data accuracy and the second is metrics selection. All metrics will not be suitable for all processes and projects. So, the selection of the metrics needs to be done carefully. Some very important and most commonly used software quality metrics and how they are helpful in driving a better code include:

- Defect Density: The first measure of the quality of any products is the number of defects found and fixed. Though there a many "conditions apply" cases this is the first ballpark estimate of the quality of the software. The more the number of defects found, would be the quality of development is poor. So, the management should strive hard to improve development and do an RCA (Root Cause Analysis) to find why the quality is taking the hit.

  Defect Density= No. of Defects Found/ Size of AUT or module

- Defect Removal Efficiency (DRE): This is an important metric for assessing the effectiveness of a testing team. DRE is an indicator of the number of defects the tester or the testing team was able to remove from going into a production environment. Every quality team wants to ensure a 100% DRE.

  DRE = A/(A+B) x 100

  A – number of defects found before production

  B – Number of defects found in production

- Meantime between failures (MTBF): As the name suggests it is the average time between two failures in a system. Based on the AUT and expectation of business the definition of failure may vary. No team can produce software that never breaks or fails, so the onus is always to increase the MTBF as much as possible, which means that in a time frame the number of times the applications fail should be reduced to an acceptable number.
- Meantime to recover (MTTR): This again is quite self-explanatory. The mean time to recover is basically the time it takes for the developers to find a critical issue with the system, fix it and push the fix patch to production. Hence the average time which the team needs to fix an issue in production. It is more of maintenance contract metrics, where an MTTR of 24 hours would be preferred over an MTTR of 2 days for obvious reasons.
- Application Crash Rate: Important metrics especially for mobile apps and online websites. It is a measure of how often the mobile app or website crashes in any environment. It is an indicator of the quality of the code. The better the code, the longer it will be able to sustain without crashing. In recent times where the speed of delivery has taken utmost importance, the traditional methods life the SDLC and waterfall models have taken a backseat, giving way for more dynamic and fast-paced agile, scrum and lean methodologies.
- Lead Time: Lead time is defined as the time it takes from the time of project or sprint kick-off to the completion. In an agile process, we normally pick up user stories that will be delivered at the end of the sprint. The lead time is thus defined as the time it takes to complete and deliver these user stories.
- Cycle Time: Cycle time is similar to the lead time with a difference that leads time is measured per user story, while cycle time is measured per task. For example, if the database creation is part of the user story related to client data. Then, the time taken to create the database would be the cycle time, while the time taken to have the complete database ready would be the lead time. The cycle time data is used to arrive at delivery estimation timelines for future sprints.
- Team Velocity: Team Velocity is a very important metric for Agile/Scrum. It is an indicator of the number of tasks or user stories a team is able to complete during a single sprint. This does not include the items moved to the backlog and incomplete items. Only fully completed user stories are included for velocity calculations. This is an important metric

because based on the team velocity, the management would decide on the number of stories they can pick up for the next sprint.

- First Time Pass Rate: These metrics are in line with the agile principle of dynamic, fast and quality delivery. It is an indicator of the number of test cases that pass in the first run itself. It is also an indicator of the quality of development. In simpler terms, it means that no defects were found in the developed code when it went through testing for the first time.
- Defect Count Per Sprint: As the same suggests, these metrics take the count of defects found in each sprint. This is a very simple yet useful metric for assessing the quality of the user stories delivered during any sprint.

11.9 Measurement of Software Quality

Software quality measurement is about quantifying to what extent a system or software possesses desirable characteristics. This can be performed through qualitative or quantitative means or a mix of both. In both cases, for each desirable characteristic, there are a set of measurable attributes the existence of which in a piece of software or system tend to be correlated and associated with this characteristic. For example, an attribute associated with portability is the number of target-dependent statements in a program. More precisely, using the Quality Function Deployment approach, these measurable attributes are the "hows" that need to be enforced to enable the "whats" in the software quality definition.

The structure, classification and terminology of attributes and metrics applicable to software quality management have been derived or extracted from the ISO 9126-3 and the subsequent ISO/IEC 25000:2005 quality model. The main focus is on internal structural quality. Subcategories have been created to handle specific areas like business application architecture and technical characteristics such as data access and manipulation or the notion of transactions.

The dependence tree between software quality characteristics and their measurable attributes is represented in the diagram on the right, where each of the 5 characteristics that matter for the user (right) or owner of the business system depends on measurable attributes (left):

- Application Architecture Practices
- Coding Practices
- Application Complexity
- Documentation
- Portability
- Technical and Functional Volume

Correlations between the programming errors and production defects unveil that basic code errors account for 92 percent of the total errors in the source code. These numerous code-level issues eventually count for only 10 percent of the defects in production. Bad software engineering practices at the architecture levels account for only 8 percent of total defects but consume over half the effort spent on fixing problems, and lead to 90 percent of the serious reliability, security, and efficiency issues in production.

Code-based analysis

Many of the existing software measures count structural elements of the application that result from parsing the source code for such individual instructions, tokens, control structures (Complexity), and objects. Software quality measurement is about quantifying to what extent a system or software rates along these dimensions. The analysis can be performed using a qualitative or quantitative approach or a mix of both; to provide an aggregate view [using for example weighted average(s) that reflect relative importance between the factors being measured].

This view of software quality on a linear continuum has to be supplemented by the identification of discrete critical programming errors. These vulnerabilities may not fail a test case, but they are the result of bad practices that under specific circumstances can lead to catastrophic outages, performance degradations, security breaches, corrupted data, and myriad other problems that make a given system de facto unsuitable for use regardless of its rating based on aggregated measurements. A well-known example of vulnerability is the Common Weakness Enumeration, a repository of vulnerabilities in the source code that make applications exposed to security breaches.

The measurement of critical application characteristics involves measuring structural attributes of the application's architecture, coding, and in-line documentation, as displayed in the picture above. Thus, each characteristic is affected by attributes at numerous levels of abstraction in the application and all of which must be included calculating the characteristic's measure if it is to be a valuable predictor of quality outcomes that affect the business.

The layered approach to calculating characteristic measures displayed above was first proposed by Boehm and his colleagues at TRW (Boehm, 1978) and is the approach taken in the ISO 9126 and 25000 series standards. These attributes can be measured from the parsed results of a static analysis of the application source code. Even dynamic characteristics of applications such as reliability and performance efficiency have their causal roots in the static structure of the application.

Structural quality analysis and measurement

Structural quality analysis and measurement is performed through the analysis of the source code, the architecture, software framework, database schema in relationship to principles and standards that together define the conceptual and logical architecture of a system. This is distinct from the basic, local, component-level code analysis typically performed by development tools which are mostly concerned with implementation considerations and are crucial during debugging and testing activities.

Reliability

The root causes of poor reliability are found in a combination of non-compliance with good architectural and coding practices. This non-compliance can be detected by measuring the static quality attributes of an application. Assessing the static attributes underlying an application's reliability provides an estimate of the level of business risk and the likelihood of potential application failures and defects the application will experience when placed in operation.

Assessing reliability requires checks of at least the following software engineering best practices and technical attributes:

- Application Architecture Practices
- Coding Practices
- Complexity of algorithms
- Complexity of programming practices
- Compliance with Object-Oriented and Structured Programming best practices (when applicable).
- Component or pattern re-use ratio
- Dirty programming
- Error & Exception handling (for all layers - GUI, Logic & Data)
- Multi-layer design compliance
- Resource bounds management
- Software avoids patterns that will lead to unexpected behaviors
- Software manages data integrity and consistency
- Transaction complexity level

Depending on the application architecture and the third-party components used (such as external libraries or frameworks), custom checks should be defined along the lines drawn by the above list of best practices to ensure a better assessment of the reliability of the delivered software.

Efficiency

As with reliability, the causes of performance inefficiency are often found in violations of good architectural and coding practice which can be detected by measuring the static quality attributes of an application. These static attributes predict potential operational performance bottlenecks and future scalability problems, especially for applications requiring high execution speed for handling complex algorithms or huge volumes of data.

Assessing performance efficiency requires checking at least the following software engineering best practices and technical attributes:

- Application architecture practices
- Appropriate interactions with expensive and/or remote resources
- Data access performance and data management
- Memory, network and disk space management
- Compliance with coding practices

Security

Software quality includes software security. Many security vulnerabilities result from poor coding and architectural practices such as SQL injection or cross-site scripting.

- o Assessing the security requires at least checking the following software engineering best practices and technical attributes:
- o Implementation, management of a security-aware and hardening development process, for example, Security Development Lifecycle (Microsoft) or IBM's Secure Engineering Framework.
- o Secure application architecture practices
- o Multi-layer design compliance.
- o Security best practices (Input Validation, SQL Injection, Cross-Site Scripting, Access control etc.).
- o Secure and good programming practices
- o Error & exception handling

Maintainability

Maintainability includes concepts of modularity, understandability, changeability, testability, reusability, and transferability from one development team to another. These do not take the form of critical issues at the code level. Rather, poor maintainability is typically the result of thousands of minor violations with best practices in documentation, complexity avoidance strategy, and basic programming practices that make the difference between clean and easy-to-read code vs. unorganized and difficult-to-read code.

Assessing maintainability requires checking the following software engineering best practices and technical attributes:

- o Application Architecture Practices
- o Architecture, Programs and Code documentation embedded in source code
- o Code readability
- o Code smells
- o Complexity level of transactions
- o Complexity of algorithms
- o Complexity of programming practices
- o Compliance with Object-Oriented and Structured Programming best practices (when applicable)
- o Component or pattern re-use ratio
- o Controlled level of dynamic coding
- o Coupling ratio
- o Dirty programming
- o Documentation
- o Hardware, OS, middleware, software components and database independence
- o Multi-layer design compliance
- o Portability
- o Programming Practices (code level)
- o Reduced duplicate code and functions
- o Source code file organization cleanliness

Maintainability is closely related to the concept of technical debt, which is an expression of the costs resulting from a lack of maintainability. Reasons for low maintainability can be classified as reckless vs. prudent and deliberate vs. inadvertent, and result from the developer’s lack of time and goals, their carelessness, and discrepancies in the creation cost.

Size

Measuring software size requires that the whole source code be correctly gathered, including database structure scripts, data manipulation source code, component headers, configuration files etc. There are essentially two types of software sizes to be measured, the technical size (footprint) and the functional size. There are several software technical sizing methods that have been widely described. The most common technical sizing method is number of Lines of Code (#LOC) per technology, number of files, functions, classes, tables, etc., from which backfiring Function Points can be computed.

The most common for measuring functional size is function point analysis. Function point analysis measures the size of the software deliverable from a user's perspective. Function point sizing is done based on user requirements and provides an accurate representation of both size for the developer/estimator and value (functionality to be delivered) and reflects the business functionality being delivered to the customer.

11.10 Software Quality Models for Measurement of Software Quality

Software quality models were proposed to measure the quality of any software model. There are three widely accepted models when it comes to measuring software quality. They are:

Mc Call's Model- Mc Call's model was first introduced in the US Airforce in the year 1977. The main intention of this model was to maintain harmony between users and developers (Figure 3).

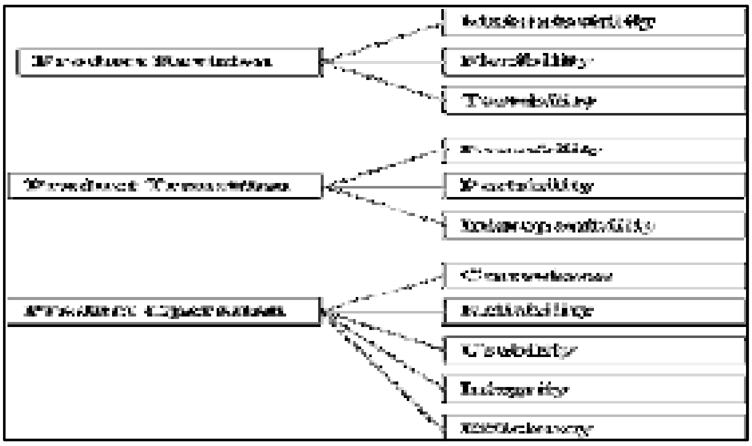

Figure 3: McCall's Quality Model

Boehm Quality Model- Boehm model was introduced in the year 1978. It was a kind of hierarchical model that's structured around high-level characteristics (Figure 4). The Boehm model measures software quality on the basis of certain characteristics.

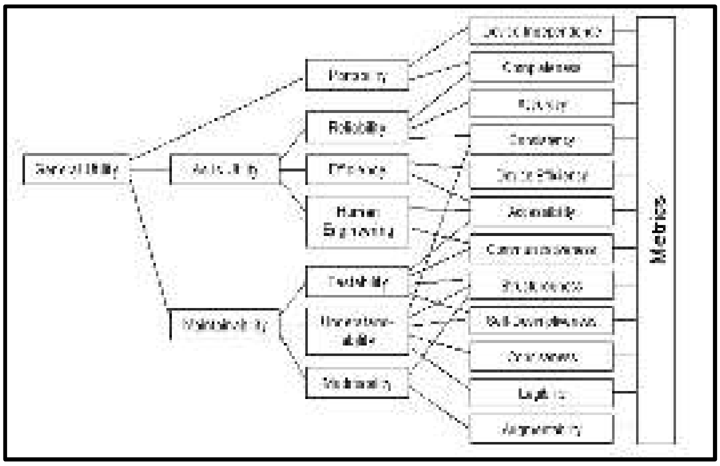

Figure 4: Boehm Quality Model

Dromey's quality model- Dromey's model (Figure 5) is mainly focused on the attributes and sub-attributes to connect properties of the software to the quality attributes. There are three principal elements to this model:

- o Product properties that affect the quality
- o High-level quality attributes
- o Linking the properties with quality attributes

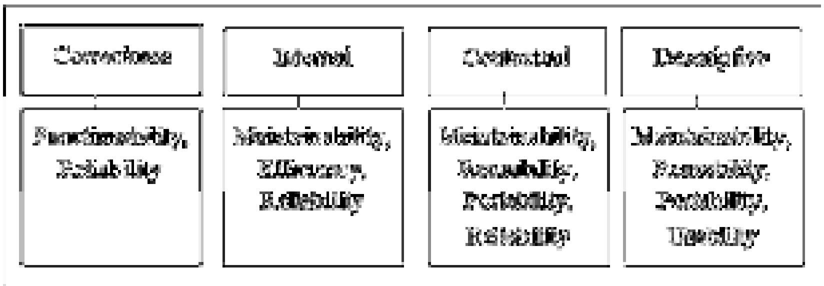

Figure 5: Dromey's Quality Model

11.11 Product Quality

Product quality refers to how well a product satisfies customer needs, serves its purpose and meets industry standards. When evaluating product quality, businesses consider several key factors, including whether a product solves a problem, works efficiently or suits customers' purposes. Companies may also evaluate product quality based on various perspectives that show how different groups perceive the usefulness of a product.

The perspectives to consider when assessing product quality include customer perspectives, manufacturing perspectives, product-based and value-based perspectives, and transcendental perspectives, which perceive a product's value in relation to its cost. Using these perspectives, you can define product quality according to:

- o Performance and intended function
- o Reliability of the product within a specific time frame
- o Conformity to product specifications
- o Product durability and lifespan
- o Product serviceability
- o Physical features of the product
- o Customers' perception of the product

Product quality is important because it affects the success of the company and helps establish its reputation in customer markets. When companies can create high-quality products that continue to meet customer demands, it can lead to fewer production costs, higher investment returns and increases in revenue.

Product quality also matters to the customers who depend on a company's attention to detail and customer demand. The companies create products to fill a need in the market, and consumers expect products to meet that need as the company advertises them. They want products that help them establish a connection with a brand so they know they can rely on the company's offerings. Quality products provide customers with safe, effective ways to solve their problems.

Quality Management

Quality management is the act of overseeing different activities and tasks within an organization to ensure that products and services offered, as well as the means used to provide them, are consistent. It helps to achieve and maintain a desired level of quality within the organization. Quality management consists of four key components, which include the following:

- Quality Planning: The process of identifying the quality standards relevant to the project and deciding how to meet them.
- Quality Improvement: The purposeful change of a process to improve the confidence or reliability of the outcome.
- Quality Control: The continuing effort to uphold a process's integrity and reliability in achieving an outcome.
- Quality Assurance: The systematic or planned actions necessary to offer sufficient reliability so that a particular service or product will meet the specified requirements.

11.12 Product Quality Management

Product quality is a characteristic that is a further conglomeration of different features for fulfilling the customer needs and maintaining the industry standards, so the product does not include any deficiency. There are different factors such as raw materials, implementations of product technologies, workforce expertise, and production-related overheads, etc. to decide the quality of a product.

In recent years, the companies reached out to their consumers to get to know even if the customers are happy with the product or not. As a result of this process, they concluded that some of the consumers are dissatisfied with their products. So, taking those feedbacks into account, the companies started to improve the quality of their product to meet the consumer's expectations. This whole process is known as products quality.

It consists of two different types of characteristics- Measured characteristics & Attributes characteristics

1. Measured Characteristics of Products Quality- Such sorts of aspects comprise size, shape, color, appearance, strength, weight, height, diameter, thickness, volume, diameter, consumption, fuel, and sorts of traits of a product.
2. Attributes Characteristics of Products Quality- It deals with the checking and controlling of deficiencies per item, defective units per item, cracks in ceramic, number of a mistake on avg. Basis, discoloring of garments, and sorts of feature sets of any product.

Paying heed upon these characteristics and making sure that the product has the adept inclusion of such features based upon the consumer needs, their past feedbacks, and Industry standards are the products quality management. How these qualities are incorporated into a product decide if the product is of good quality or bad quality.

The products quality is not a static term; it is always dynamic as it evolves to meet the consumer's requirement of the product. Products quality decides the overall goodness of a product and maintaining it is very important for businesses. Delivering products with high quality— defined as "meeting specifications at the lowest possible cost" as well as "delivering the value a customer derives from a product or service"— is a top priority for the manufacturers and industrial operations.

Quality has many aspects and certain operations management applications provide an integrated quality management functionality to tens of thousands of companies worldwide. Many of the quality applications cover the gamut: from real-time process visibility to methods for data monitoring and alarming; historian data capture and reporting functionality to store and display voluminous process data for quality analysis; enterprise-wide SPC; downtime monitoring; batch recipe management software to collect information on batch quality and recipe specifications; and underlying frameworks for monitoring and configuring data levels and application templates to deliver nearly any quality capability.

Benefits of Product Quality Management

- Regulatory adherence and compliance
- Respond to process variation in real-time
- Productivity and cost of manufacturing improvements

- Actionable, real-time quality-related information.
-

Did you Know?

What are the Key Capabilities of PQM?

Data monitoring and alarming

Best-in-class enterprise SPC, with database backbone

Advanced, interactive trending and charting

Government and regulatory reporting capabilities

Historical data collection

Integration with Laboratory Information Management Systems (LIMS)

Process Quality Management

Technology without great design will not achieve the marketplace advantage that is a requirement for business success. When the technology is supported by sophisticated design, the result is a supercharged and extremely potent business tool.

Quality Process specializes in the efficient development and delivery of appealing and satisfying customer experiences that aid our clients in their success. An effective quality management process provides support for rapid adoption, consistent and repeatable application of quality improvement methodologies. As the manufacturers across the globe are experiencing increased competitive pressure, price erosion and shorter time-to-market requirements, they also face the challenge of products being developed and manufactured by dispersed teams and locations. Quality can suffer in this distributed environment if it's not made a priority. As a result, many companies are now focused on improving overall product quality and streamlining the processes across the product development and manufacturing organizations.

By adopting quality management processes, companies will be able to implement a formalized quality process that is optimized for their unique requirements, use a common language and shared terminology across the company, expose performance bottlenecks and drive continuous, yet controlled, process improvements. Ultimately, quality management process improvements lead to time-to-market benefits, increased competitive advantage, and happier customers.

Steps of Product Quality Management

There are lots of factors involved in deciding the products quality. These factors explain how the products quality is decided and how it plays a role in improving a product. There are seven different factors that are relevant in determining products quality:

1. Checking for the conformance: When a product is designed and executed, the manufacturer of that product will ensure that the product has met all the requirements. The product will be checked under different circumstances to ensure that the product has absolute dimensions and durability. They also will check the product for different usage circumstances to ensure that the usage of the product will meet the requirement of the consumers. The design and outcome of a product are seriously viewed because this is the first and foremost factor in creating high products quality.
2. Checking if the product is fit for the purpose: All the products that are manufactured in a company mainly intend to solve an environmental problem that is faced by the people daily. So, the products quality also comes into the consideration of the fit of the purpose of that product. If there isn't any requirement for that product in the world, then the product is an utter waste, and there will not be a future either for the product or the company.

3. Paying heed to the feedbacks- The success of a product is mainly based on customer satisfaction. So, satisfying all the stream of customers with one product is also a more significant challenge for a company. To find the fulfillment of the customers, the company needs feedback from the customer to improve their product. It is one of the crucial factors which decides the products quality. The negative feedback from the customers can help the company to improve its product; and reload it with the missing features that are asked by the customer.
4. Checking the reliability of the product: If the customer can't rely on the product due to any reason, then the products quality of the product is low. That is the reason why the feedbacks and conformance are helping the company to understand the requirement of the customers, so the company can make an improved and reliable product that will allow the customers to rely on them at every use of it.
5. Analyzing safety and security of the product: It is crucial to create a product safe and secure. If the product is neither safe nor secure, it can damage the whole reputation of a company. The product that is created by a company should have all the safety measures and security, so that, the customer can rely on the product without any uneasiness. These are continuously checked in the conformance session from the start of selecting the raw material to the end of the end product.
6. Analyzing the efficiency of the product: It is the first and foremost consideration of a product. The quality of a product is mainly decided on its effectiveness. If a product is not efficient, the customers cannot rely on them every time. This can slowly spoil the reputation of the product and the company. Thereby, creating a product with maximum efficiency is the first and foremost consideration. The companies always try to create the product with maximum efficiency.
7. Ensuring better user experience with the product management: The user experience of a product is also essential. If the consumers find difficulties to use your product because of your complicated interface, there is a chance for that product to become a failure. The companies always face many challenges to create a user-friendly interface for their products. But, there are numerous challenges in creating interfaces like making creative and different interface for the products which can make the products distinctive from other company's products.

How is the Quality of a Product Decided?

The quality of a product is decided depending on various factors. To define quality is not straightforward because the definition of quality is defined by many terms. The description of quality is confusing, but there are some facts by which you can clearly understand the same. These facts are the collections of explanations and thoughts of quality which is explained by many people:

- The fitness of the purpose of the need.
- Making a product flawlessly and defect-free.
- Maximum efficiency and completely user-friendly.
- Creating the product with good material and precise design.
- Come up with a suitable design that will suit the environment.
- To introduce the correct solution at the right time.
- Giving the product that can fill the problem of environment.
- Pricing the product with reasonable value and a worthy product.
- To meet all the requirement of the customer.
- Understanding customer needs and giving them the correct product.
- Giving updates of the product frequently and appropriate to consumer's feedback.

11.13 Maintaining Products Quality

Creating a product within a safe and secure circumstance is essential. Maintaining product quality throughout production is a crucial factor. Considering this factor, the companies have differentiated the maintaining process of product quality into three sections. They are-

- Before production- Before the production process, companies try to find the problems that are faced by people daily. After seeing the problem, the companies will define the problem and give a name to it. By naming it, the companies gather information about the identified problem and categorize it based on the preference. The company tries to find a solution during this phase.
- During production- In this, the company designs and ideates the answer to the problem that they found previously. They will make a prototype and test it for its compatibility and durability. If the prototype becomes a success, they will proceed that to the production, and they will plan all the administration and financial report to that product. They will manufacture the complete product in this section.
- After production- After production, the company checks the product under different possible situations and circumference to test its durability and particle applications. If the quality of the product clears the entire test and comes within the limits the company fixed, then the product proceeds for the launch.

11.14 External Standards

External standard is an established benchmark or set of criteria that is used to measure and compare the quality of software products, processes, and services. It is used to measure the effectiveness of software products against industry standards and customer requirements. The examples of external standards include ISO 9000, CMMi, IEEE, and CMMI for Process Improvement.

ISO 9000

The SEI CMM is an attempt to improve software quality by improving the underlying software processes. Another attempt based on International Standards Organization (ISO) 9000 series is based on software quality improvement. This standard although being used in over 130 countries is not industry specific and can be applied to a wide range of products, that is, automobiles, televisions, refrigerators, etc. Thus, we can conclude that ISO 9000 series is a set of documents dealing with quality systems that can be used for software quality assurance purposes. Within the ISO 9000 series, standard ISO 9001 is most applicable to software development.

ISO 9001

ISO 9001 is a standard for quality management systems and CMMI is a model for process improvement. If an ISO-certified organization wishes to improve its processes continuously, implementing CMMI would be a good choice, as it provides more detailed practices for process improvement than the ISO standards. However, there are two issues that need to be resolved when an ISO-certified organization implements CMMI. First, it is not easy to identify any reusable parts of the ISO standards, and it would be advantageous to be able to reuse selected portions of the ISO standards during CMMI adoption in order to use existing resources to their best advantage. Second, it is difficult for an ISO-certified organization to implement CMMI in a straightforward, easy manner because of the differences in the language, structure, and details of the two sets of documents.

Capability Maturity Model (CMM)

According to the Carnegie Mellon University Software Engineering Institute, CMM is a commonsense application of software or business process management and quality improvement concepts to software development and maintenance. It's a community-developed guide for evolving towards a culture of engineering excellence, model for organizational improvement. The underlying structure for reliable and consistent software process assessments and software capability evaluations.

Capability Maturity Model for Software (CMM) is a framework that describes the key elements of an effective software process. There are CMM's for non-software processes as well, such as Business Process Management (BPM). The CMM describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process. The CMM covers practices for planning, engineering, and managing software development and maintenance.

When followed, these key practices improve the ability of organizations to meet goals for cost, schedule, functionality, and product quality. The CMM establishes a yardstick against which it is possible to judge, in a repeatable way, the maturity of an organization's software process and compare it to the state of the practice of the industry.

The CMM can also be used by an organization to plan improvements to its software process. It also reflects the needs of individuals performing software process, improvement, software process assessments, or software capability evaluations; is documented; and is publicly available.

ISO 9002

ISO 9002 is no longer in use. It was the standard that applied to organizations that did not do design or development. It was made obsolete with the 2000 year revisions. Now, the companies that do not do design are registered to ISO 9001; they include a "Permissible Exclusion" in the Quality Manual stating that design and development do not apply and are not included in the quality system.

ISO 15504

ISO/IEC 15504 is a standard for process assessment that shares many concepts with CMMI. The two standards should be compatible. Like CMMI, the standard is designed to provide guidance on the assessment of software development process.

11.15 Quality Assurance Plans

A quality plan is a document, or several documents, that together specify quality standards, practices, resources, specifications, and the sequence of activities relevant to a particular product, service, project, or contract. The quality plans should define:

- Objectives to be attained (for example, characteristics or specifications, uniformity, effectiveness, aesthetics, cycle time, cost, natural resources, utilization, yield, dependability, and so on).
- Steps in the processes that constitute the operating practice or procedures of the organization.
- Allocation of responsibilities, authority, and resources during the different phases of the process or project.
- Specific documented standards, practices, procedures, and instructions to be applied
- Suitable testing, inspection, examination, and audit programs at appropriate stages.
- A documented procedure for changes and modifications to a quality plan as a process is improved.
- A method for measuring the achievement of the quality objectives.
- Other actions necessary to meet the objectives.

At the highest level, quality goals and plans should be integrated with overall strategic plans of the organization. As organizational objectives and plans are deployed throughout the organization, each function fashions its own best way for contributing to the top-level goals and objectives.

At lower levels, the quality plan assumes the role of an actionable plan. Such plans may take many different forms depending on the outcome they are to produce. Quality plans may also be represented by more than one type of document to produce a given outcome.

Quality assurance or quality control plans evaluate and/or modify an organization's procedures to help ensure they provide the desired results. Quality control plans are often viewed as a set of instructions that should be followed. They document the planning, implementation, and assessment procedures for a project, as well as any QA or QC activities.

A quality assurance plan is more of a detailed document that outlines how a company will ensure the quality of its products or services. It includes all quality control procedures, policies, and standards that a company must follow to ensure that its products or services meet all customer requirements. Creating a quality assurance plan may seem daunting, but it doesn't have to be.

Notes: It is important to note that each plan is unique based on the organization's needs and their quality management system (QMS). However, quality control plans should always have a structure that permits improvements to the plan. This allows employees to offer input on how to improve efficiency and quality. In addition, the plan should be reviewed by others periodically, including stakeholders, to ensure the plan is comprehensive.

Quality assurance or control plans generally include detailed information on:

- An overview or introduction of the project or process detailing the background, need, scope, activities, and important dates or deadlines.
- The organizational structure or org chart detailing necessary team members, including external vendors.
- Each team member's responsibilities and qualifications necessary to fulfill stated duties.
- Work verification (for example, who is responsible for carrying out a task, as well as who is responsible for checking the work).
- Supplier standards
- A list of qualified suppliers
- Testing parameters
- Performance standards and how performance will be documented
- Acceptance criteria
- Deliverables
- A feedback mechanism for internal and/or external customer feedback.
- Quality control procedures
- Audits
- Training
- Corrective action and preventive actions, including the person(s) responsible for CAPA.
- Suggested corrective action
- Required notifications
- Any references or related materials, including performance ratings or performance reports

Steps to Create Quality Assurance Plans

There are 9 steps for creating a great quality assurance plan to help a company meet all its quality goals:

Setting procedures and policies for all

Setting procedures and policies for all is the first step in creating a quality assurance plan. By doing this, you will ensure that everyone involved in the project understands what is expected of them and how they should go about meeting those expectations.

There are various things to consider when setting procedures and policies, including:

- What standards will be used to assess quality?
- How will those standards be enforced?
- Who will be responsible for ensuring that quality standards are met?

- What processes will be implemented to check for compliance with quality standards?
- How will non-compliance be dealt with?

Once you have established procedures and policies for all aspects of the project, you can create specific quality assurance plans for individual tasks.

Schedule roles and responsibilities

When creating a quality assurance plan, scheduling roles and responsibilities is essential. It will ensure that everyone knows their part in the process and that tasks are properly completed. Here, are some tips for scheduling roles and responsibilities:

- Define who will be responsible for each task.
- Delegate tasks based on skillset and experience.
- Set deadlines for each task.
- Hold regular meetings to check in on progress and cater to any issues.

By scheduling roles and responsibilities, you can create a quality assurance plan that will run smoothly and efficiently.

Documentation in different phases

Documentation is an integral part of quality assurance. It provides a record of what has been done and can be used to help track progress and identify areas for improvement. Documentation can be divided into different phases, each with its purpose. The first phase of documentation is the planning phase. It is when the project manager creates a high-level plan for the project. The plan includes the overall objectives, scope, timeline, and budget. This phase also includes creating a quality assurance plan. The quality assurance plan outlines how the project will be monitored and controlled.

The second phase of documentation is the execution phase. This is when the actual work of the project is carried out. During this phase, documents are created that describe how the work was done and what was accomplished. These documents can help assess whether the project met its objectives and identify any areas for improvement. The third phase of documentation is the monitoring and evaluation phase. It is when quality assurance activities are carried out to ensure that the project remains on track and meets its objectives. If problems are identified, they are documented, and corrective actions are taken to address them. The fourth and final phase of documentation is the closure phase. This is when the project is completed, and all remaining work is documented. The closure report includes a summary of the project, an assessment of its success, and recommendations for future projects.

Review and Audit

Reviewing and auditing in a quality assurance plan is a process of monitoring the quality of the products or services being delivered by a company. This can be done internally by employees or externally by independent third-party organizations. The purpose of reviewing and auditing is to ensure that the company meets its quality standards and delivers its products or services consistently and reliably. There are many benefits to conducting reviews and audits as part of a quality assurance plan:

- It helps to identify the areas where the company may fall short of its quality standards. This information can be used to improve how the company operates.
- The review and audit results can provide valuable feedback to management about how well the company’s quality assurance plan is working.
- Regular reviews and audits can help build confidence among customers and other stakeholders in the company’s ability to deliver high-quality products or services.

Testing phase

Testing helps to ensure that products and systems are designed and built correctly and meet customer expectations. The testing phase in the quality assurance plan is verifying that a product or system meets the requirements specified in the design. It also includes checking to see if the product or system works as expected and identifying any areas where it does not meet the requirements.

This allows businesses to make necessary improvements before release, which can save time and money in the long run. A well-executed testing phase can also help to boost customer confidence in a product or service.

- Functional testing focuses on the specific features of your software and how well they work. For example, if you're developing a web application, functional testing would involve: Testing things like login functionality, adding items to a shopping cart, checking out.
- Non-functional testing assesses how well your software performs in terms of things like speed, scalability, and security. This type of testing is significant for web applications since they need to handle large amounts of traffic and data.

Troubleshooting problems

There are some general steps that you can take to troubleshoot any problems that may arise:

- First, identify the problem. This may seem obvious, but it's essential to be specific when identifying the issue. What exactly is not working? What are the symptoms?
- Once you've identified the problem, try to reproduce it. This will help you narrow down the potential causes of the issue.
- Once you've reproduced the problem, start eliminating potential causes one by one. Check for common issues, such as incorrect configuration or data entry errors.
- If you're still having trouble finding the root cause of the problem, consider enlisting the help of a more experienced colleague or consultant.
- Finally, document what went wrong and how you fixed it once you've found and resolved the issue.

Project control

Project control in a quality assurance plan is the process of monitoring and regulating the progress of a project to ensure that it meets the requirements for quality. It involves setting up a system to track progress, identify issues and risks, and take corrective action as needed. Project control helps to ensure that a project stays on track and meets its objectives. It can help identify potential problems early on, so they can be catered to before they cause significant delays or cost overruns. It also allows stakeholders to see the project's progress and whether it is meeting their expectations.

Training

When it comes to creating a quality assurance plan, training is one of the most critical steps. After all, if your team isn't adequately trained on how to implement and follow the plan, it won't be effective. The two main types of training should be included in the quality assurance plan:

- Initial training– This is the training that should be provided to new employees or those who will be responsible for carrying out the quality assurance plan. It should cover the basics of the plan and how it should be implemented.
- Ongoing training– Once the initial training is complete, ongoing training should be provided on an as-needed basis. This could include refresher courses or more detailed training on specific aspects of the plan.

Risk Management

Risk management is a vital element of any quality assurance plan. By identifying and assessing risks early on, you can avoid potential problems down the road. There are few ways for creating an effective risk management plan:

1. Identify all potential risks: It includes both external and internal risks.
2. Assess the probability and impact of each risk: How likely is the risk that will occur? And if it does occur, how severe will the impact be?

3. Create mitigation strategies for each risk: Once you've identified and assessed the risks, it's time to develop mitigation strategies.
4. Implement and monitor your risk management plan: Regularly monitor your plan to ensure it effectively reduces or eliminates risks. Make necessary adjustments as needed.

Best Practices of a Quality Assurance Plan

The best practices of a quality assurance plan are necessary to follow to create a great plan. Four main best practices should be followed:

- Define the scope of the quality assurance plan.
- Identify who is responsible for each step of the quality assurance process.
- Develop measurable criteria for assessing whether quality objectives have been met.
- Establish a process for monitoring progress and taking corrective action as needed.

Benefits of Quality Assurance Plans

Quality assurance plan is a document that outlines the processes and procedures that will be followed to ensure quality standards are met. It is an essential tool for any business, as it can help to improve customer satisfaction, reduce costs, and increase efficiency. There are many benefits to having a quality assurance plan in place (Figure 6):

- Improved customer satisfaction- One of the essential advantages of having a quality assurance plan is that it can lead to improved customer satisfaction. Customers who receive products or services that meet their expectations are more likely to be satisfied with the purchase.
- Reduced costs- Another benefit of implementing a quality assurance plan is that it can help to reduce costs associated with rework or product defects. By ensuring that products meet quality standards before they are released to customers, businesses can avoid the costly process of fixing issues after the fact.

Figure 6: Benefits of Quality Assurance Plans

- Increased Efficiency- Having a quality assurance plan can also help increase efficiency within your business operations. When everyone understands the procedures that need to be followed and there is a straightforward process for measuring quality, it becomes easier to streamline operations and eliminate wastefulness. This increased efficiency can save the company time and money in the long run.
- Greater competitiveness- In today's marketplace, the businesses need to be able to compete on quality as well as price. Having a quality assurance plan in place can demonstrate to potential customers that you are serious about providing high-quality products and services.

- Enhanced reputation- Finally, another benefit of having a quality assurance plan is that it can help to enhance your company's reputation. When customers know that you have high standards for quality, they will be more likely to trust your brand.

Notes: Quality Assurance vs. Quality Control

The main difference between QA and QC is that quality assurance focuses on planning to prevent risks that could affect quality during the production of services or goods, while quality control focuses on testing the quality of the output once the product or service has been delivered.

Summary

- Software quality products are defined in terms of its fitness of purpose. Software quality is defined as a field of study and practice that describes the desirable attributes of software products.
- Software quality models are a standardized way of measuring a software product. They are proposed to measure the quality of any software model. There are widely accepted models when it comes to measuring software quality.
- ISO9126-1 symbolizes the latest research into characterizing software for the purposes of software quality control, software quality assurance and software process improvement (SPI).
- Software quality measurement is about quantifying to what extent a system or software rates along these dimensions. The analysis can be performed using a qualitative or quantitative approach or a mix of both; to provide an aggregate view [using for example weighted average(s) that reflect relative importance between the factors being measured].
- Creating a product within a safe and secure circumstance is essential. Maintaining product quality throughout production is a crucial factor.
- Quality Process specializes in the efficient development and delivery of appealing and satisfying customer experiences that aid our clients in their success.
- An effective quality management process provides support for rapid adoption, consistent and repeatable application of quality improvement methodologies.
- Function point analysis measures the size of the software deliverable from a user's perspective.

Keywords

Software Quality: Software quality is defined as a field of study and practice that describes the desirable attributes of software products.

Metrics: Metrics are pointers or numbers which help you understand the attributes of a product, the attributes of the process and the attributes of the project.

Product Metrics: Product metrics are used to evaluate the state of the product, tracing risks and undercover prospective problem areas.

Process Metrics: Process metrics pay particular attention to enhancing the long-term process of the team or organization.

Quality Management: Quality management is the act of overseeing different activities and tasks within an organization to ensure that products and services offered, as well as the means used to provide them, are consistent.

Structural quality analysis and measurement: Structural quality analysis and measurement is performed through the analysis of the source code, the architecture, software framework, database schema in relationship to principles and standards that together define the conceptual and logical architecture of a system.

Self Assessment

1. SPI stands for
A. Software Power Implementation
B. Software Project Implementation
C. Software Process Improvement
D. Super Proportion Improvement

2. Maintainability stands for,
A. Modularity
B. Changeability
C. Reusability
D. All the above.

3. Measuring software size requires that the whole source code be correctly gathered, including database structure scripts, data manipulation source code, component headers, configuration files etc.
A. True
B. False

4. The statement(s) aptly describing about Function Point Analysis is/are
A. Function point analysis measures the size of the software deliverable from a user's perspective.
B. Function point sizing is done based on user requirements.
C. Function point analysis provides an accurate representation of both size for the developer/estimator and value (functionality to be delivered) and reflects the business functionality being delivered to the customer.
D. All the above.

5. The full form of FPA is
A. Function Pointer Accomplishment
B. Function Point Analysis
C. Formula Pointer Accomplishment
D. Formula Point Analysis

6. _____________ model is mainly focused on the attributes and sub-attributes to connect properties of the software to the quality attributes.
A. Boehm’s
B. SATC's
C. Dromey’s
D. FURPS

7. Metrics are pointers or numbers which help you understand the attributes of a product, process, and project.
A. True
B. False

8. ISO9126 is a worldwide standard for the evaluation of software. The standard is split into four parts. Which of the following is one of the four metrics?

A. quantity model

B. extern matters

C. quality in use metrics

D. intern matters

9. Quality management is,

A. an act of overseeing different activities and tasks within an organization.

B. ensures that products and services offered, as well as the means used to provide them, are consistent.

C. helps to achieve and maintain a desired level of quality within the organization.

D. All the above.

10. Product quantity refers to how well a product satisfies customer needs, serves its purpose, and meets industry standards.

A. True

B. False

11. The metrics used to evaluate the state of the product, tracing risks and undercover prospective problem areas.

A. Product metrics

B. Process metrics

C. Project metrics

D. Analysis metrics

12. Quality management process improvements lead to

A. time-to-market benefits

B. increased competitive advantage

C. happier customers

D. All the above.

13. ISO 9000 defines a set of guidelines for the production process and is not directly concerned about the product itself.

A. True

B. False

14. Which of the following encompass(es) the quality system activity(ies)?

A. Auditing of projects

B. Review of the quality system

C. Development of standards, methods, and guidelines

D. All the above.

15. A software defect can be regarded as any failure to address end-user requirements. Defects are commonly categorized by

A. softness
B. severity
C. availability
D. None of the above.

Answers for Self Assessment

1.	C	2.	D	3.	A	4.	D	5.	B
6.	C	7.	A	8.	C	9.	D	10.	B
11.	A	12.	D	13.	A	14.	D	15.	B

Review Questions

1. What does software quality means. What techniques are used to enhance the software quality?
2. Discuss external standard.
3. What steps are used to create quality assurance plans?
4. What are the steps for product quality management?
5. How do quality assurance plans aid in quality management?
6. What are quality assurance plans and list their benefits?
7. Indicate the various steps for product quality management.
8. What is different ISO 9000 standards?
9. Discuss software quality measurement.
10. Write a short note on:
   (a) Software quality
   (b) Importance of product quality

Further Readings

Robert K. Wyzocki, Rudd McGary, Effective Project Management, WILEYDreamtech India Pvt. 8th edition, 2019.

Roger S. Pressman, Software Engineering a Practitioner's Approach, Fourth Edition, McGraw Hill International, 2005.

Bob Hughes, Mike Cotterell, Software and Project Management, Tata McGraw-Hill Publishing Company Limited, Fifth Edition, 2009.

Web Links

Software Engineering | Software Quality - javatpoint

Software Engineering | ISO 9000 Certification - javatpoint

What is Software Quality? and How to achieve it? - Testbytes https://youtu.be/YmscnVRLwy0

https://youtu.be/e-jDBB-pE-E

https://youtu.be/ifrFnUcSmG4

https://youtu.be/M1uc3Fq5z4c

What is a Quality Management System (QMS)? | ASQ

Quality Management- Understanding How Quality Management Works (corporatefinanceinstitute.com)

What is Product Quality? 7 Steps of Products Quality Management (marketing91.com)

Dr. Tarandeep Kaur, Lovely Professional University

Unit 12: Software Configuration Management (SCM)

CONTENTS

Objectives

After studying this unit, you will be able to:

- understand the basics of Software Configuration Management (SCM)
- know the purpose and members of SCM.
- explore the process of SCM.
- learn about different SCM tools.
- analyze the concept of contract management in detail.

Introduction

Whenever a software is built, there is always scope for improvement and those improvements bring changes in picture. The changes may be required to modify or update any existing solution or to create a new solution for a problem. The requirements keep on changing on a daily basis and so we need to keep on upgrading our systems based on the current requirements and needs to meet desired outputs.

Changes should be analyzed before they are made to the existing system, recorded before they are implemented, reported to have details of before and after, and controlled in a manner that will improve quality and reduce error. This is where the need for System Configuration Management comes. It is essential to control the changes because if the changes are not checked legitimately then they may wind up undermining a well-run programming. SCM is a fundamental piece of all project management activities.

System Configuration Management (SCM) is an arrangement of exercises which controls change by recognizing the items for change, setting up connections between those things, making/characterizing instruments for overseeing diverse variants, controlling the changes being executed in the current framework, inspecting and revealing/reporting on the changes made.

Software Configuration Management (SCM) is a process to systematically manage, organize, and control the changes in the documents, codes, and other entities during the Software Development Life Cycle. The primary goal is to increase productivity with minimal mistakes. SCM is part of cross-disciplinary field of configuration management, and it can accurately determine who made which revision (Figure 1).

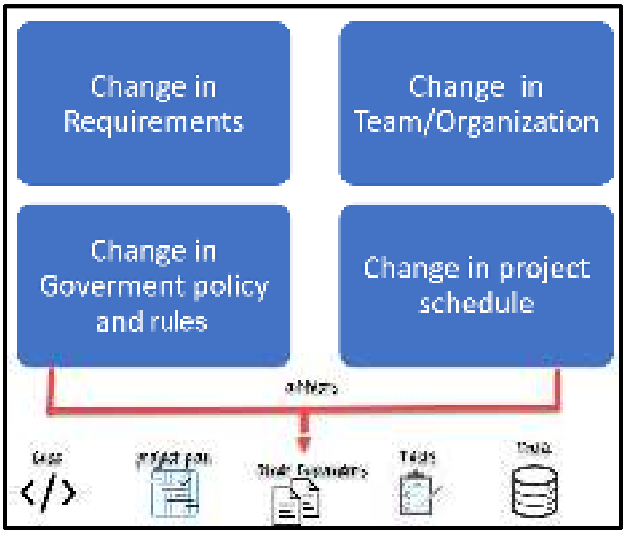

Figure 1: Need for Configuration Management

The primary reasons for Implementing Technical Software Configuration Management System are:

- There are multiple people working on software which is continually updating.
- It may be a case where multiple versions, branches, and authors are involved in a software config project, and the team is geographically distributed and works concurrently.
- Changes in user requirement, policy, budget, schedule need to be accommodated.
- Software should be able to run on various machines and Operating Systems.
- Helps to develop coordination among stakeholders.
- SCM process is also beneficial to control the costs involved in making changes to a system.
- Any change in the software configuration Items will affect the final product. Therefore, changes to configuration items need to be controlled and managed.

12.1 Key Objectives of SCM

System Configuration Management (SCM) is a software engineering practice that focuses on managing the configuration of software systems and ensuring that software components are properly controlled, tracked, and stored. It is a critical aspect of software development, as it helps to ensure that changes made to a software system are properly coordinated and that the system is always in a known and stable state.

SCM is a critical component of software development, and effective SCM practices can help to improve the quality and reliability of software systems, as well as increase efficiency and reduce the risk of errors.

- Control the evolution of software systems: SCM helps to ensure that changes to a software system are properly planned, tested, and integrated into the final product.

- Enable collaboration and coordination: SCM helps teams to collaborate and coordinate their work, ensuring that changes are properly integrated and that everyone is working from the same version of the software system.
- Provide version control: SCM provides version control for software systems, enabling teams to manage and track different versions of the system and to revert to earlier versions if necessary.
- Facilitate replication and distribution: SCM helps to ensure that software systems can be easily replicated and distributed to other environments, such as test, production, and customer sites.
- Enforcement: With enforcement feature execution, SCM ensures that the system is configured to the desired state.
- Cooperating Enablement: This feature helps to make the change configuration throughout the infrastructure with one change.
- Version Control Friendly: With this feature, the user can take their choice of version for their work.
- Enable Change Control Processes: As Software Configuration Management tools are version control and textual friendly, we can make changes in code. Changes can be made as a merge request and send for review.

12.2 Participants of SCM Process

Figure 2 depicts the different participants of SCM process.

- Configuration Manager: The configuration manager is the head who is responsible for identifying configuration items. CM ensures team follows the SCM process. He/ She needs to approve or reject change requests.
- Developer: The developer needs to change the code as per standard development activities or change requests. He/she is responsible for maintaining the configuration of the code. The developer should check the changes and resolve conflicts.
- Auditor: The auditor is responsible for SCM audits and reviews and needs to ensure the consistency and completeness of a release.

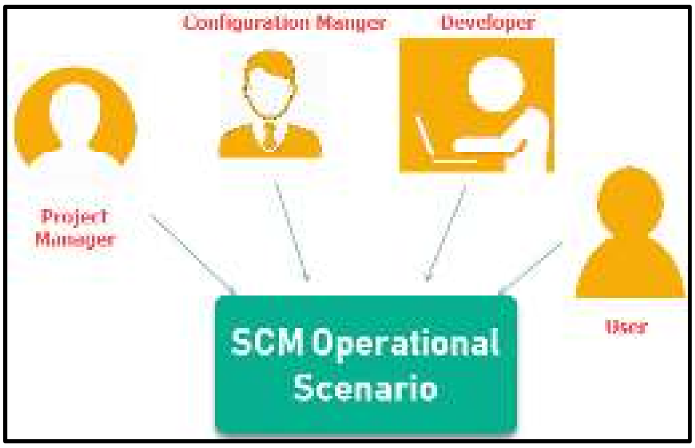

Figure 2: SCM Participants

- Project Manager: A project manager ensures that the product is developed within a certain time frame. A PM monitors the progress of development and recognizes issues in the SCM process and generates reports about the status of the software system. They make sure that processes and policies are followed for creating, changing, and testing.

- User: The end user should understand the key SCM terms to ensure he has the latest version of the software.

Advantages of SCM

- Improved productivity and efficiency by reducing the time and effort required to manage software changes.
- Reduced risk of errors and defects by ensuring that all changes are properly tested and validated.
- Increased collaboration and communication among team members by providing a central repository for software artifacts.
- Improved quality and stability of software systems by ensuring that all changes are properly controlled and managed.

Disadvantages of SCM

- Increased complexity and overhead, particularly in large software systems.
- Difficulty in managing dependencies and ensuring that all changes are properly integrated.
- Potential for conflicts and delays, particularly in large development teams with multiple contributors.

12.3 Process of Software Configuration Management (SCM)

System Configuration Management (SCM) is a software engineering practice that focuses on managing the configuration of software systems and ensuring that software components are properly controlled, tracked, and stored. It is a critical aspect of software development, as it helps to ensure that changes made to a software system are properly coordinated and that the system is always in a known and stable state.

SCM involves a set of processes and tools that help to manage the different components of a software system, including source code, documentation, and other assets. It enables the teams to track changes made to the software system, identify when and why changes were made, and manage the integration of these changes into the final product. The configuration management provides a disciplined environment for smooth control of work products. It involves the following activities (Figure 3):

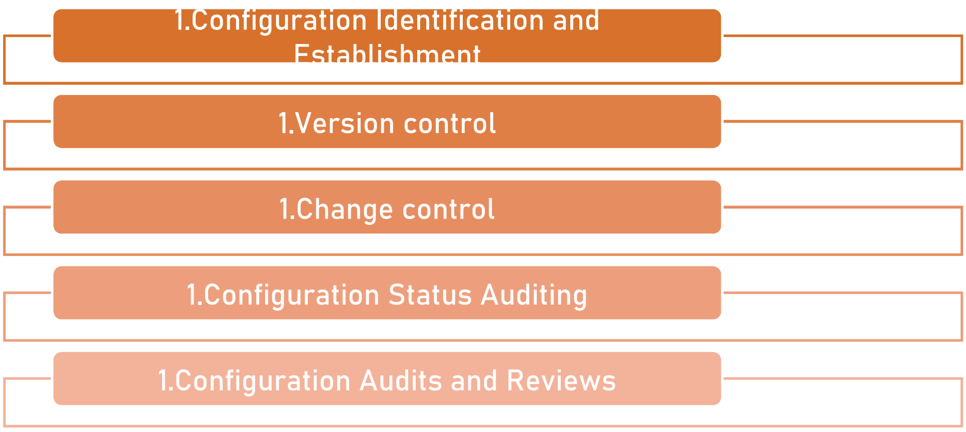

Figure 3: SCM Process

1. **Configuration Identification and Establishment:** Configuration identification is a method of determining the scope of the software system. With the help of this step, you can manage or

control something even if you don't know what it is. It is a description that contains the CSCI type (Computer Software Configuration Item), a project identifier and version information. It involves identifying the Configuration Items (CI) from products that compose baselines at given points in time (a baseline is a set of mutually consistent Configuration Items (CI), which has been formally reviewed and agreed upon, and serves as the basis of further development). Establishing relationships among items, creating a mechanism to manage multiple levels of control and procedure for change management system. The configuration identification and establishment consist of following activities:

- Identification of configuration Items like source code modules, test case, and requirements specification.
- Identification of each CSCI in the SCM repository, by using an object-oriented approach
- The process starts with basic objects which are grouped into aggregate objects. Details of what, why, when and by whom changes in the test are made.
- Every object has its own features that identify its name that is explicit to all other objects.
- List of resources required such as the document, the file, tools, etc.

2. Version control: This involves creating versions/specifications of the existing product to build new products with the help of SCM system.

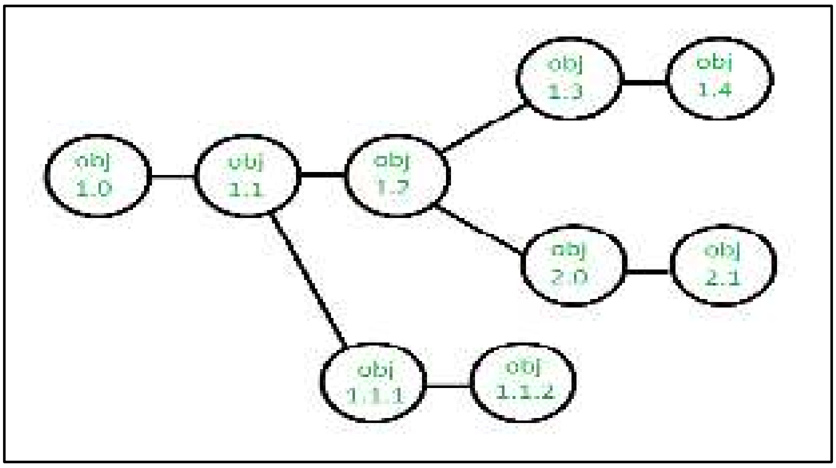

Figure 4: Version Control

A description of version is given in the Figure 4: Suppose after some changes, the version of configuration object changes from 1.0 to 1.1. Minor corrections and changes result in versions 1.1.1 and 1.1.2, which is followed by a major update that is object 1.2. The development of object 1.0 continues through 1.3 and 1.4, but finally, a noteworthy change to the object results in a new evolutionary path, version 2.0. Both versions are currently supported.

3. Change control

Change control is a procedural method which ensures quality and consistency when changes are made in the configuration object. In this step, the change request is submitted to software configuration manager. It involves controlling changes to Configuration Items (CI). It involves the following activities:

- Control ad-hoc change to build stable software development environment. Changes are committed to the repository.
- The request will be checked based on the technical merit, possible side effects and overall impact on other configuration objects.

- o It manages changes and makes configuration items available during the software lifecycle.

A change request (CR) is submitted and evaluated to assess technical merit, potential side effects, overall impact on other configuration objects and system functions, and the projected cost of the change. The results of the evaluation are presented as a change report, which is used by a change control board (CCB)- a person or group who makes a final decision on the status and priority of the change.

An Engineering Change Request (ECR) is generated for each approved change. Also, CCB notifies the developer in case the change is rejected with proper reason. ECR describes the change to be made, the constraints that must be respected, and the criteria for review and audit. The object to be changed is "checked out" of the project database, the change is made, and then the object is tested again. The object is then "checked in" to the database and appropriate version control mechanisms are used to create the next version of the software.

4. **Configuration Status Auditing:** Configuration status accounting tracks each release during the SCM process. This stage involves tracking what each version has and the changes that lead to this version. A software configuration audit complements the formal technical review of the process and product. It focuses on the technical correctness of the configuration object that has been modified. The audit confirms the completeness, correctness, and consistency of items in the SCM system and track action items from the audit to closure. It involves the following processes:
   - o Keeps a record of all the changes made to the previous baseline to reach a new baseline.
   - o Identify all items to define the software configuration.
   - o Monitor status of change requests.
   - o Complete listing of all changes since the last baseline.
   - o Allows tracking of progress to the next baseline.
   - o Allows to check previous releases/versions to be extracted for testing.

This phase answers the following questions:

- o What elements are to be tracked and reported for baselines and changes?
- o What types of status accounting reports are to be generated? What is their frequency?
- o How is information to be collected, stored, and reported?
- o How is access to the configuration management status data controlled?

5. **Configuration Audits and Reviews:** Software Configuration audits verify that all the software product satisfies the baseline needs. It ensures that what is built is what is delivered. It involves providing accurate status and current configuration data to developers, tester, end users, customers and stakeholders through admin guides, user guides, FAQs, Release notes, Memos, Installation Guide, Configuration guide etc. The activities included in this are:

- o Configuration auditing is conducted by auditors by checking that defined processes are being followed and ensuring that the SCM goals are satisfied.
- o To verify compliance with configuration control standards. auditing and reporting the changes made.
- o SCM audits also ensure that traceability is maintained during the process.
- o Ensures that changes made to a baseline comply with the configuration status reports.
- o Validation of completeness and consistency.

12.4 Software Configuration Management Planning

Software configuration management planning starts during the early phases of a project. The outcome of the SCM planning phase is the Software Configuration Management Plan (SCMP)

(Figure 5) which might be extended or revised during the rest of the project. The SCMP can either follow a public standard like the IEEE 828, or an internal (example, company specific) standard.

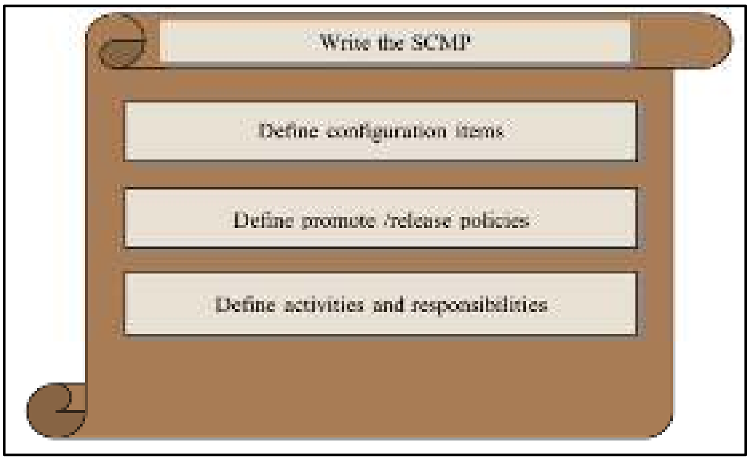

Figure 5: Software Configuration Management Plan

12.5 Software Configuration Management Plan (SCMP)

SCMP defines the types of documents to be managed and a document naming scheme. It defines who takes responsibility for the configuration management procedures and creation of baselines. Also, it defines policies for change control and version management.

SCMP describes the tools which should be used to assist the configuration management process and any limitations on their use. It defines the configuration management database used to record configuration information. The SCMP has the following sections:

- Introduction: It describes the plan's purpose, scope of application, key terms, and references.
- SCM management (WHO?): Identifies the responsibilities and authorities for managing and accomplishing the planned SCM activities.
- SCM activities (WHAT?): Identifies all activities to be performed in applying to the project.
- SCM schedule (WHEN?): Establishes required coordination of SCM activities with other activities in the project.
- SCM resources (HOW?): Identifies the tools, physical, and human resources required for the execution of the plan.
- SCM plan maintenance: Identifies how the plan will be kept current while in effect.

SCMP Section 1: Introduction

- Overview description of the software project.
- Identification of the software CI(s) to which SCM will be applied.
- Identification of other software to be included as part of the plan.
- Relationship of SCM to the hardware or system configuration management activities for the project.
- The degree of formality, depth of control, and portion of the software life cycle for applying SCM on this project.
- Limitations, such as time constraints, that apply to the plan.
- Assumptions that might have an impact on the cost, schedule, or ability to perform defined SCM activities.

SCMP Section 2: SCM Management

- Organizational context (technical and managerial) within which the configuration management activities are implemented.
- Responsibilities
  - o List name or job title of people how perform activities.
  - o For each board, list
  - o purpose and objectives
  - o membership and affiliations
  - o period of effectivity
  - o scope of authority
  - o operational procedures

SCMP Section 3: SCM Activities (1/2)

- ❑ Configuration identification
  - o Identify configuration items (events, items, procedures)
  - o Name configuration items (unique identifiers)
  - o Acquiring configuration items (physical procedures)
- ❑ Configuration control
  - o Requesting changes
  - o Evaluating changes
  - o Approving or disapproving changes
  - o Implementing changes
- ❑ Configuration status accounting
  - o Metrics to be tracked and reported and type of report.
  - o Storage and access control of status data.

SCMP Section 3: SCM Activities (2/2)

- ❑ Configuration evaluation and reviews
  - o At minimum, an audit on a CI prior to its release.
  - o Defines objective, schedule, procedures, participants, approval criteria etc.
- ❑ Interface control
  - o Coordination of changes to CIs with changes to interfacing items outside of the scope of the plan.

SCMP Section 4: SCM Schedules

- Sequence and coordination of SCM activities.
- Relationship of key SCM activities to project milestones or events, such as
  - o Establishment of configuration baseline.
  - o Implementation of change control procedures.
  - o Start and completion dates for a configuration audit.
- Schedule either as absolute dates, relative to SCM or project milestones or as sequence of events.
- Graphical representations can be used here.

SCMP Section 5: SCM Resources

- Identifies environment, infrastructure, software tools, techniques, equipment, personnel, and training.

- Key factors for infrastructure: functionality, performance, safety, security, availability, space requirements, equipment, costs, and time constraints; Identify which tools etc. are used in which activity.

SCMP Section 6: SCM Plan Maintenance

This section answers the following questions:

- Who is responsible for monitoring the plan?
- How frequently updates are to be performed?
- How changes to the plan are to be evaluated and approved?
- How changes to the plan are to be made and communicated?
- Also, it includes the history of changes made to the plan.

12.6 Software Configuration Management (SCM) Tools

Software Configuration Management is the task of tracking and controlling changes in the software part of the larger disciplinary field of configuration management. The SCM practices include vision controls in the establishment of baselines. If something goes wrong, SCM can determine what was changed and who changed it.

The term "management of configuration" appeared quite often in the IT industry. Several companies expect IT services to be available at maximum efficiency and without interruption. The administrators need a structured server design and management approach to satisfy these demands.

Ideally, the tools for configuration management will support multiple operating systems. That is why supplier build the configuration management tools to help servers control networks and lock systems to optimum configuration.

Key Features Requirements of SCM Tools

Any change management software should have the following 3 key features:

- Concurrency Management: When two or more tasks are happening at the same time, it is known as concurrent operation. Concurrency in context to SCM means that the same file being edited by multiple persons at the same time. If concurrency is not managed correctly with SCM tools, then it may create many pressing issues.
- Version Control: SCM uses archiving method or saves every change made to file. With the help of archiving or save feature, it is possible to roll back to the previous version in case of issues.
- Synchronization: The users can check out more than one file or an entire copy of the repository. The user then works on the needed file and checks in the changes back to the repository. They can synchronize their local copy to stay updated with the changes made by other team members.

The following are the various SCM tools:

SolarWinds Server Configuration Monitor: SolarWinds provides a Server Configuration Monitor to detect unauthorized configuration changes to your servers and applications. It will help you to baseline server and application configurations on Windows and Linux. It will improve visibility & team accountability and decrease the troubleshooting time. The prominent features of SolarWinds are:

- SolarWinds Server Configuration Monitor provides alerts and reports for deviations from the baseline in almost real-time.
- It can track server and application changes.
- It has features to spot the differences between configs.

- It has enhanced change auditing capabilities by monitoring the script outputs.

It has various advantages that include:

- The tool provides the features to help you decrease the troubleshooting time.
- It provides the facility of hardware and software inventory tracking and hence you will have an up-to-date list of hardware and software assets.

Notes: Why should SolarWinds be chosen?

The solution is for multiple projects, easy to understand, and offers affordable licensing.

Auvik: Auvik is the provider of cloud-based network management tools. These tools offer true network visibility and control. It provides real-time network mapping & inventory, automated config backup & restore on network devices, deep insights of network traffic, and automated network monitoring. It helps with managing the network from anywhere you are. The prominent features include:

- Configuration management
- Automated network discovery, mapping, and inventory.
- Network monitoring & alerting.
- Application visibility powered by machine learning.
- Syslog search, filter, export capabilities, etc.

ManageEngine Endpoint Central: Endpoint Central is a tool one can employ to keep sensitive business data secure on managed endpoints from all sorts of cyber-attacks. One of the ways in which it does so is by managing software configurations. Endpoint Central offers solutions that can detect potentially harmful software misconfigurations and fix them to prevent security breaches. The key features are:

- Audit high-risk software to detect misconfigurations.
- Download, test, and deploy patches automatically.
- Continuously monitor all software on enterprise network.
- Comprehensive analytical reporting.

Notes: Why should Endpoint Central be chosen?

With Endpoint Central, you get a comprehensive suite of robust unified endpoint management and security solutions.

SysAid: With SysAid, you are basically getting a complete ITIL package that can be customized as per the specific requirements of your organization. The software excels at tracking changes to software and hardware components of a business in real-time. The system will notify you of any configuration changes in your CPU, memory usage, network equipment, and more. The prominent features include:

- Asset Monitoring, Management, and Securing directly from the service desk.
- Automated password reset and one-click issue submission.
- Codeless workflow design and editing.
- Redundant IT Task Automation.

Notes: Why should SysAid be chosen?

It is easy to deploy, highly configurable, and delivers AI-driven automation.

CFEngine Configuration Tool: CFEngine is a configuration management tool that provides automation configuration for huge computer systems, inclusive of the unified management of servers, systems, users, embedded networked devices, mobile devices, and systems. It offers many features such as configuration management, process management, task management and patch management.

Puppet Configuration Tool: Puppet is an open-source software configuration management tool. It is used for deploying, configuring, and managing servers. It uses master-slave architecture. The configurations are pulled from the master by the nodes. The prominent features include:

- Reporting and Compliance i.e. gain real-time visibility into the state of your infrastructure.
- Event Inspection
- Automated Provisioning
- Get enterprise support all-day
- Orchestration

There are many positive aspects as mentioned below:

- Puppet has strong compliance in automating and reporting tools.
- Puppet provides active community support across development tools.
- Puppet provides an Intuitional web UI to handle multiple tasks, which includes reporting and real-time node management.

CHEF Configuration Tool: The chef is basically an automation platform that provides a way to configure and manage infrastructure. Infrastructure as code implies executing by coding rather than doing manual execution. The chef works on Ruby and DSL for writing the configurations. There are many reasons to prefer CHEF:

- Chef supports multiple platforms like Microsoft Windows and Ubuntu and also some client platforms like Debian and Fedora etc.
- Chef provides an active, smart and fastest-growing community support.
- Chef follows the Push model and allows cloud adoption.
- Chef helps to increase service resiliency, to develop more defect-free software as it captures bugs before they occur.
- Chef helps to improve risk management. Chef's automation abilities are able to lower risk and improve compliance at all stages of development.

Ansible Configuration Tool: It is an open-source software configuration management tool. Apart from configuration management, it also offers application deployment & task automation. Ansible is the best configuration management, deployment, orchestration tool and also an automation engine. It is a push-based configuration tool. It helps to automate the entire IT infrastructure by providing large productivity gains. Ansible generally connects through SSH, remote PowerShell or via other remote APIs. The feature of configuration tool Ansible are:

- Agentless means no need for agent installation and management.
- Uses SSH for secure connections.
- Follows push-based architecture for sending configurations so that the user can control the changes made on servers.
- Ansible can be idempotent if written carefully.
- Minimal learning is required.

SALTSTACK Configuration Tool: SaltStack is also a configuration tool that works on a master-client setup model or a non-centralized model. SaltStack is based on Python programming language, SaltStack provides a push and SSH methods to communicate with clients. SaltStack allows to group together clients and configuration templates to take control of the environment simple and easy. The most important features of Saltstacks are as follows:

- Salt Cloud integrates with many other cloud providers like Google Cloud, AWS, etc. so it's easy to take benefit of all the assets with one command.
- Saltstack has minions that can check files, processes also host other things.

- With orchestrate in bucket Saltstack deploys a complex application by executing single-line commands.

The major advantages include:

- It is simple, straight and usage is easy once you go through the setup phase.
- Saltstack has a DSL feature, so it doesn't require logic and states.
- Saltstack's input, output, and configs are very stable and consistent because it uses the concept of YAML.
- The introspection feature plays a handy role as it makes it simple to look at what is happening inside Salt.

JUJU Configuration Tool: Juju is one of the famous configuration management tools which is open-source and is created by Canonical Ltd. Juju mainly emphasizes on decreasing the operational overhead of new generation software by providing facilities like quick deployment, configuring, scaling, integration, and doing operational tasks on a huge range of public and private cloud services along with only servers, open stacks, and local system-based deployments. It has several features that include:

- It provides software provisioning capabilities.
- Offers instant integration and scaling.
- It can resolve almost all complexities regarding service scaling by using charm.
- It can be used to run multiple PaaS on a platform.
- Kubernetes cluster deployment.

RUDDER: The rudder is one of the famous and most used open-source, web-driven, role-based solutions, configurations, and audit management tools to make automated system configuration across huge IT organizations and compliance. Rudder depends on a light local agent which are installed on each and every managed system. Rudder's server-side web interface is built by Scala language and its local agent is written in C language. The different features of RUDDER are:

- Rudder Tool provides Web Interface to manage the nodes and also define policies.
- Rudder hosts the inventory part.
- Rudder provides a custom policy editor, which is very unique.
- Rudder automates the simple tasks of administration like installing or configuring.
- Rudder supports FULL REST API to communicate with Rudder Server.
- The rudder has GIT in its backend.
- Rudder dynamically generates each host policy.

Bamboo Configuration Management: Bamboo is one of Atlassian's continuous delivery and releases management tools. Bamboo offers a high standard of support for regular delivery. Bamboo gives output as a single flow. Bamboo provides developers, testers, build engineers, and system administrators a common shared space to work and share information storing sensitive operations like production deployment and security. The features are:

- Bamboo is basically a tech-stack as it is suitable for any language and other big technologies like AWS, Docker, etc.
- Bamboo provides justice to the deployment of projects and environments.
- Bamboo provides dedicate agents feature, with the help of which user can run hotfixes and critical builds right away and there is no need to wait for it.

TeamCity Configuration Tool: TeamCity is also one of the management and continuous integration server developed by Jet Brains and based on Java Programming Language. TeamCity provides up to 100 build configurations (jobs) and run unlimited builds. Concurrently it runs 3 agents and if needed it to add extra also. It possesses a public bug tracker and forum open to all the users. It's open-source so free for all users. The key features are:

- TeamCity provides technology awareness.
- TeamCity has a configuration feature that avoids code duplication.
- TeamCity version control system is comprehensive.
- TeamCity provides support for integrations.
- TeamCity supports build history.
- TeamCity helps you with multiple ways of interaction, customization, and extending your server.
- Cloud integration functionality is also supported.

ConfigHub: ConfigHub helps the team's control, protect, and customize the whole stack. It allows you, for a given application or distributed system, to save, manage, and distribute program configurations. The different features of ConfigHub are:

- It will eliminate the error and duplicate configuration.
- From one place it will help to configuration all control
- To the system topology, it also has dynamic modeling

Alibaba Configuration Tool: You should centralize program configuration management. The platform strengthens DevOps, Big Data, and Microservices 'application capabilities.

12.7 Contract Management

Managing a project is complex. Project managers are trained to plan schedules and allocate resources to meet deadlines and stay within budgets. But once you're contracting with people outside of the organization, the legal and logistic issues can be overwhelming.

Companies employ contract managers to manage this often-complicated contract process. While not every organization has a contract manager, everyone who is leading a project that employees, vendors and contractors needs to have an understanding of contract management.

Contract management is defined as the overall process of effectively planning, administering and managing commercial contracts with various entities such as vendors, partners, customers, and employees at all stages of their engagement with a business. Contract management is the process of managing legally binding agreements from initiation through to execution. The activities involved can be administrative and strategic- depending on who handles which stage. The objective is to effectively implement contracts and oversee them from beginning to end.

Contract management or contract administration is the management of contracts made with customers, vendors, partners, or employees. It includes negotiating the terms and conditions in contracts and ensuring compliance with the terms and conditions, as well as documenting and agreeing on any changes or amendments that may arise during its implementation or execution. It can be summarized as the process of systematically and efficiently managing contract creation, execution, and analysis for the purpose of maximizing financial and operational performance and minimizing risk.

A contract is a written or oral legally-binding agreement between the parties identified in the agreement to fulfill the terms and conditions outlined in the agreement. A prerequisite requirement for the enforcement of a contract, amongst other things, is the condition that the parties to the contract accept the terms of the claimed contract.

Contracts can be of many types, example, sales contracts (including leases), purchasing contracts, partnership agreements, trade agreements, and intellectual property agreements. There are different types of contracts:

- Sales Contract: A sales contract is a contract between a company (the seller) and a customer where the company agrees to sell products and/or services and the customer in return is obligated to pay for the product/services bought.
- Purchasing Contract: A purchasing contract is a contract between a company (the buyer) and a supplier who is promising to sell products and/or services within agreed terms and

conditions. The company (buyer) in return is obligated to acknowledge the goods / or service and pay for liability created.

- Partnership Agreement: A partnership agreement may be a contract which formally establishes the terms of a partnership between two legal entities such that they regard each other as 'partners' in a commercial arrangement.

12.8 Contract Manager

Some organizations will have a dedicated person for contract management known as a contract manager. They direct and oversee contracts as they move through their lifecycle. In a sense, they're the middlemen who work as a bridge connecting companies, employees, customers, vendors and contractors.

A contract manager will facilitate the negotiations, recommendations and all record-keeping associated with the contract process. They research all legal issues related to the contract and help with negotiating terms and conditions with the client and the third party.

Importance of Contract Management

Contracts are a big deal in modern business. Every business runs on paperwork, and it doesn't take long before effective contract management becomes critical to operational success. Failing to manage contracts correctly is also a costly oversight.

According to the IACCM, the global contract management association, poor contracting practices lead to an average value leakage of around 9.2% of company revenue. The effective contract management helps the businesses to improve outcomes and realize maximum value from their agreements.

How the business manages its contracts- from the systems it uses to how teams work together- will ultimately influence its levels of visibility, control and compliance. The strength of these pillars will determine the business's overall success- so people, processes and technology need to be built with this.

Contract management is important because how you handle the agreements end-to-end will influence the outcomes of the agreements. The process of Contract Lifecycle Management (CLM) is designed to help businesses extract maximum value from contracts while remaining compliant with regulations and staying in control of relationships with third parties.

An effective contract management can be characterized by the phrase "No Surprises". When done right, everyone knows what and when things are expected of them. The business can see what's on the horizon, it can prepare confidently for any audits, and it can demonstrate compliance at any given time.

Building standardized and collaborative contract management processes throughout the organization is important because it gets all stakeholders working in the same way. The business can expect to achieve its negotiated outcomes time and time again- as well as find opportunities to strengthen its position.

Example: To illustrate, suppose a company seeks to engage a supplier for IT services. The company creates a contract specifying work scope, deliverables, timelines, and other relevant terms. Once approved by the chosen vendor and signed by both parties, the contract begins and is managed for performance. As the contract is being carried out, the company assesses the vendor's ability to fulfill obligations and ensure compliance with the contract. This highlights how contract management encompasses the complete contract lifecycle, from creation and initiation to execution and evaluation.

Contract management affects the organization's revenue, budget, and operations. It also influences the way the customers view the organization as well as its public image. The way the company manages its contracts can touch upon almost every aspect of the company. Contracts are crucial to the success of any business arrangement.

Here are some ways that good contract management can affect your business and your bottom line:

- Improves the process for generating, negotiating, signing, and renewing contracts.
- Increases revenue (and reduces expenses) because you can streamline contract creation and implementation processes.
- Creates strong relationships with your partners and vendors because you monitor contract performance and quickly identify problem areas.
- Promotes long-term profitability because you can renew more contracts with the partners who provide the best business opportunities.
- Ensures your suppliers are cooperative and respond to your organization's needs.
- Supports strategic decision making because you can easily see the areas for growth, the partners and vendors that provide the best opportunities, and your organization's ability to commit to additional work.
- Converts your strategy, partnerships, practices, policies, and capabilities into specific terms and conditions for any contract, providing deep insight into your business.
- Through a contract manager, advises C-suite stakeholders and executives on the effectiveness of the contract in implementing the organization's goals.
- Supports commercial management because it ensures that you meet all your legal commitments once you've entered into a contract.
- Helps you assess, monitor, and mitigate financial, legal, and procurement risks.
- Creates standard processes for routine contracts and business, freeing time to address new business prospects and unique or infrequent processes or implementations.

Elements of Successful Contract Management

It isn't enough that an organization has professionals in place to handle contract management. Employees must be augmented with the presence of processes and software companions to satisfy increasing compliance and analytical needs.

- When a contract management strategy is successfully implemented, organizations can expect to see:
- The expected business benefits and financial returns are being realized.
- The supplier is cooperative and responsive to the organization's needs.
- The organization encounters no contract disputes or surprises.
- The delivery of services is satisfactory to both parties.

Contract Lifecycle Management

Contract lifecycle management or CLM is about automating and streamlining the processes involved in contract management's various stages, such as initiation, authoring, process and workflow, negotiation and approval, execution, ongoing management and compliance, and renewal. The end goal is to save time and money while reducing errors.

This is done by using CLM software, which gives users greater visibility into what a corporation is spending and streamlines the contract process for more efficiency leading to lower administrative costs. This is accomplished through management of procurement and sales contracts, automation, standardization and more to create contracts quickly and easily.

Figure 6: Phases of Contract Lifecycle Management

Applying relevant contract management principles and practices throughout the contract lifecycle will create opportunities to restore visibility, take back control, safeguard compliance and create more meaningful relationships with your contracted vendors. The stages of the lifecycle can be grouped into two main areas:

- Pre-signature: A summary term covering the period and actions prior to a contract being signed. Involves steps like contract authoring, templating, redlining and negotiation.
- Post-signature: A summary term covering the period and actions which follow a contract being signed. Includes items such as obligation tracking, performance & compliance management, dispute resolution and contract renewals.

The contract lifecycle can be broken down into different stages (Figure 6):

Stage 1- Request: The request for a new contract usually arrives from the sales team, a hiring manager, or a project stakeholder who is close to reaching a tentative agreement with a client, vendor, or potential hire. When the request is received by the contract manager or designated contracting authority within the organization, this individual notifies all relevant parties— including the legal department and financial team— and oversees the contract throughout its lifecycle. The contract manager may also provide a checklist to project stakeholders or request additional documentation in order to proceed with the procurement or expenditure.

Stage 2- Creation and review: During this stage, the contract agreement is written and reviewed internally by your project stakeholders, legal experts, and the financial team. For complex contracts with specific requests that go beyond a standard boilerplate, this process can take several rounds of negotiation before all teams sign off or approve the document. At this stage of the process, a contract manager will liaise with each department and work to resolve outstanding issues that stop the contract from moving forward.

Stage 3- Pre-approval: When sign-offs from all major departments are complete, the contract is ready to be sent from your company to the vendor, client, or employee. At this stage, the contracting manager sends the contract on behalf of the organization. This is a minor but critical step in CLM because it introduces external partners to the contracting process and positions the contract manager as the primary point of contact to an outside source.

Stage 4- Negotiation and redlining: During this phase of the contract lifecycle, the business and the customer negotiate the terms of the agreement and finalize the details of the contract. During this process, a contract manager may act as a primary point of contact for each side of the negotiation, ensuring that both sides have the documentation that they need to finalize the deal. And that's a good thing because contracts are likely to change hands multiple times.

Stage 5- Signing and capture: This stage of contract management signals that all involved parties are satisfied with the original contract and any negotiated changes.

All parties sign the contract— either physically or via electronic signature— and copies of the contract are captured by all parties. The signing process can be challenging, especially if one side becomes unresponsive during the negotiation process or if new customer stakeholders get involved before the signing process is complete. Based on our internal data, four out of five changes to a contract are related to the signing process. The contract managers and project stakeholders can try to jumpstart negotiations and get their contracts signed more quickly by staying on top of this process and setting firm deadlines.

Stage 6- Execution, management and maintenance: When all sign-offs are completed, the contract is then implemented. The external suppliers follow the letter of the contract to deliver goods and services to the organization, and the organization works to satisfy and maintain that vendor relationship. During this stage, contract managers may act as the primary point of contact for any contracting-related issues that need clarification. They may also issue approvals for invoices or milestone payments and ensure that the contract is maintained by both parties.

Stage 7- Storage, compliance and retention: All of your business contracts should be stored and maintained in accordance with company policy and government regulations. During this stage of contract management, the original contract (along with any addenda or modifications) must be stored or retained based on government compliance and industry guidelines. A contract manager may be responsible for organizing and maintaining all contract data in a searchable format so that all contracts are accessible in the event of an audit, renegotiation, or vendor conflict.

Stage 8- Performance and renegotiation: As contracts age, they may need to be renegotiated based on expected performance or upcoming expiry. This requires pulling contracts out of storage or connecting with internal and external partners in order to maintain existing terms or set up a new agreement. If either company has experienced a change in leadership, direction, or personnel, this process may spark the creation of an entirely new contract or result in the discontinuation of goods or services from the external party.

Stage 9- Analysis and optimization: The final step in contract lifecycle management is the most important process for ensuring organizational streamlining. When the company amasses a sizable number of similar contracts, those contracts should be analyzed and optimized based on their goals, similarities, and performance. Multiple vendor agreements may be consolidated into a single company boilerplate that requires minimal modification.

Best Practices for Contract Lifecycle Management

When applying contract lifecycle management, there are things to do to help the process work more effectively. For one, digitizing and automating the process is always advisable. This is doubly so when managing a portfolio of contracts or dealing with contractors and vendors who are geographically spread apart.

- Automation: Automating notifications to keep track of when contracts are up for renewal or obligations therein are delivered. Human error can be costly, but when reminders are set on the software then you're always aware of when deadlines are coming.
- Reporting: Having reporting features on a software tool is important for a budget, which is constantly changing over the course of a project. A budget is planned and is outlined on the contract, but the actual project might find you overspending. You need a tool to check against what you planned to spend and what you're actually spending.
- Using Project Management Software: Most of these best practices are dependent on project management software that is cloud-based and therefore delivers real-time data. Using an online tool fosters greater transparency in your contract management process.

12.9 Challenges in Contract Management

Contract management is a complex function that is central to the success of every organization. Because it includes so many aspects of the business, contract management faces an array of challenges:

- Lack of Coordination and Communication: Misunderstanding and conflicts can arise when you don't have clear lines of responsibility and authority. Strong contract managers ensure consistent communication with internal and external stakeholders, as well as a defined process for feedback and approval at each stage of the contract life cycle.
- Legal Is the "Department of No": In-house counsel assists with most contract preparations and can even create, manage, and maintain contracts in the organization. Without a smooth process for viewing and vetting contracts, the work can progress slowly, resulting in other departments— especially sales— seeing legal as the obstacle to moving forward with contracts, sales, and strategic initiatives.
- Time-Consuming process: It takes time to generate, review, approve, implement, and renew contracts. Look for ways you can standardize and streamline the process, including maintaining a library of contract templates and boilerplate, communication tools that gather feedback and approvals in a timely fashion, reporting tools that automatically gather information about deliverables and track timelines, and searchable document archives that allow you to see the outcome of any contract at a glance. These methods help to avoid the bottlenecks that can form when creating and approving contracts.
- Impact on the Bottom Line: Contracts are all about your business and its profitability. It's essential, therefore, that you clearly spell out all the details. When a contract is phrased poorly, you may miss a technicality that could cost the organization thousands of dollars.

Contract Management Software

Contract Management Software is a program that organizes and manages a company's legal agreements such as service contracts, license agreements, leases and others. The fundamental idea of this software is to optimize the process and order the administration of contracts and provide a unification of the processes of each contract with the modification and analysis of contract data. This makes the company manage in a faster and more efficient way the legal processes that are held or archived. In this way, risks can be reduced.

Contract management software is an electronic approach to solving these problems. Contract management software suites can organize all contract paperwork. The software can put signing and renewing on an electronic calendar that is easy to manage, and it can help you track and allocate resources related to the contract management process. The integration with an automated contract management service can free up countless man-hours and automate countless processes associated with managing a contract, thus creating more value for a company.

"Contract management software stores key information about contracts relating to providers, commercial leases and licensing agreements," said Robert Powell, CEO and founder of the Rob Powell Biz Blog. The overall purpose of contract management software is to streamline administrative tasks by creating a centralized and uniform record for each contract's processes. The most important aspect of contract management software is that it allows employees in multiple locations to access contracts in one place.

Benefiters from contract management software

Right now, about 65% of businesses currently use a contract management software solution, according to the Corporate Legal Operations Consortium. You can find use cases at all stages of business. There are few examples of candidates who would benefit from a software solution:

- Small businesses that regularly issue contracts but lack the budget to hire a dedicated contract manager.
- Large businesses with a contracting specialist that want to optimize their contracting workflow.
- Organizations looking to transition to a cloud-based environment to handle contract management, e-signatures, and safe, dedicated storage.

- o As with most digital software, contract management software brings a variety of new management and administrative tools to the table.
- o Whether you have a dedicated contract manager on staff or you're trying to run the business with a minimal headcount, these tools are worth consideration at every stage of business.

At its core, contract management software centres on four essential functions:

- o Contract creation: The ability to create and personalized contracts quickly typically through the use of templates or automation tools.
- o Contract collaboration: Tools to help negotiators quickly parse the provisions of a contract, negotiate details, and reach resolutions quickly.
- o Contract management: An intuitive system that allows contracts to be managed based upon specific criteria, such as upcoming expirations (for renewals), signers, or business partners.
- o Contract storage: The ability to securely store contracts within the system for a set or unlimited) amount of time.

Different Contract Management Software

- PandaDoc: PandaDoc is an all-in-one solution for secure collaboration, management, and contract tracking. It's a complete contract lifecycle management solution that makes it easy to handle contract creation at scale and for internal teams to manage contracts from contract automation, contract drafting, and contract approval (before they're delivered to clients) to signature and payment. Its contract management platform flexibility means that it can support almost any business process that requires document management and electronic signatures.
- ContractWorks CLM Software: ContractWorks offers industry-leading security, transparent pricing, and custom reporting automation. With ContractWorks document tagging, including their artificial intelligence (AI) Smart Document Tagging feature, it's easy to locate contracts and track action. This software prioritizes security and offers several backup options. ContractWorks restores contract visibility, encouraging you to stay organized, reduce costs, and minimize risk. ContractWorks enables quick access to key contract details using intuitive reminders that have enviable functionality and help you stay ahead of your obligations and never miss another renewal, upcoming milestone, or deadline. In addition, ContractWorks gives the power to create detailed reports and take control of the contracts. With its intuitive base, you can drag and drop files to store them in one searchable, scalable, secure contract repository with controlled access and permission-based user roles.
- Ironclad: Ironclad is a contract management software solution that helps legal departments automate workflows, generate reports, and process contracts efficiently. Its drag-and-drop user interface makes it easy for all stakeholders to use even without technical knowledge. Ironclad offers various approval workflows, including signature and approval conditionality, regardless of the agreement types. You can store all your contracts in a central location with an intuitive search capability, including a structured and full-text search of the entire contract database. The software lets you automate the contract creation process with no coding required; it comes with built-in editing, redlining, and auditing capabilities that make your workflow seamless and enjoyable.
- DealHub: Featuring native integration with Salesforce, DealHub.io helps organizations create and send contracts quickly and effortlessly. Its easy-to-use interface works for staff with various levels of tech training, ensuring that everyone on your team feels comfortable using the software. Also, the administrators can use preapproved templates to ensure accuracy. Deal

Hub.io makes contract creation a breeze, allowing users to generate new contracts, quotes, and other business documents from directly within the DealHub.io platform. Moreover, the software supports collaboration among team members with easy document-sharing features.

- Concord: Concord is a software solution that makes compliance and negotiation simple with its contract management software. Concord comes with preapproved templates for faster contract creation, with the version-control feature ensuring that all users receive up-to-date versions of the document. It offers the ability to track changes and hold discussions with stakeholders and other reviewers inside the platform. In addition, users can see the status of all contracts to speed up the buying cycle.

Summary

- Changes should be analyzed before they are made to the existing system, recorded before they are implemented, reported to have details of before and after, and controlled in a manner that will improve quality and reduce error.
- System Configuration Management (SCM) is an arrangement of exercises which controls change by recognizing the items for change, setting up connections between those things, making/characterizing instruments for overseeing diverse variants, controlling the changes being executed in the current framework, inspecting and revealing/reporting on the changes made.
- System Configuration Management (SCM) is a software engineering practice that focuses on managing the configuration of software systems and ensuring that software components are properly controlled, tracked, and stored.
- SCM is a critical component of software development, and effective SCM practices can help to improve the quality and reliability of software systems, as well as increase efficiency and reduce the risk of errors.
- Change control is a procedural method which ensures quality and consistency when changes are made in the configuration object. In this step, the change request is submitted to software configuration manager.
- A change request (CR) is submitted and evaluated to assess technical merit, potential side effects, overall impact on other configuration objects and system functions, and the projected cost of the change.
- Software Configuration Management Plan (SCMP) describes the tools which should be used to assist the configuration management process and any limitations on their use. It defines the configuration management database used to record configuration information.
- Contract management is the process of managing legally binding agreements from initiation through to execution.

Keywords

Software Configuration Management (SCM): Software Configuration Management (SCM) is a process to systematically manage, organize, and control the changes in the documents, codes, and other entities during the Software Development Life Cycle.

Configuration Manager: The configuration manager is the head who is responsible for identifying configuration items. CM ensures team follows the SCM process. He/ She needs to approve or reject change requests.

Developer: The developer needs to change the code as per standard development activities or change requests. He/she is responsible for maintaining the configuration of the code. The developer should check the changes and resolve conflicts.

Auditor: The auditor is responsible for SCM audits and reviews and needs to ensure the consistency and completeness of a release.

Change Control: Change control is a procedural method which ensures quality and consistency when changes are made in the configuration object. In this step, the change request is submitted to software configuration manager.

Software Configuration Management Plan (SCMP): SCMP describes the tools which should be used to assist the configuration management process and any limitations on their use. It defines the configuration management database used to record configuration information.

Contract management: Contract management is the process of managing legally binding agreements from initiation through to execution.

Self Assessment

1. An effective contract management can be characterized by the phrase "No Surprises". When done right, everyone knows what and when things are expected of them.

A. True

B. False

2. CLM stands for

A. Contact Lifecycle Management

B. Contract Lifecycle Management

C. Contract Livelihood Management

D. Communication Live Management

3. Which of the following statement is/are TRUE for contract management?

A. Contract management affects the organization's revenue, budget, and operations.

B. It influences the way the customers view the organization as well as its public image.

C. The way the company manages its contracts can touch upon almost every aspect of the company.

D. All the above.

4. ______________ is about automating and streamlining the processes involved in contract management's various stages, such as initiation, authoring, process and workflow, negotiation and approval, execution, ongoing management and compliance, and renewal.

A. Resource management

B. Provisioning management

C. Contract lifecycle management

D. Communication management

5. SCM involves

A. controls change by recognizing the items for change.

B. setting up connections between those things, making/characterizing instruments for overseeing diverse variants.

C. controlling the changes being executed in the current framework.

D. All the above.

6. System Configuration Management (SCM) is an arrangement of exercises which involves inspecting and revealing/reporting on the changes made.

A. True

B. False

7. Changes should never be analyzed before they are made to the existing system, never recorded before they are implemented, non-reported to have details of before and after, and not controlled in any manner.

A. True

B. False

8. Which of the following is/are participants of SCM process?

A. Configuration manager

B. User

C. Auditor

D. All the above.

9. When two or more tasks are happening at the same time, it is known as _____________ operation.

A. revision

B. repeating

C. concurrent

D. repent

10. The Software configuration Management Plan answeres many questions. The questions pertaining to SCMP maintenance can include :

A. Who is responsible for monitoring the plan?

B. How frequently updates are to be performed?

C. How changes to the plan are to be evaluated and approved?

D. All the above.

11. The statement aptly describing characteristic feature(s) of SCM is

A. It is the task of tracking and controlling changes in the software part of the larger disciplinary field of configuration management.

B. The SCM practices include vision controls in the establishment of baselines.

C. If something goes wrong, SCM can determine what was changed and who changed it.

D. All the above.

12. SCM is a critical component of software development, and effective SCM practices can help to improve the ___________ of software systems, as well as reduce the risk of errors.

A. quality and reliability

B. quantity

C. error increase level

D. non-adaptability

13. ____________ is a summary term covering the period and actions prior to a contract being signed. It involves steps like contract authoring, templating, and redlining.

A. Post-signature

B. Pre-signature

C. Negation

D. Workgroup

14. _____________ is a procedural method which ensures quality and consistency when changes are made in the configuration object. In this step, the change request is submitted to software configuration manager.

A. Change control

B. Contact control

C. Procedural control

D. Review control

15. ECR stands for

A. Evaluation Change Request

B. Engineering Change Request

C. Evaluation Control Response

D. Engineering Control Response

Answers for Self Assessment

1.	A	2.	B	3.	D	4.	C	5.	D
6.	A	7.	B	8.	D	9.	C	10.	D
11.	D	12.	A	13.	B	14.	A	15.	B

Review Questions

1. What is configuration management. What techniques are used for configuration management?
2. What are the primary reasons for implementing technical Software Configuration Management System?
3. Enlist the key feature requirements of SCM tools?
4. Which are the different types of contracts?
5. Explain the various steps in SCM process.
6. What are the different participants in SCM?
7. Discuss about contract management.
8. List different SCM tools and their features.
9. What are the different sections of SCMP?
10. Write a short note on:
    (a) Software Configuration Management Plan
    (b) Configuration Management

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Unit 13: People Management

CONTENTS

Objectives

After studying this unit, you will be able to:

- understand people management and the people management practices.
- learn about the concept of process management in detail.
- analyze the concept of performance management.
- investigate the Internal workflow.
- explore the People Capability Maturity Model (PCMM).
- know about project scheduling and staffing and the activities associated with the project scheduling and staffing.

Introduction

The employees are one of the company's most significant assets, and their performance greatly affects the bottom line. However, simply hiring skilled employees isn't enough; how the business leaders manage these team members can strongly influence the company's overall performance. The managers and business owners need to understand the principles that underlie people management and develop specific skills to become good managers and ultimately lead their teams and organizations to success.

People management is about managing people in the workplace: making sure they are provided for and have everything they need to get their jobs done. But people management is about much more than this. At its heart, it's about paying attention to and caring for employees. This could mean looking after their wellbeing, compassionately helping them overcome stumbling blocks, or inspiring them to do their best work and strive to meet their personal and professional development goals.

People management, a subset of human resource management, organizes employees and builds teams to optimize business performance. The successful people management involves hiring and training the right employees, guiding and empowering each employee to reach their maximum potential, effectively communicating across all teams, and directing all team members toward a common goal.

People management includes formal, procedural duties such as hiring, training, evaluating, and disciplining employees—at least, these tasks are what come to mind when most people think of people management. But people management involves a range of more care-based responsibilities that are often overlooked, such as:

- Ensuring that employees are getting the compensation they deserve.
- Making sure each employee and team has the resources they need to do what is expected of them (including having enough time to do what they are asked to, or enough team members with whom to share a workload).
- Ensuring that employees have the wellness resources they need to feel safe and happy at work (including, for example, listening and compassion from their manager when they are struggling).
- Helping mediate and resolve conflicts between employees or on a team, or better still, cultivating a communicative and cooperative environment that doesn't breed conflict.
- Going beyond workplace training to help employees develop the confidence and enthusiasm they need to realize their potential.
- Helping employees overcome challenges that hamper their job performance.

13.1 Benefits of People Management

A poorly managed team can hurt multiple aspects of your business. A properly managed team, by contrast, can improve company morale, optimize the production levels and efficiency, and give the company a competitive advantage in the marketplace.

Why should company leaders care about People Management?

- Business leaders should care about people management skills in their organizations because they can make or break a company. Bad people management can decrease productivity, disengage employees, and stifle innovation in an organization. The potential effects of subpar people management skills include:
- Low productivity due to disorganization or poor optimization of resources
- Workflow errors because of poor communication
- Employees and teams being ill-equipped to deal with challenges
- Unresolved or ongoing conflict between employees
- High employee turnover rates
- Lack of professional development among employees
- Lack of knowledge and idea-sharing within the organization.

Company morale: Companies with low morale and poor engagement often have high employee turnover and burnout rates. However, implementing optimal people management strategies can give your employees a strong sense of ownership over their work and improve their overall job satisfaction. Creating a solid environment in the workplace will lead to happier and more productive employees, and that shows in the quality of output in their work. Effective people management leads to employees who feel supported, who are then more likely to be happy, engaged, and have a positive attitude at work. That contributes to a positive workplace atmosphere for everyone.

Productivity and efficiency: People management involves organizing your team to increase productivity and optimize efficiency. When you have the right employees in place, train your team properly and collaborate with employees to reach their goals, you set your team up for success. Successful people managers "are focused on helping the team align around a common goal and mission, and are able to help the team isolate, prioritize and focus on high-value work," Bainbridge said.

Competitive advantage in the marketplace: Understanding how to orchestrate teams can give small businesses a competitive advantage. Because small businesses often lack the budget or market presence of their larger, corporate counterparts, maximizing a smaller pool of resources is crucial, Bainbridge said. This includes optimizing human capital and prioritizing team orchestration.

Conflict resolution: People management skills enable managers and HR to have open and direct conversations with employees. Team managers and HR professionals can navigate conflict and address any issues sooner rather than later to reduce dysfunctional conflict at work.

Skills development: Good managers help employees develop in their careers and gain the skills and confidence they need to meet their personal and professional goals, which also benefits the organization.

13.2 People Management Challenges

People management presents managers and HR with a unique set of challenges, the primary one being the conflict between advocating for employees while simultaneously striving to meet business objectives.

Lack of people management skills: One of the main challenges in people management is a lack of skills and knowledge in how to nurture and champion people and bring out the best in them at work. Often, managers desire stronger relationships with their team but lack the skills needed.

Lack of consistency and transparency in managing people: People managers often struggle to be consistent because they don't have a clear set of guidelines to follow. That results in a lack of consistency in managing people. There's also a lack of knowing how to effectively deal with conflict and address poor performance. For this reason, many managers skirt the issue and are not open and honest with their employees.

Communication issues: There's a natural distance between managers and their teams, but if they don't craft the skills to bridge this gap, it will result in poor communication. Employees will feel like they aren't listened to or valued. This can have a negative effect on team morale as well as business operations. Employees need to have an open line of communication with their managers, know what is expected of them, and be kept up with their progress and any changes occurring in the business that affect them.

Balancing team and individual needs: Another challenge of people management is being able to balance the needs of each employee as well as the whole team and the wider business. Every employee will have slightly different goals, communication styles, personalities, and ways of working. Successful managers are able to connect with people from a wide variety of backgrounds and meet their needs while empowering them to play a larger role in the goals of the organization

Managing change: Employees are often the last people to find out when someone is leaving the company for a new role, being made redundant, moving teams, being promoted, a new employee is joining the team, or a new department is being created. At the same time, managers may not know the full story and may also be kept in the dark until the department heads or business leaders have made the final decision. But when managers withhold this information from their team, it leads to mistrust and confusion.

13.3 Effective People Management

Mastering effective people management is essential to retain employees, maintain productivity and engagement and boost business performance. It has been observed that 50% of employees have to quit a job to get away from their manager, and 69% of managers often feel uncomfortable communicating with their employees and giving feedback on performance. This suggests that people management in organizations is often lacking.

People Management Practices

There are several qualities an individual should possess to become an effective manager. Joe Mullings, founder and CEO of The Mullings Group, listed integrity, communication, organization and empowerment as the top four people management skills.

Ethics and integrity: Team members want to know that a leader does the right thing. A great manager is honest and accountable and acts with integrity. A lack of trust in a team is a culture killer.

Clear communication: An effective leader communicates clearly, frequently and thoughtfully, keeping team members apprised of what is happening in the business. Good managers encourage two-way communication and are receptive to feedback.

Organization and conscientiousness: Managers must clearly define goals, processes, timelines and success metrics to their teams. Each goal should be aligned with the company's overall mission and vision statement.

Empowerment: Great leaders develop others. Leaders who enable and mentor employees can create high performers and improve company retention.

Nurture a Learning Culture: Embedding continuous learning into the organization's day-to-day processes can do wonders for its people management—or at least set it on a path of constant improvement. For one thing, people managers—no matter how "high up" they are—need to keep building their management skills through leadership learning. For another, implementing learning structures like career development plans, regular workplace training, and team knowledge- sharing rituals can help acquaint managers with their people's goals, strengths, and weaknesses. This provides valuable context for understanding and motivating them. Importantly, a key element of any learning culture is embracing setbacks and mistakes as a necessary part of a positive learning process. This attitude helps people feel safe and build trust in approaching their managers for help correcting a mistake or overcoming a setback.

Practice constant feedback: Feedback keeps an organization running smoothly, but it needs to go both ways: from managers to their people and vice versa. After all, nobody can fix a problem without knowing it exists. However, freely giving and listening to feedback doesn't come naturally to everyone, and so it needs to be constantly encouraged. A good idea is to consciously build feedback into everyday processes like internal meetings, for example by putting five minutes of open feedback onto every agenda.

Put it all together: Managers get paid to get work done. If something goes wrong with your plan, don't immediately go to plan B. Leverage personalities and the way each approaches a problem.

Summarily, a people manager must:

- Make sure each employee understands their role and responsibilities.
- Ensure that the company's expectations of each employee are aligned with the resources (including time) they have to fulfil this expectation.
- Communicate clearly with their employees, listen to their feedback, and encourage their people to do the same with their fellow team members.
- Help their employee's problem-solve and overcome challenges.
- Forestall and manage conflict between team members.
- Oversee employees' professional development in the workplace.
- Facilitate knowledge-sharing and brainstorming within a team by making sure people feel free to share their ideas.

Notes: People Management Training Resources

The companies that offer training courses in people management include:

American Management Association (AMA)

Coursera

edX

Future Learn

LinkedIn Learning

13.4 Process Management

Process Management refers to aligning processes with an organization's strategic goals, designing and implementing process architectures, establishing process measurement systems that align with organizational goals, and educating and organizing managers so that they will manage processes effectively.

Process management, often known as business process management (BPM), is the identification, improvement, and management of a business's processes. Process management is a systematic approach to ensure that effective and efficient business processes are in place. It is a methodology used to align business processes with strategic goals. The aim of BPM is to create clarity and alignment on the strategic direction of the business, maximize the use of the firm's resources, and increase productivity in business outcomes and operations.

In contrast to project management, which is focused on a single project, process management addresses repetitive processes carried out on a regular basis. It looks at every business process, individually and as a whole, to create a more efficient organization. It analyzes current systems, spots bottlenecks, and identifies areas of improvement.

Process management often considers goals like:

- Aligning processes with the company's vision and values.
- Standardizing processes to facilitate training and quality assurance efforts.
- Automating repetitive or simple tasks.
- Sourcing new technologies.
- Performing risk analyses to mitigate process risks.
- Tracking process metrics to measure efficiency.

Types of Processes

Process management can refer to several types of business processes. Business processes are the series of structured activities and tasks that an organization's staff and stakeholders perform and complete to achieve a particular goal. Sometimes these processes repeat frequently, and sometimes they might only exist for specific projects or goals. The management strategies used can depend on the types of process you're managing.

- Information process: This involves researching and collecting data on the organization's business needs.
- Management process: This entails planning, controlling and decision-making regarding the organization's business operations.
- Operations process: This includes hiring and designating personnel and deploying work tools to undertake necessary tasks, implement workplace policies and to monitor the workflow.

Example: Business processes examples: There are many business processes that exist within an organization. The processes of an organization may depend on the industry, the size of the organization and the goals of the company. Developing process management strategies for different processes within a company can ensure better alignment and make it easier for departments to work together.

Some examples of common business processes include:

Product research and development

Customer acquisition and relationship building

Employee development and management

Raw materials procurement

Quality control

Process improvement

Financial analysis

Capital management

Product delivery

Customer service

Infrastructure development

New employee onboarding and training

Importance of Process Management

When managing any organization, it is imperative to understand why process management is important. More than creating seamless workflows, it enables all aspects of business operations to run at an optimal pace. With business processes systematically implemented, you reduce time wasted on repetitive tasks and minimize errors due to human inefficiency. Process management in business is more of Business Process Management (BPM).

It also prevents the loss of data and missed steps within a process. Moreover, it ensures that resources are used properly so the business becomes more cost-efficient. Aside from improving business operations, process management also aligns the processes with the needs of the customers. This increases customer satisfaction and leads to higher revenues. Effective process management has several benefits for businesses. Overall, it offers:

Streamlined processes: BPM restructures tangled operations into smooth workflows, simplifying operations and improving business agility.

Increased productivity: BPM makes sure that resources and capital are utilized properly. It also improves business processes and working conditions to increase overall productivity.

Minimized risks: By clearly defining responsibilities, BPM demands higher accountability. This minimizes risks due to human error and reduces inefficiencies.

Reduced costs: BPM helps spot inefficiencies so they can be corrected. It also tracks the usage of resources. With fewer inefficiencies and proper utilization of resources, BPM can reduce costs and expenditures.

Enables agility: In ever-changing markets, businesses need to remain flexible so they can pivot their operations and set of activities. The mature process management allows businesses to quickly review and adapt their processes in real-time and remain responsive to unforeseen situations.

Promotes efficiency: Good process management means continually monitoring and optimizing business rules and processes. This means quickly identifying and resolving bottlenecks and reducing delays. Automating processes reduces risk as it removes the possibility of human error.

Increases visibility: Part of an effective process management approach involves overseeing human involvement (example, assigning ownership over each process). The information from the process owner plus data from automation improves reporting transparency and enables timely insight into operational performance.

Increases revenue potential: 46% of companies surveyed felt that process management offered a route to cost savings and increased revenue, resulting in a stronger business strategy.

Increases employee engagement: Comprehensive process management includes identifying opportunities to automate repetitive administrative tasks. This means employees can focus on tasks that add value to the business. Feeling purposeful increases employee engagement, and it frees up time for employees to focus on other areas such as their development, further increasing engagement levels.

Promotes a culture of continuous improvement: Embedding an effective process management approach fosters a culture of improvement. The process owners and wider employee groups should be encouraged to brainstorm innovative ideas that optimize processes and increase productivity and be rewarded for doing so.

Stages of Process Management

There are five key stages in the process management lifecycle. Figure 1 depicts the various stages in the Business Process Management (BPM).

Figure 1: Stages of Business Process Management

1. Analyzing

- The analysis stage is an important pre-step before the management process kicks in.
- At this stage, the business should identify its business management processes and analyze what it wants to improve.
- Compiling the data on every performance metric provides a strong indication of those processes that are the least efficient.
- Business analysts can use qualitative and quantitative approaches to gather this data. These may include value-added analysis to measure each process's contribution to the business or cause and effect modeling to identify efficiencies.

2. Designing/Modeling

- During this next stage, the current process, or "as-is" state, should be drawn out and the ideal future process management model, or "to-be" state, is designed.
- The aim is to create a sequence of logical steps that visually document the end-to-end process.
- Once these steps have been documented, you can add additional information, such as the time and duration of tasks, where they occur, who is involved, and how information flows through the process.
- After the process is fully mapped, end-users should review it to ensure its accuracy and check that improvements proposed in the "to-be" state are likely to deliver value.

3. Implementing

- At the implementation or execution stage, the "to-be" state is adopted into the business. This may require the addition of technology, procedural updates, or changes to resourcing, training, or project management.
- Where possible, it can make sense to trial the "to-be" process on a small group to monitor the impact and iron out any teething problems.

4. Monitoring

- During the monitoring stage, the "to-be" process is allowed to run freely while you collect data on its performance.
- Gather information about whether the re-designed process is effective and whether the expected improvements are seen, therefore reaching business goals.
- Comparing relevant metrics with baseline data from the "as-is" state should determine if there is a worthwhile return on its investment.
- Performance data can also inform decisions as to what steps should be taken next regarding workflow management.

5. Optimizing/ Executing

- At this stage, you'll continually refine the process based on information gathered in the monitoring stage and as the business changes over time. You may introduce process automation to reduce the amount of repetitive, manual tasks.
- Sometimes, as the business grows or its external environment changes significantly, the processes become sub-optimal or overly complex, resulting in less than efficient organization.
- In these cases, it may be worth creating an entirely new process to support the changes. This is known as process re-engineering.

Strategies to Optimize Process Management

Process management offers a traditional methodology to embed and improve the business processes. But, like any tool or approach, it can be applied well or applied poorly. There can be few strategies to optimize the process management that can include:

- **Create ownership:** Once you establish or optimize processes, it's important to create a process owner. Assigning ownership means there's someone responsible for embedding the new process in the business and remaining committed to the process design. Having a process owner also means there's someone familiar with the end-to-end process who can continuously assess the need for further improvements.
- **Build a culture of continuous improvement:** It is important to create a culture of continuous improvement within the organization. This can be extremely beneficial to an organization, as they can source good ideas from employees closest to the processes involved. The organizations can add creative thinking and problem-solving as desirable skills to job descriptions within the recruitment process. And there should be visible and accessible feedback mechanisms that reward innovation and process improvement ideas.
- **Standardize repeated processes:** It's crucial to ensure that businesses standardize and repeat processes, such as procurement or recruitment. Standardizing the processes reduces the likelihood of error and mitigates risk. It also makes it easier for cross-functional teams to be productive and simplifies employee onboarding, even as they move between internal roles.
- **Optimization before automation:** Automation is the fast track to improving process management. Automation of repetitive, administrative tasks frees up employees to focus on tasks that add real value to the business. However, it's important to optimize the process before you automate it. Without taking the time to review and improve processes, automation just makes the same (imperfect) process run faster.
- **Value performance over perfection:** Where it's possible to do so, focus on improving an existing process rather than building new ones. The point of process improvement is to drive performance gains, not to achieve the "perfect" process. Also, focus on the desired outcome when organizing and sequencing work rather than the tasks themselves. Try making smaller

changes and monitoring their effect which means increasing value sooner. Sometimes the delay involved in creating a radical new process can reduce the potential value.

Task: Find the different process management software.

13.5 Performance Management

Performance management is a set of processes and systems aimed at developing employees, so they perform their job to the best of their ability. The goal is to help employees build on skills that enable them to perform better in their roles, reach their potential, and boost their success while also accomplishing the strategic goals of the organization. Effective performance management establishes a continuous conversation between employees, managers, and HR.

The performance management process is strategic and systematic. It combines verbal and written components, which take place throughout the year, culminating in an annual performance appraisal. The process involves the following:

- Establishing clear expectations,
- Setting individual objectives and goals that align with team and organizational goals,
- Providing ongoing feedback, and
- Evaluating results.

Did You Know?

Interestingly, career decisions, including promotions, bonuses, and dismissals, are linked to the performance management process.

Performance Management Goals

Performance management aims to develop the skills and competencies employees need to improve performance and success in their job. In turn, these skills help the organization meet its goals. As per a study reported by Betterworks, "21% of employees say their goals are set annually and never looked at again, while 16% say they do not set any goals. A third of employee's report that they don't have one-to-ones with managers or receive feedback to help them work towards goals more than twice a year. 1 in 10 employees claim they rarely or never receive this type of feedback".

Performance management goals include setting performance expectations so that employees have clarity on what is expected of them and what they can gain by meeting these expectations, including compensation, rewards, or even a promotion. Continuous, real-time feedback helps employees understand where they are, learn, self-correct, and grow. They can constantly improve their performance at work, providing them with a greater sense of accomplishment. This equips the organization with a skilled, engaged, and qualified workforce.

Performance management improves individual and team performance which helps businesses achieve their goals and objectives. For example, if a business objective is to grow revenue, effectively managing the performance of the sales employees can help to achieve this. Performance management also allows employees to see how their individual goals align with the company goals and understand how they contribute to achieving those, encouraging engagement.

Importance of Effective Performance Management

If the performance management goals are achieved, there are several benefits for both the employees and the wider organization that include:

Future-proofing the workforce's skills: Establishing a continuous line of communication with employees and monitoring their skills, learning, and training developments helps uncover potential skills and performance gaps in the organization. One can then work to close these, providing the business with a strong competitive advantage.

Increased employee engagement: When carried out effectively, performance management sets expectations for the employees in a transparent way. It provides them with learning and development opportunities, a clear career path in the organization, and an understanding of their role's impact on meeting organizational goals. Plus, continuous performance management helps employees feel valued and cared for, making them more open to receiving constructive feedback and working to improve.

Higher employee retention: When an employee can see their progression at work and clearly understands their career path and what they need to do to earn a promotion, it leads to more engaged employees who are likely to stay with your organization.

Culture of feedback and trust: Establishing a culture of communication, transparency, and trust begins with leadership and HR initiatives that will trickle down to the rest of the organization. That includes the nature of your performance management process and a transparent performance management policy. When managers are open and give honest, constructive feedback to employees, this encourages employees also to be open and honest, building mutual trust. It also fosters a healthy overall company culture.

Improved organizational performance: Managing employee performance ultimately leads to significant improvements in organizational performance, including revenue growth and customer satisfaction. Helping the employees learn, develop and perform better in their roles has a positive knock-on effect on the wider business. According to Bryan Adelson, a consultant at Red Clover HR, organizations need to understand the "why" behind their performance management strategy. "Why are they conducting these conversations in the first place, what is their value, and what takeaways do they want from them? Understanding these questions will ultimately help structure and provide the most effective outcomes to the employee and organization," Adelson points out.

Performance Management Stages

The performance management cycle is an annually reoccurring phenomenon in which employees are evaluated throughout the year. All employees go through this cycle, starting with goal setting at the beginning of the year, followed by the monitoring of their progress, helping them develop to do better, and ending with a formal evaluation afterward. The goal of this cycle is to develop and execute employee performance plans. These plans help in focusing employee efforts on achieving organizational goals which, in turn, helps to align employee priorities with the goals of the organization.

It is important to realize that the goal of the performance management cycle is explicitly aimed at improving performance. All the activities in the performance cycle model are aimed at setting goals and coaching the employee to reach or even overreach, these goals. Another element to point out is that performance management can work for both individual employees as well as teams (Figure 2).

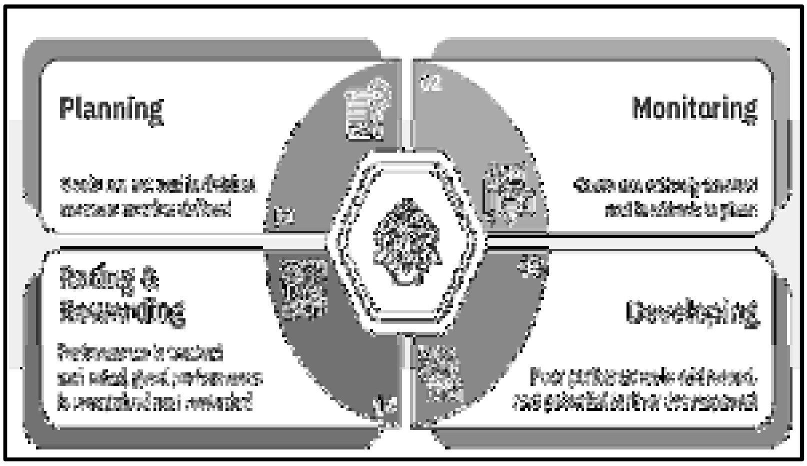


Figure 2: Stages of Performance Management

- **Planning:** The planning stage is dedicated to establishing performance expectations with employees. Job descriptions should clearly outline these goals to attract the right candidates. After hiring the candidate, you need to reconfirm these expectations and set SMART goals and employee performance metrics together. The performance management plans must also be flexible so they can be adjusted as organizational objectives change along the way. The employee should be actively involved in the planning process because this increases satisfaction and motivation to improve.

- **Monitoring:** The second stage is monitoring. During this stage, HR and managers must regularly monitor employee performance concerning the goals set and provide feedback to employees on their progress. Doing this regularly rather than annually allows issues to be highlighted and corrected sooner rather than later. The performance management software can assist in tracking employee performance in real time. Still, data and reports should not be a substitute for face-to-face discussions.
- **Developing:** During the developing stage, the data collected during the monitoring stage is analyzed and used to boost employee performance. The underperformance may be corrected by suggesting refresher courses, further training, performance coaching, and other L&D methods. The managers and HR could further facilitate superior performance by assigning an extra project to help improve knowledge and performance, allowing the employee to excel further.
- **Rating & rewarding:** The final stage is rating and rewarding. The employee's performance needs to be rated regularly throughout the year and during a performance review or appraisal. This helps quantify employee performance, determine the value added by each employee to the organization, and make any changes as needed. Both employees and managers should give their evaluations for 360-degree feedback. Continual sub-par performance could lead to a cross-function move or dismissal. The organization should also recognize and reward superior performance, whether it's through praise and recognition, a raise in salary, or a promotion.

Key Elements of Effective Performance Management

Effective performance management helps organizations ensure that employees understand their roles, receive constructive feedback, and have the support they need to achieve their goals and business objectives (Figure 3).

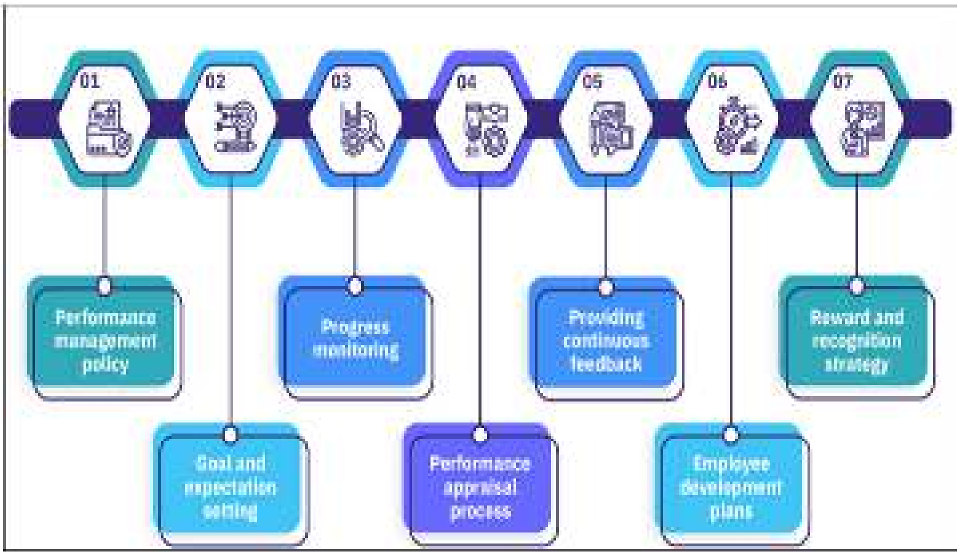


Figure 3: Key Elements of Effective Performance Management

Performance Management: Best Practices

Evaluate what currently is and isn't working: Before making any changes to the current performance management process or tools, you must understand what is currently working, what's not, and why. HR should survey both employees and managers and collect opinions on the current process and suggestions on what could be done better. You can then convey these internal findings, coupled with studies and evidence-based research, to business leaders and decision-makers who can sponsor and drive change in the business. Show them the impact of an improved performance management process on business results.

Choose the right approach: There are two common approaches to performance management: a behavioral approach and a results-oriented approach.

- Behavioral approach: Behaviors are identified and evaluated, and employees are evaluated based on their behaviors and effort. This approach is suitable for giving detailed feedback on behaviors by mapping desirable future behaviors and when individual results are hard to measure. Examples include individual players in a team, support staff, and HR professionals.
- Result-oriented approach: Employees are evaluated based on objective criteria. The focus is not on input but on output in terms of quality and quantity. This approach is suitable when there are multiple ways to do the job. The end result matters rather than how it has been achieved. Examples include contact center employees who have specific success metrics, as well as sales professionals. The evaluation of lawyers and accountants is also highly result-oriented, as they keep track of their billable hours.

Notes: Consider what the role is when choosing the approach to ensure the effectiveness of the performance management process.

Meet & train managers: Managers are integral to the success of your performance management program. They play a vital role in engaging, motivating, and developing employees. Therefore, it's essential that HR has a clear plan in place for training managers to give and receive constructive feedback. The managers should also get coaching on how to maintain a continual, open feedback dialogue with their staff.

Help set SMART goals: Managers and employees should set SMART goals for employee performance and involve HR when setting goals for employee development. Every employee should have their own clear, personalized set of key performance indicators (KPIs) so that they understand their manager's expectations and so that their manager can keep track of their scores and achievements. Personalization is important based on the job and function and the employee's personal and professional ambitions. Having regular developmental conversations and effectively tracking the goals means targets stay up to date, and there's no doubt around what needs to be achieved to progress.

Apply continuous performance management: Performance management should be an ongoing dialogue that happens throughout the year, not just during an annual review. This approach allows for timely feedback, effective goal setting, and more accurate assessments of employee performance. One of the primary reasons for this is relying on an annual performance appraisal or review and failing to follow up on this regularly throughout the year or conduct one-to-one check-in meetings where constructive feedback and coaching are provided. HR can educate managers on providing employees with this type of ongoing constructive feedback. This drives motivation, catches issues early on, and helps to manage underperforming employees correctly and offer them tools to improve.

Set up a formal system: Continual performance management boosts employee engagement, motivation, and performance. However, a formal performance review or appraisal system where top-performing employees can get a raise, a bonus, or a promotion for meeting certain goals and objectives is just as important. This communicates to all the staff that great work will be recognized and rewarded.

Help workers create employee development plans: When employees have a solid plan for their career progression with the organization, it empowers them at work and helps them take charge of their professional development while reducing turnover rates. Human Resources professionals can work closely with managers to understand their employees' needs, schedule meetings to discuss their career development, and help provide employees with the required training.

Employee development plans are notoriously hard to implement simply because managers and employees are too busy. This is where HR can help by creating plan templates for managers which they can use to create development plans with their team members.

Employ technology: Leveraging HR technology and software helps improve the efficiency and effectiveness of the performance management process. Performance management data can offer detailed insights and patterns that manual tracking and surveys cannot compete with. The right technology can also save a manager's time, but only if a clear performance management strategy is in place. They also need to be able to view real-time data at any time to determine the right goals for success.

13.6 Internal Workflow

A people management team may be a single person within a small organization, a small group or department within a medium-sized organization, and a large group or collection of teams within a large organization. In many organizations the people management team is still being called the human resources (HR) team or the HR department, although some organizations use terms such as Talent Management team or even People Operations team.

Requests that are unusual, perhaps because they require a large effort to address or because they are the result of a unique event for the organization, are either handled via a project lifecycle or are organized into smaller pieces of work and handled by the day-to-day workflow. Figure 4 depicts the high-level workflow for a people management team.

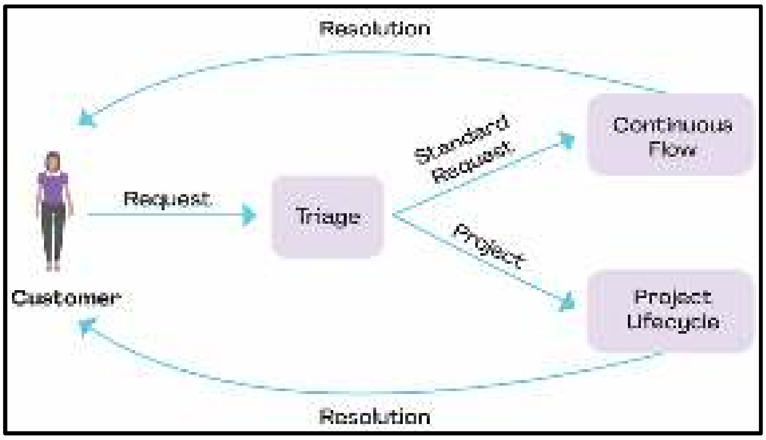
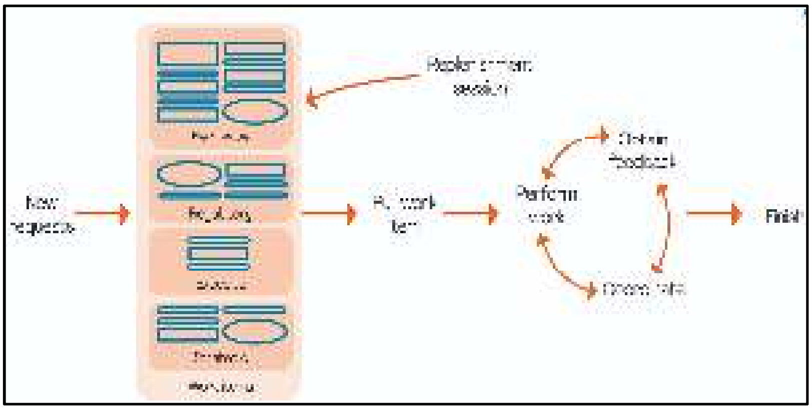


Figure 4: High-level Workflow for a People Management Team

A customer of the team, perhaps an employee somewhere in the organization asking for career guidance or a manager asking for help with their staff, submits a request to the team. This request is triaged. Straightforward requests that are addressed on a regular basis are handled via the day-to-day workflow.

Internal Workflow: Day-to-Day (Continuous Flow)

There is a lean approach where the work is performed in a continuous manner is the most appropriate for the day-to-day work of people management teams. The fundamental idea is that people management professionals face a constant stream of requests for help, each of which should be prioritized and worked on appropriately. The lean lifecycle of Figure below addresses this situation well.



New requests: Other teams within your organization will make requests of a people management team on a regular basis. Examples of new requests may include onboarding someone, offboarding someone, helping someone identify a mentor, addressing behavioral issues of an employee, consulting with a team or manager to help them to understand people management issues surrounding a decision, executing on a communication strategy, addressing a minor regulatory change, and many more.

Work items: The work items for the team are often maintained via a Kanban board. For a team working at the same location these are very likely sticky notes on a whiteboard or wall that is easily accessible by the team. For a team that is geographically distributed it very likely be a digital tool such as Jile or Trello. The aim is for the team to self-organize and manage their own work.

Prioritize the work: Someone within the team, or collaboratively with the team itself, will need to prioritize the work items. On a software development team there is often someone in the role of Product Owner who would do this work. On a People Management team this role typically doesn't exist, so this responsibility tends to fall either on the Team Lead/Manager. Prioritization is typically performed on a just-in-time (JIT) basis when the work is pulled into a team, although it can be done any time at the discretion of the person responsible. The more frequent new requests for work come in, the greater the need to prioritize JIT.

Pulling work into the team: The team pulls a single work item into their process when they have the capacity to do more work. You want to pull in the highest-priority work that can be performed by the person(s) with the ability to do that sort of work.

Performing work: The team, or typically a subset of the team, performs the work to be done to fulfill the given work item.

Obtain feedback: As the work progresses the people doing it should obtain feedback from others, in particular the person(s) from which the request came from, to ensure that they are on the right track. Feedback can come from informal demonstrations, formal demonstrations, requests for feedback, reviews, and so on.

Coordinate: The team should regularly coordinate the work that they are doing. During the coordination sessions the team will typically discuss their priorities for the day, their expected capacity to do work that day, and any bottlenecks they foresee or are currently experiencing. Each team will discover a coordination strategy that works for them: when to hold the sessions, what to discuss in them, and most importantly how to keep them short and focused.

Replenishment sessions: This is a working session where team members identify work that they believe should be performed. This may be to address team-health issues, to address long-term strategic goals, or to run experiments with new ways of working (WoW) amongst other things.

Finish: When a work item is complete the appropriate customer(s) of that work item are notified, and the team now has capacity to pull more work in.

Internal Workflow: Projects

A project is a piece of planned work or activity that is performed over a period of time to achieve a particular outcome. Projects are large pieces of work, typically taking many days or weeks to accomplish, that require a significant (for your team/organization) budget. The common projects that a people management team may experience:

- o Review and rework of organizational policies due to regulatory changes.
- o A layoff/downsizing event.
- o An acquisition/large onboarding event.
- o Annual reviews.
- o Organizing a hackathon or college recruiting event.
- o Large learning events such as conferences or team-building exercises.

Figure 5 depicts an agile project lifecycle that a people management team may choose to follow to implement a project. This lifecycle is based on the Scrum method and has been extended to address the full lifecycle from beginning to end.

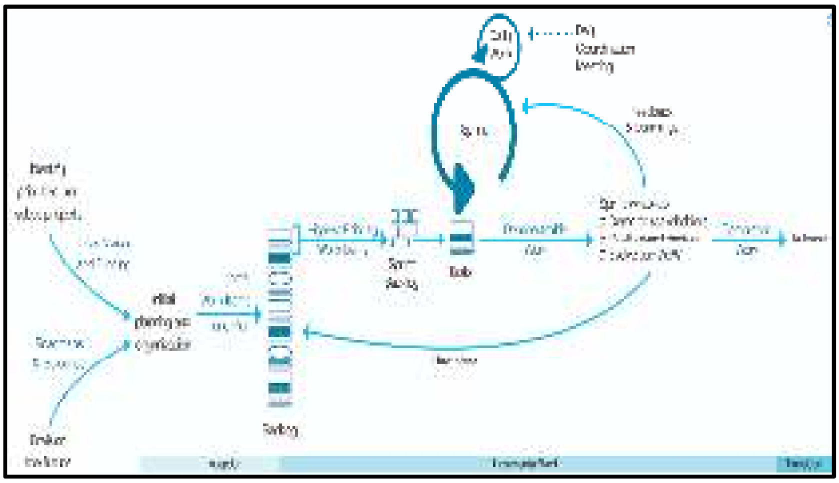


Figure 5: An Agile Project Lifecycle for a Business Team

Initial vision and funding: Someone within the organization will identify this new project, the outcomes they would like to achieve from it, and initial funding to do the detailed inception work to get it going.

Organizational roadmaps and guidance: Each organization very likely has guidance (standards, principles, guidelines, …) that it expects teams to follow as well as business roadmaps that the team should work towards. These things should be known to the team and will guide and constrain the decisions made.

Project inception/initiation: This should be a short period of time, typically hours or days. The aim is to perform fundamental project initiation activities such as putting the project team together, identifying and understand what work needs to be performed, and plan how to intend to do the work.

Work backlog: The backlog will first be identified during Inception but then allowed to evolve over time based on feedback and evolving needs. It is very common, and should be expected, that understanding of what work needs to be performed will evolve as the project progresses. The work backlog is typically ordered by business value so that the team will focus on the most valuable work at all times. It is also common to consider dependencies between work items as well– sometimes if you do X first then Y and Z are much easier to perform.

Iterations/sprints: At the beginning of the sprint the team identifies the work the believe they can complete during that period, they plan what they need to do and how they're do it, and then they do it.

Iteration/sprint planning: At the beginning of each sprint the team gets together, they identify the work items they believe they can accomplish during the sprint, and they collaboratively identify what needs to be done and who will do it. Agile teams are self-organizing in that the people doing the work are the ones who plan the work– the manager or team lead may facilitate this planning work, but they don't tell people what to do.

Daily work: People on the team collaborate to accomplish the work. The team members are able to work with the customer, or at least someone who can fairly represent the customer, so that they can get input into their work to ensure that what they're doing reflects the actual needs of the customer.

Iteration/sprint wrap up: At the end of each sprint the team should seek feedback on what they have done, which is particularly important when they have not had access to their customer(s) earlier in the sprint. This feedback session is often a "show and tell" or a demonstration. The team should also consider taking some time to reflect on how well they've been working together so as to identify potential improvements.

New ideas: Customers/stakeholders will often generate new ideas for the team when they're given the opportunity to see what has been done. These ideas can come in at any time although it is common to generate ideas during demo/ feedback sessions.

Transition: Once the work is complete, or at least a valuable portion of the work is complete, it should be delivered or transitioned to the customers.

13.7 People Capability Maturity Model

People Capability Maturity Model (People CMM) is a roadmap for implementing workforce practices that continuously improve the capability of an organization's workforce. People Capability Maturity Model Integration (PCMM) is a framework for process improvement and is developed by Software Engineering Institute at Carnegie Mellon University in Pittsburgh for Software Development, Service Providers and Organization involved with Acquisitions. A Process improvement approach that defines essential elements of effective processes.

Every PCMM model is a process improvement approach that provides organizations with the essential elements of effective processes. It can be used to guide improvement across a team, project, division, or entire organization, and helps to set process improvement goals. It can provide priorities, provide guidance for quality processes and support a point of reference for appraising current processes.

The People Capability Maturity Model describes an evolutionary improvement path from ad hoc, inconsistently performed workforce practices, to a mature infrastructure of practices for continuously elevating workforce capability. Currently, there are three models that address the following:

- The development of Software Products and Services, that is, CMMI–DEV.

The acquisition (the learning or developing of a skill, habit, or quality.) of Products and Services, that is, CMMI–ACQ.

- The establishment, management, and delivery of services, that is, CMMI–SVC.

Maturity Levels of People Capability Maturity Model (PCMM)

A maturity level represents a new level of organizational capability created by the transformation of one or more domains of an organization's processes. The People CMM applies the principles of the process maturity framework to the domain of workforce practices.

A maturity level consists of practices for a set of process areas that improve an organization's overall performance.

- CMMI-DEV is a set of guidelines for 22 process areas related to systems development.

Identifying an organization's current maturity level enables it to specify necessary actions to improve the organization's future performance.

- CMMI-DEV can also be used as a benchmark for comparing organizations.

The model also enables an organization to track, evaluate, and demonstrate its progress over the years. Achieving Maturity Level 5, the highest possible rating, is a significant accomplishment for any organization, and it can lead to substantial business benefits (Figure 6).

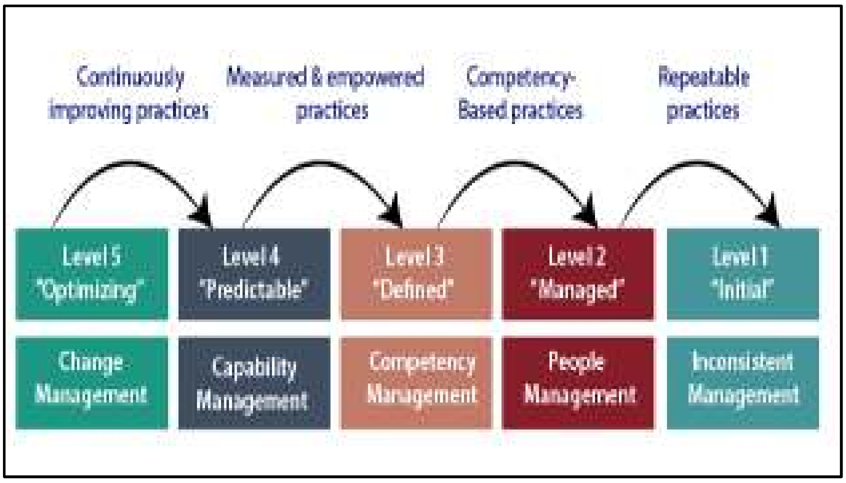


Figure 6: Maturity Levels of PMMI

Initial Level (Maturity Level 1): The Initial Level of maturity includes no process areas. Although workforce practices implement in Maturity Level, 1 organization tend to be inconsistent or ritualistic, virtually all of these organizations perform processes that are defined in the Maturity Level 2 process areas.

Managed Level (Maturity Level 2): To achieve the Managed Level, Maturity Level 2, managers start to perform necessary people management practices such as staffing, operating performance, and adjusting compensation as a repeatable management discipline. The organization establishes a culture focused at the unit level for ensuring that a person can meet their work commitments. In achieving Maturity Level 2, the organization develops the capability to handle skills and performance at the unit level. The process areas at Maturity Level 2 are Staffing, Communication and Coordination, Work Environment, Performance Management, Training and Development, and Compensation.

Defined Level (Maturity Level 3): The fundamental objective of the defined level is to help an organization gain a competitive benefit from developing the different competencies that must be combined in its workforce to accomplish its business activities. These workforce competencies represent critical pillars supporting the strategic workforce competencies to current and future business objectives; the improved workforce practices for implemented at Maturity Level 3 become crucial enablers of business strategy.

Predictable Level (Maturity Level 4): At the Predictable Level, the organization handles and exploits the capability developed by its framework of workforce competencies. The organization is now able to handle its capacity and performance quantitatively. The organization can predict its capability for performing work because it can quantify the ability of its workforce and of the competency-based methods they use performing in their assignments.

Optimizing Level (Maturity Level 5): At the Optimizing Level, the integrated organization is focused on continual improvement. These improvements are made to the efficiency of individuals and workgroups, to the act of competency-based processes, and workforce practices and activities.

Benefits of PCMM

The adoption of the model:

- Drives a "systems" approach to its people related processes and initiatives.
- Promotes long-term thinking in terms of the people.
- Increases transparency, democracy, and openness.
- Builds organizational agility and ability to execute cross-functional projects.
- Increases the level of automation.
- Drives a competency culture.
- Enables handling of rapid growth and scale.

- o Makes the HR function become more of a business partner.
- o Transforms line managers to better people managers.

13.8 Project Scheduling

Project scheduling is the process of developing a well-documented and detailed plan for completing the project on time. Scheduling a project usually starts from drawing an outline and making a step-by-step guide of the tasks that require accomplishment at every stage of the project.

A well-documented schedule allows project managers to transparently share critical project information with clients, team members and other stakeholders. The process of scheduling also involves deciding and designing different tasks with a timeframe.

Project-task scheduling is a significant project planning activity. It comprises deciding which functions would be taken up when. No matter the size or scope of the project, the schedule is a key part of project management. The schedule tells when each activity should be done, what has already been completed, and the sequence in which things need to be finished.

Importance of Project Schedule

Project schedules help in the following ways:

- o They provide a basis for monitoring and controlling the project activities.
- o They help to determine how best to allocate resources so one can achieve the project goal.
- o They help to assess how time delays will impact the project.
- o One can figure out where excess resources are available to allocate to other projects.
- o They provide a basis to help track the project progress.

To schedule the project plan, a software project manager has to do the following:

1. Identify all the functions required to complete the project.
2. Break down large functions into small activities.
3. Determine the dependency among various activities.
4. Establish the most likely size for the time duration required to complete the activities.
5. Allocate resources to activities.
6. Plan the beginning and ending dates for different activities.
7. Determine the critical path. A critical way is the group of activities that decide the duration of the project.

13.9 Project Scheduling Process

The first method in scheduling a software plan involves identifying all the functions required to complete the project. A good judgment of the intricacies of the project and the development process helps the supervisor to identify the critical role of the project effectively.

Next, the large functions are broken down into a valid set of small activities which would be assigned to various engineers. The WBS formalism supports the manager to breakdown the function systematically after the project manager has broken down the purpose and constructs the work breakdown structure; he/she has to find the dependency among the activities.

Dependency among the various activities determines the order in which the various events would be carried out. If an activity A necessary the results of another activity B, then activity A must be scheduled after activity B. In general, the function dependencies describe a partial ordering among functions, that is, each service may precede a subset of other functions, but some functions might not have any precedence ordering describe between them (called concurrent function). The dependency among the activities is defined in the pattern of an activity network.

Once the activity network representation has been processed out, resources are allocated to every activity. Resource allocation is usually done using a Gantt chart. After resource allocation is completed, a PERT chart representation is developed. The PERT chart representation is useful for program monitoring and control.

For task scheduling, the project plan needs to decompose the project functions into a set of activities. The time frame when every activity is to be performed is to be determined. The end of every action is called a milestone. The project manager tracks the function of a project by audit the timely completion of the milestones. If he examines that the milestones start getting delayed, then he/she has to handle the activities carefully so that the complete deadline can still be met.

1. Schedule Inputs- You need several types of inputs to create a project schedule such as:
   - Personal and project calendars: Understanding working days, shifts, and resource availability is critical to completing a project schedule.
   - Description of project scope: From this, you can determine key start and end dates, major assumptions behind the plan, and key constraints and restrictions. You can also include stakeholder expectations, which will often determine project milestones.
   - Project risks: You need to understand these to make sure there's enough extra time to deal with the identified risks– and with unidentified risks.
   - Lists of activities and resource requirements: Again, it's important to determine if there are other constraints to consider when developing the schedule. Understanding the resource capabilities and experience you have available– as well as company holidays and staff vacations– will affect the schedule. A project manager should be aware of deadlines and resource availability issues that may make the schedule less flexible.
2. Scheduling Tools- Here are some tools and techniques for combining these inputs to develop the schedule:
   - Schedule Network Analysis: This is a graphic representation of the project's activities, the time it takes to complete them, and the sequence in which they must be done. Project management software is typically used to create these analyses– Gantt charts and PERT Charts are common formats.
   - Critical Path Analysis: This is the process of looking at all of the activities that must be completed and calculating the 'best line'– or critical path – to take so that you'll complete the project in the minimum amount of time. The method calculates the earliest and latest possible start and finish times for project activities, and it estimates the dependencies among them to create a schedule of critical activities and dates.
   - Schedule Compression: This tool helps shorten the total duration of a project by decreasing the time allotted for certain activities. It's done so that you can meet time constraints, and still keep the original scope of the project. You can use two methods here:
     - Crashing: This is where you assign more resources to an activity, thus decreasing the time it takes to complete it. This is based on the assumption that the time you save will offset the added resource costs.
     - Fast-Tracking: This involves rearranging activities to allow more parallel work. This means that things you would normally do one after another are now done at the same time. However, do bear in mind that this approach increases the risk that you'll miss things, or fail to address changes.
3. Project Review: Once you have outlined the basic schedule, you need to review it to make sure that the timing for each activity is aligned with the necessary resources. Here are tools commonly used to do this:
   - 'What if' scenario analysis– This method compares and measures the effects of different scenarios on a project. You use simulations to determine the effects of various adverse, or

harmful, assumptions– such as resources not being available on time, or delays in other areas of the project. You can then measure and plan for the risks posed in these scenarios.

13.10 Project Staffing

Personnel Planning deals with staffing. Staffing deals with the appoint personnel for the position that is identified by the organizational structure. It involves:

- Defining requirement for personnel
- Recruiting (identifying, interviewing, and selecting candidates)
- Compensating
- Developing and promoting agent

For personnel planning and scheduling, it is helpful to have efforts and schedule size for the subsystems and necessary component in the system. At planning time, when the system method has not been completed, the planner can only think to know about the large subsystems in the system and possibly the major modules in these subsystems.

Once the project plan is estimated, and the effort and schedule of various phases and functions are known, staff requirements can be achieved. From the cost and overall duration of the projects, the average staff size for the projects can be determined by dividing the total efforts (in person-months) by the whole project duration (in months). Typically, the staff required for the project is small during requirement and design, the maximum during implementation and testing, and drops again during the last stage of integration and testing.

Using the COCOMO model, the average staff requirement for various phases can be calculated as the effort and schedule for each method are known. When the schedule and average staff level for every action are well-known, the overall personnel allocation for the project can be planned. This plan indicates how many people will be required for different activities at different times for the duration of the project. The total effort for each month and the total effort for each step can easily be calculated from this plan.

Project Staffing Plan is a formal document that defines the number and quality of personnel involved in participating in a particular project. Its purpose is to make certain that the project is provided with sufficient personnel with the right skills and experience to ensure successful completion of project goals and objectives. Staffing a project means the process of selecting and training individuals for specific job functions required by the project and charging those individuals with the associated responsibilities. The process results in developing a staffing plan (Figure 7).

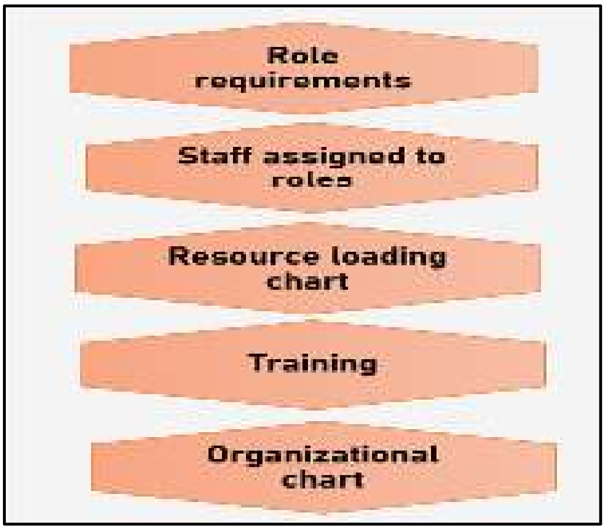


Figure 7: Project Staffing Plan

A typical project staffing plan contains the following sections:

- Role requirements: A detailed list of staff roles required to perform the project, with details on skills, number of staff required, estimated start date, and expected duration for every role.
- Staff assigned to roles: A breakdown of actual personnel assigned to project roles, with details on the number of working hours requested for each role, the labor rate, and the source(s) from which staff members are recruited.
- Resource loading chart: A visual representation of the estimated effort measured in working hours for each staff resource assigned to the project.
- Training: An outline of training exercises and activities to take employees to a level of skills required for project execution.
- Organizational chart: A graphical picture of the role hierarchy and reporting relationships between project staff members.

13.11 Project Team Structure

Team structure addresses the issue of arrangement of the individual project teams. There are some possible methods in which the different project teams can be organized. There are primarily three formal team structures:

- chief programmer
- ego-less or democratic
- and the mixed team organizations

Notes: The problems of various complexities and sizes often need different team structures for the chief solution.

- **Chief Programmer Team:** A chief-programmer team, in contrast to the ego-less team, has a hierarchy. It consists of a chief-programmer, who has a backup programmer, a program librarian, and some programmers. The chief programmer is essential for all major technical decisions of the project. He does most of the designs, and he assigns coding of the different part of the design to the programmers. The backup programmer uses the chief programmer makes technical decisions and takes over the chief programmer if the chief programmer drops sick or leaves. The program librarian is vital for maintaining the documentation and other communication-related work. This structure considerably reduces interpersonal communication. The communication paths, as shown in the Figure 8:

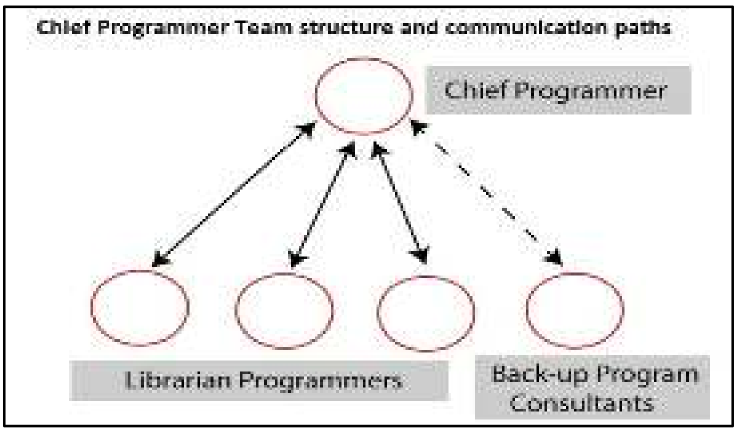


Figure 8: Project Team Structure

- **Ego-Less or Democratic Teams:** The ego-less teams subsist of a team of fewer programmers (depicted in Figure 9 below). The objective of the group is set by consensus, and input from each member is taken for significant decisions. Group leadership revolves among the group members. Due to its nature, egoless teams are consistently known as democratic teams. The structure allows input from all representatives, which can lead to better decisions in various problems. This suggests that this method is well suited for long-term research-type projects that do not have time constraints.

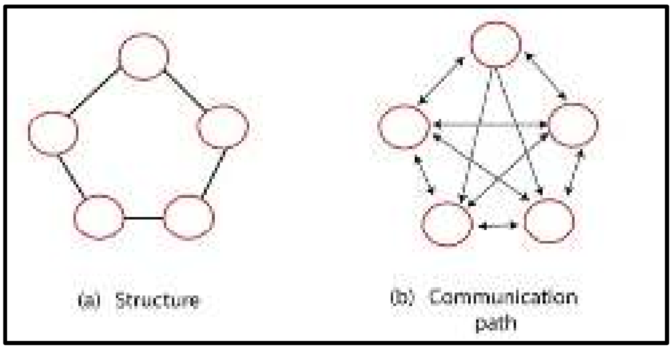


Figure 9: Ego-less Programming Team Structure and Communication Paths

- Controlled Decentralized Team (Hierarchical Team Structure): A third team structure known as the controlled decentralized team tries to combine the strength of the democratic and chief programmer teams. It consists of project leaders who have a class of senior programmers under him, while under every senior programmer is a group of a junior programmer.

The group of a senior programmer and his junior programmers behave like an ego-less team, but communication among different groups occurs only through the senior programmers of the group. The senior programmer also communicates with the project leader. Such a team has fewer communication paths than a democratic team, but more paths compared to a chief programmer team. This structure works best for large projects that are reasonably straightforward. It is not well suited for simple projects or research-type projects.

Staffing Management Plan

Staffing management plan and resource management plans are important part of project resource management. Every project will require resources for executing project activities. There will be a need for both manpower resources and physical resources. The resource requirement for each activity will be estimated. The resources will be acquired during project execution as per the schedule.

Staffing management plan, which part of overall resource management plan will specifically focus on the manpower aspects of the project. Staffs are the most important part of project. It is important to select and acquire the right staff with right skills at the right time.

A staffing management plan contains a plan for addressing all the aspects of manpower and will include below information:

- Identification of human resources.
- How the human resources will be acquired?
- Criteria to be used for how the human resources will be selected.
- From where the human resources will be acquired.
- How to acquire resources from within the organization.
- How to acquire resources from external sources.
- When the resources will be acquired (based on the project schedule).
- When the resources will be released (based on the project schedule).
- Process for maintaining the resource calendars.

- o Resource loading table depicting total number of resources needed at different points in the project.
- o Safety and security guidelines for the human resources.
- o Identification of training needs and plan for fulfilling the training needs of the team.
- o Rewards and recognition plan for the team.
- o How to build the team and enhance team performance?
- o How to monitor the performance of each team member and help keeping them motivated?

Summary

- People management is about managing people in the workplace: making sure they are provided for and have everything they need to get their jobs done.
- The successful people management involves hiring and training the right employees, guiding and empowering each employee to reach their maximum potential, effectively communicating across all teams, and directing all team members toward a common goal.
- People management includes formal, procedural duties such as hiring, training, evaluating, and disciplining employees—at least, these tasks are what come to mind when most people think of people management.
- People management involves organizing your team to increase productivity and optimize efficiency. Mastering effective people management is essential to retain employees, maintain productivity and engagement and boost business performance.
- Process management refers to aligning processes with an organization's strategic goals, designing, and implementing process architectures, establishing process measurement systems that align with organizational goals, and educating and organizing managers so that they will manage processes effectively.
- Process management is a systematic approach to ensure that effective and efficient business processes are in place. It is a methodology used to align business processes with strategic goals.
- The performance management process is strategic and systematic. It combines verbal and written components, which take place throughout the year, culminating in an annual performance appraisal.
- Performance management aims to develop the skills and competencies employees need to improve performance and success in their job. An effective performance management helps organizations ensure that employees understand their roles, receive constructive feedback, and have the support they need to achieve their goals and business objectives.
- People Capability Maturity Model Integration (PCMM) is a framework for process improvement that defines essential elements of effective processes.

Keywords

People Management: People management, a subset of human resource management, organizes employees and builds teams to optimize business performance.

Feedback: Feedback keeps an organization running smoothly, but it needs to go both ways: from managers to their people and vice versa. After all, nobody can fix a problem without knowing it exists.

Process management: Process management, often known as business process management (BPM), is the identification, improvement, and management of a business's processes.

Performance management: Performance management is a set of processes and systems aimed at developing employees, so they perform their job to the best of their ability.

People Capability Maturity Model: People Capability Maturity Model (People CMM) is a roadmap for implementing workforce practices that continuously improve the capability of an organization's workforce.

Maturity Levels in PCMM: A maturity level represents a new level of organizational capability created by the transformation of one or more domains of an organization's processes.

Self Assessment

1. People management is about managing people in the workplace: making sure they are provided for and have everything they need to get their jobs done. A successful people management involves

A. hiring and training the right employees

B. guiding and empowering each employee to reach their maximum potential

C. involving effective communication across all teams

D. All the above.

2. People management, a subset of human resource management, organizes employees and builds teams to optimize business performance.

A. True

B. False

3. Which of the following statement(s) is TRUE for People Capability Maturity Model?

A. PCMM model is a process improvement approach that provides organizations with the essential elements of effective processes.

B. It can be used to guide improvement across a team, project, division, or entire organization, and helps to set process improvement goals.

C. It can provide priorities, provide guidance for quality processes, and support a point of reference for appraising current processes.

D. All the above.

4. A people manager is a thoughtful person responsible for leading or managing people and ensuring that all are happy at work. The people manager performs ______________.

A. helping the employee's problem-solve and overcome challenges.

B. forestalling and managing conflict between team members.

C. Facilitation of knowledge-sharing and brainstorming within a team by making sure people feel free to share their ideas.

D. All the above.

5. The full form of BPM is

A. Business Process Management

B. Business Procedure Management

C. Building Process Measurement

D. Business Procedure Measurement

6. A(n) ____________ involves researching and collecting data on the organization's business needs.

A. Management process

B. Information process

C. Triggering process

D. Operational process

7. Process management, often known as _____________, is the identification, improvement, and management of a business's processes.

A. business procedure management

B. business process management

C. building process management

D. building procedure model

8. Once you establish or optimize processes, it's important to create a process owner. Assigning ownership means there's someone responsible for embedding the new process in the business and remaining committed to the process design.

A. True

B. False

9. A good process management can consist of

A. continually monitoring and optimizing business rules and processes.

B. quickly identifying and resolving bottlenecks

C. reducing delays

D. All the above.

10. In ___________ approach, the employees are evaluated based on their behaviors and effort. This approach is suitable for giving detailed feedback on behaviors by mapping desirable future behaviors and when individual results are hard to measure.

A. Behavioral

B. Effort

C. Reliability

D. Feedback

11. Automating processes increase the risk as it elevates the possibility of human error.

A. True

B. False

12. The performance management cycle is an annually reoccurring phenomenon in which employees are evaluated throughout the year. Which of the following is a stage in performance management?

A. Goofing

B. Varying

C. Rating & rewarding

D. Annulling

13. In which of the following approach, the employees are evaluated based on objective criteria is suitable when there are multiple ways to do the job.
A. Multi-oriented approach
B. Workload-oriented approach
C. Result-oriented approach
D. Objectivity-oriented approach

14. As the work progresses the people doing it should obtain feedback from others, in particular the person(s) from which the request came from, to ensure that they are on the right track. Feedback can come from
A. informal demonstrations
B. formal demonstrations
C. requests for feedback
D. All the above.

15. PCMM stands for
A. Personal Capability Multimodal Model
B. People Capability Maturity Model
C. People Course Multiphase Model
D. People Coping Multimodal Model

Answers for Self Assessment

1.	D	2.	A	3.	D	4.	D	5.	A
6.	B	7.	B	8.	A	9.	D	10.	A
11.	B	12.	C	13.	C	14.	D	15.	B

Review Questions

1. What is the significance of using People Capability Maturity Model?
2. Enlist the process of project staffing plan.
3. What are the various benefits of people management?
4. What do you understand by process management? Differentiate the different types of processes.
5. Explain the importance of process management in detail?
6. What is performance management? Discuss the importance of effective performance management.
7. Briefly discuss the importance and process of project scheduling.
8. Discuss the strategies to optimize the process management.
9. Describe how the process management is carried out enlisting the stages involved in it.
10. Write a short note on:

(a) Project Staffing Plan

(b) Project Team Structure

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Unit 14: Project Communication Management (PCM)

CONTENTS

Objectives

After studying this unit, you will be able to:

- learn about Project Communication Management (PCM).
- explore the phases of communication in project management.
- understand in detail about effective communication and decision making in project management.
- investigate the importance of leadership in project management.
- know about Wrike and other project management tools.

Introduction

Communication skills are more than just speaking well. For some project managers, communicating effectively is natural and easy. For others, effective communication is a learning experience. Either way, we spend considerable time in verbal as well as formal and informal written communication. Whether these communications involve exchanging status information or setting project objectives, project managers must ensure that the information is transmitted and received effectively. A Guide to the Project Management Body of Knowledge (PMBOK® Guide) defines project communication management as "the processes required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information."

In this Information age, the project managers have more data at their disposal than at any time in the past. As our technologies mature and advance into the next century, we will be bombarded with more and more information, and it will come to us quicker than we can probably imagine. This rapid influx will force project managers to develop skills to deal with information overload, which can result from receiving too much or conflicting information and from not being able to transmit data effectively. Such problems can be characterized as communication management issues. It is imperative that project managers develop the general management skills of communicating. It is equally important for them to effectively manage project communications.

14.1 Phases of Project Communication Management (PCM)

Project communication management is a crucial aspect of project management as it ensures all stakeholders are kept informed about the project's progress, issues, and changes, thereby facilitating effective decision making and collaboration. Project communication management is a collection of processes that help make sure the right messages are sent, received, and understood by the right people.

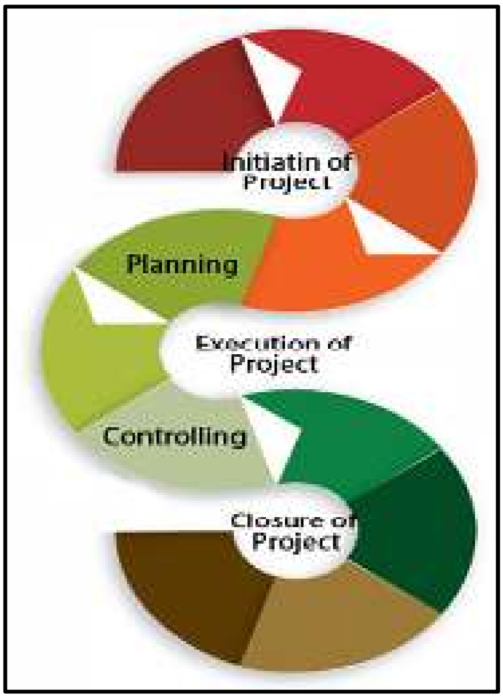

Figure 1: Phases of Project Communication Management

From conceptualization to completion, there are five phases used to deliver a successful articulated outcome (Figure 1):

1. Initiation: This phase determines the beginning of the project. Once the project manager gets approval, he or she starts the documentation of the concept description, which includes the objective based on the purpose of the project and its desired outcome with the calculation of risks.
2. Planning: In this phase, the project manager verbalizes a strategy to accomplish the target with strict adherence to the timeline. He or she may choose team members and ascertain the tasks/activities, allocating the same among the team members with given milestones and key success parameters. Setting a work schedule and communication line is also considered during this phase.

3. Execution: The project manager implements the resources to produce the desired outcome as chalked out in the project plan.
4. Controlling: In this phase, the project manager monitors the teamwork to align the projected performance as determined in the planning phase.
5. Closure: At the final stage, the project manager delivers the final outcome to his or her superiors and facilitates the administrative task if any remains.

14.2 Effective Project Communication

To accomplish the target successfully, effective communication is the key factor that the project manager should keep in mind from formulating a strategy. That is why we can say efficient and effective communication is the lifeblood of any kind of project management. Many projects fail due to ineffectiveness or lack of communication.

According to the report of PMI (Project Management Institute), a project manager should spend 90% of his or her time communicating with stakeholders and team members. Successful leadership depends on clear communication about goal, performance, responsibility, achievement, challenges, as well as customer feedback with the team members who generally belong to a diverse group of people.

Regular reporting of the project's progress and status to the stakeholders is the decisive portion of efficacious project leadership. So, proper communication management, which consists of three processes, mitigates the risk of failure to some extent. These are some of the effective communications in project management.

Project communication management is one of the 10 key knowledge areas in the PMBOK (Project Management Book of Knowledge). The processes included in this area have changed over the years but, in the current version, there are three primary project communication management processes. These are:

- Plan communications management
- Manage communications
- Monitor communications

Plan communications management

Project managers need to clearly outline how they will manage communications across their projects. This is done by creating a project communication management plan.

How to create a project communication management plan?

When creating a plan, project managers should follow these five steps:

1. Decide your objectives: What will be the purpose of your communication? You may use some communication tools for awareness, such as a status report. Others may require action, such as requiring a sponsor to authorize spending or a customer to approve project testing.
2. Determine your audience: Who are the stakeholders in this project? You should make an extensive list of everyone involved. Consider anyone impacted by the project or who influences its success. This list should include team members, sponsors, customers, and other interested parties.
3. Write your message: What will the message be for each type of communication? This is the actual content that will be shared. Key components to be communicated include scope, schedule, budget, objectives, risks, and deliverables.
4. Choose your channel: How will the message be delivered? Will it be a formal report emailed out to all stakeholders? Or will it be an informal verbal debrief during a team meeting?

5. Set a timeline: When will you deliver your message? Do your stakeholders require weekly or monthly reports? Is there a deadline to meet? Consider varying time zones and employee schedules here.

Notes: Your project communication management plan should be detailed enough to lay out why you're sending a message, who you're sending it to, what specific information will be sent, how you're going to send it, and when.

Did You Know?

Involving your stakeholders in the creation of this plan is important. You need to understand their communication preferences and expectations. If you over-communicate, they may stop paying attention. But, if you under-communicate, it can lead to misunderstandings and issues.

Caution: The golden rule here is, to be a good communicator, you need to be a good listener.

Manage Project Communication

Once the project communication management plan has been created and approved, it's the project manager's job to ensure it's carried out successfully. This means the plan needs to be reviewed and updated on a regular basis to reflect any changes to the project or its stakeholders. The project manager also has to manage the execution of the project communication management plan. This includes:

- Collection and analysis of data.
- Creation of messages for communication.
- Transmission or distribution of communications.
- Storage of any communication reports, files, or documents.
- Retrieval of any stored communications.
- Disposal of any old communications upon project closure or a set date.

Monitor project communication

This process used to be called 'control communications,' but was updated in the sixth edition of the PMBOK. Despite the title change, the process is the same. It involves monitoring and controlling project communications throughout the entire lifecycle. This may include the confirmation of the following:

- Communications went out as planned.
- They were received by the proper stakeholders.
- Messages were understood.
- Any relevant feedback was provided to the appropriate project members.
- The actual type of monitoring, including method and frequency, should be a part of the project communication management plan.

14.3 Methods of Effective Communication

Communicating effectively helps to develop a positive environment.

1. **Active or Synchronous Communication-** If all the members or parties are taking part in exchanging information at the same time, communication is called synchronous communication.

- Live Meeting: Joining all team members at the same location.

- Video Conference: Live video conference.
- Conference Call: A telephone call where two or more people participate.
- Audio con-Call: Like conference call, but it is conducted online using software like Skype.
- Computer-Assisted Conference: Audio conference call with a connection of computers where a spreadsheet or document is displayed, and both the parties can edit it.
- I.M (Instant Messaging): Exchange of voice messages or text using pop-up windows like Google Hangout.
- Texting: Exchange of messages through mobile phones or personal digital assistants.

2. **Passive or Asynchronous Communication-** Many types of communication in project management do not require the presence of all team members or parties at the same place. This type of communication is called asynchronous communication.

- E-mail: Electronic mail is widely used to coordinate the project and to communicate among team members.
- Fax: The fax machine is widely used around the world as a trustworthy process of transmitting documents.
- Blogs: Some project managers write blogs of their experiences of various challenges they have faced during the execution of the project. These blogs may be helpful for the future decision-making process.

With the advancement of modern technologies, it becomes possible to assemble all the team members from anywhere in the world. The project manager may choose any channel of communication with team members or stakeholders, but the communication becomes effective by the realization of what is being communicated with effective feedback being obtained from various stakeholders. Therefore, active listening, strong presentation skills, conflict resolution skill, etc., are the traits of core competencies of a successful project manager.

14.4 Decision Making

Productive project management can drive a company towards success, giving employees a clear, easy-to-follow path towards completing their work objectives in a highly efficient manner. If done strategically, project management can keep everyone on track, including upper management, and create much-needed transparency in business processes.

To be able to create realistic goals in line with the company's vision and still retain flexibility for any unseen circumstances during the project's life cycle, making effective decisions is crucial to adhere to a structure that keeps the team's momentum moving forward.

The decision-making process in project management can heavily influence the success employees feel as individuals (and as a team) or, unfortunately, create a litany of workflow issues and interpersonal misunderstandings.

14.5 Importance Of Decision-Making in Project Management

There are many reasons why the decision-making process is important to project management:

- Lessens the risk of continued project delays or, in worst cases, delivery of an unfinished assignment.
- Takes into account unexpected hurdles and seamlessly keeps the progress of the project going.
- Sets up individuals on the team for success in the part of the project they own.
- Reduces the amount of overwhelm employees feel by providing achievable deadlines and clarity on relevant processes.
- Leverages the various talents on the team so they can operate within their zone of genius and produce high-quality work within the scheduled timeline.

- Provides an organized structure that's easy for everyone to understand and follow.
- Helps clarify the goals of the project from start to finish.
- Keeps the workflow focused so the team can achieve essential milestones.
- Avoids costly mistakes due to repetitive project failures.

Strategic decisions in project management are made with these four vital factors in mind:

1. **The goals of the project–** What are the milestones that need to be achieved from the beginning of the project to the very end?
2. **The resources available–** Who on the team will be responsible for particular tasks? What platforms, budget, services, and communication channels are available to the organization, ensuring collaboration and idea-sharing is an easy process?
3. **The intended outcome–** With this project, what do we want to achieve? What does success look like? And what type of value does the organization want to provide?
4. **The value the result will have on the company overall–** How does it impact the organization's bottom line? Are the goals of the various projects in line with the company's big-picture mission?

These are key elements of the decision-making process in project management. However, these types of decisions can create challenges for those involved with leading and managing various company initiatives.

14.6 Challenges of Decision-Making in Project Management

According to PMI's "Pulse of the Profession: High Cost of Low Performance," only 42% of organizations report high alignment with or projects to organizational business strategy. As little as 32% of organizations report that their projects are better aligned than previous years. In other words, if the goals of the project don't align with the company's overall strategy, the less success there will be for that organization.

To help overcome some of the inevitable challenges with project management, it's important to understand the barriers that block efficient decision-making in the workplace:

Engagement with PM tools– Much of this comes down to how familiar and comfortable employees are with using the company's chosen systems, allowing for more streamlined project management. Using new technology and adapting to its various updates is a familiar challenge in the workplace. To combat this, training and development should remain a top priority for new and more senior team members to keep their knowledge up-to-date. If a team cannot keep up with evolving technology, they'll fall behind quickly, unable to properly use these resources to their (and the company's) benefit. For example, when a new team member is not thoroughly trained in the platforms used to keep track of a project's progress, this lack of understanding and engagement with the tool can cause disruptive delays. They may not know when to mark a task as complete or how to provide an update so the project manager can make appropriate adjustments to the timeline and notify all relevant parties. This creates an unnecessary, negative domino effect for the entire team.

Scheduling– Conflicts in scheduling happen frequently, especially if an organization is working on multiple projects at a time. A successful project manager (PM) takes this into consideration when proposing and implementing a timeline that is manageable for everyone. Issues occur when there is a lack of communication about vacation or time-off requests, demands of other projects and how it impacts specific groups, and no organization when it comes time to sync all the relevant calendars together and pull in the necessary resources, enabling a smooth pipeline of simultaneous assignments.

Rapid changes– Of course, changes occur all the time during the life cycle of any project. External customers or clients can have unique demands, which potentially stray from standard company procedures. Sometimes, the changes to procedures can come from internal management trying to discover new and improved ways of doing different tasks. The PM, in coordination with the project's key players and leadership, must be able to have thorough conversations about the changes and discover workarounds that benefit everyone involved. It becomes a struggle for the team when project demands are constantly outside of normal practices. This slows down the workflow, causing a backlog of work until a solution can be found. If this happens across multiple projects at the same time, the team may not be able to produce high-quality results. For this type of barrier to be overcome, the team should collectively be upfront about their capacities and what they're able to accommodate so that the appropriate decisions can be made.

No existing practices– There are many occasions when a company is in the process of developing new methods and processes in order to find what works best for their team. Since this often takes time and consistent input from all the relevant parties about what's working and what isn't, more robust decision-making can be impacted as it can be a trial-and-error process. Those in managerial positions may have different approaches to problem-solving or the process needs to be tested multiple times before the team finds its rhythm.

Team skills– One of the biggest roadblocks to effective decision-making in project management can be the resources available, including the team's skill set. The success of a project depends on the people involved with its completion. The team must be able to rely on each other to do their respective parts, with firm checks and balances in place to guarantee a successful outcome and limit mistakes. Managers should be aware of their direct report's strengths (and provide training for areas needing improvement), assign them tasks that encourage their growth as employees, and understand how the team as a whole works together in order to ensure effective collaboration. This is a crucial part of the decision-making process: making sure that the right people are in the right seats, so the project moves forward successfully. Managers should also be able to identify when it's time to recruit positions requiring particular skill sets to address any gaps in the current team structure and provide further support.

Budget constraints– Budgets act as a guide on how to best move forward and can make it clear what projects take priority and what may be consuming too much time without enough return. It can also determine what resources are currently available and what needs to be allocated to other areas of the company. Put simply, budgets can help give a company direction in what's possible. In order to make good decisions in the short and long term, the leadership team needs to be clear on where it stands financially to ensure productive operations and continued growth and expansion. Another challenge is creating a realistic budget that considers all the individual costs that go into a project. A stricter, smaller budget may impede some teams' ability to get their work done efficiently if not coordinated strategically.

Communication– In a survey of 400 companies with 100,00 employees, it was revealed that companies lose an average of $62.4 million dollars per year due to poor communication, to and between their employees. Companies with poor communication often host a workplace environment where employees find it difficult to stay focused and feel motivated. As project management largely depends on how well a team communicates with one another to get a project to the finish line and problem-solve along the way, any breakdown in communication between leadership and employees can have disastrous results that extend beyond project management.

While many challenges exist that can heavily impact decision-making in project management, there are ways to help facilitate this process that can set the team up for success.

14.7 Decision-Making Process in Project Management

There are a few steps to consider when approaching decision-making in project management:

Identify the purpose of your decision: This is the essential first step in decision-making. You must be able to clearly define the goal behind the decision needing to be made. For example, let's say we have a PM who is working on putting together a structure for a writing project that will be read aloud on a podcast. Aside from creating a solid timeline of milestones, the PM will need to have a clear goal in mind in order to make effective decisions. The goal in this specific case would be to identify and choose the few individuals to comprise the team, whose expertise will deliver the final product in a faster manner than usual. Since this particular example is considered a high-priority project needing a finer eye, extra care and diligence must be top of mind when making choosing the appropriate team.

Have all the information you need directly related to the problem: Before you make a decision, you need to collect all the relevant information, both internally and externally. Let's take our example of the PM whose team was tasked with writing a project that will be read aloud on a podcast, expanding the company's visibility. Internally, the PM needs to know the team's availability to be able to make a decision on a feasible timeline while simultaneously understanding the needs of the external client and their own expectations. This ensures that the team is meeting important milestones.

Consider the impact it will have on the rest of the team: When it comes to decision-making, you'll need to keep in mind the proposed decision will have a ripple effect on the rest of the team. If the decision of a PM causes an imbalance of work– with one person getting more work than another– a new decision should be made in order to rectify the situation. Workplace initiatives often require regular feedback from the individuals on a team so that better, well-thought-out decisions can be made. In our example, the PM will need to review the workload of the team against the needs of the project. If there is considerable conflict in schedules or availability, a team discussion may be needed to identify a solution.

Identify different methods as alternatives: Part of a PM's job is to think about different workflow paths in the event the process doesn't go as originally planned, or identify if there is a way to work more effectively given the circumstances of the situation. When considering different alternatives, it's best to keep in mind that whichever secondary options exist still need to be in line with reaching the ultimate goal of the project. If the alternative option can help the team complete the project faster and more efficiently, this would be the time to evaluate all the information available and make a well-rounded decision.

Execute your decision: Now that you have all the information you need and have considered the overall impact it will have on the relevant parties, it's time to execute the decision. The team will carry it out as discussed with relevant check-ins during the process, especially if it is new to the organization. This ensures the workflow process is running smoothly and gives an opportunity to identify, solve, and discuss any issues that arise needing the team's input.

Evaluate continuously: As with any other decisions that impact the team and the work product, evaluation is necessary to help keep processes fresh and effective. You must consider the results of your decisions and whether or not it has met the needs of the project. If not, additional information may be needed in order to make better, more informed decisions when reviewing and improving the processes in the future.

14.8 Examples of Decision-Making in Project Management

Effective decision-making techniques are a healthy combination of intuition, experience, and analysis. The following are the examples of decision-making in project management:

- **Heuristic Technique–** This is a method of problem-solving when you want to make quick decisions given a limited time frame, accelerated deadline, or have complex data. This involves relying on past experience, recalling similar situations, intuitive guesswork, trial and error, and mental shortcuts to arrive at a fast solution. This method is intended to be flexible, leaving room for future adjustments. The one downside to this approach is that it can produce errors later in the project's life cycle. If a particular project is similar in scope and circumstances to a previous assignment, the team can use estimations based on this prior data to make decisions.
- **Multi-voting–** Multi-voting is a group decision-making technique structured to reduce a large number of action items to a manageable amount based on a team discussion and subsequent vote. The result is a prioritized list that identifies what is most important to the team. Often used during brainstorming sessions, each team member selects from a large number of items what they feel is the most important in the bunch. Depending on the group, this can be done electronically, physically (via a ballot), or through raised hands in a meeting. Each person casts one vote. Then the votes are tallied and the process is repeated until there is a prioritized list of top items. In the case of project management, multi-voting can manifest when the PM works with leadership on an upcoming project. After some discussion about the assignment and the potential issues that may

be relevant, the group can then come up with an organized list of the high-priority action items needing to be done.

- **Decision-Tree Analysis–** Decision-tree analysis is a visual representation of decisions, potential outcomes, consequences, and possible costs. Using a series of branches and nodes, this support tool can help the project management team identify solutions and evaluate their readiness for implementation. Conversely, branches holding alternative options can be cut entirely from the diagram based on their usefulness to the project. This method is most useful for complex problem-solving, operations, strategies, and cost management. Undeniably, the greatest advantage of the technique is that it is a visual tool, allowing you to see all the possible scenarios in combination with expected outcomes. To use this method in project management, you first need to define the problem in which a decision is needed. Then you can start drawing the decision tree with all the possible solutions and consequences. Anything relevant to the outcome goes into the tree. This includes the monetary value and potential payoffs.
- **SWOT analysis–** SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. It can reveal areas that need improvement and what is likely to succeed. In project management, Strengths will be your internal factors such as the resources you have available like software, the expertise of the team members, customer relationship, etc. Weaknesses, on the other hand, are the factors that hinder the project's completion such as budget constraints, an inexperienced team, or lack of transparency into established processes. Opportunities are the external factors that support the project such as another task finishing early, freeing up more resources for the team. Threats are what can impair the success of the project. When you understand how all these components work together, it's easier to come up with a strategic decision so you can take appropriate action.

14.9 Leadership

A leader is like a rudder on a boat steering the ship and keeping it on course. But the boat wouldn't float without a sound hull, it'd coast aimlessly without sails and wouldn't be able to catch the wind if it had no crew. That's just another way of saying that leadership isn't barking orders. In project management a leader is part of an integrated team with the shared responsibility of the team and stakeholders to deliver a project on time and within budget.

Project leaders rely on data, and use tools like dashboards, Gantt charts and time tracking software to achieve project success. ProjectManager offers all of these features and more—and project leaders love to use it.

14.10 Project Leadership

Project leadership, most simply, is the act of leading a team towards the successful completion of a project. But of course, it is much more than that. It's about getting something done well through others. But project leadership requires skills in both managing people and tasks. It is a soft skill; part art, part science.

If you're a practical-minded person, you might not like such an open-ended definition. But the first mistake in trying to define leadership is thinking that it's one thing. You must be willing to think broadly and accept that there are many different types of leaders in the world and even in the more rarefied world of project management.

Different Leadership Styles

Look over the management style of anyone in charge of any project, and you'll find a myriad ways in which they accomplish their goals and set a tone of leadership. Much of these differences are based on the person's personality and what style of leadership they naturally gravitate towards. That's where a project leadership matrix comes in handy. It is a tool that tells you what type of leader you are, and with that knowledge you can tweak your technique to become a better leader. The leadership matrix is made up of four parts:

- Reactive people-leadership
- Reactive task management
- Proactive people-leadership
- Proactive task management

14.11 Project Leader

A project leader is someone who leads a project, but that doesn't really get to the bottom of this seemingly simple title. There are project managers, who are responsible for many of the aspects that we associate with leadership. They assemble the team, devise the plan and manage resources to maintain the schedule and keep within budget.

But leadership is a quality that should be expressed by everyone. It's not just leading by example, such as the project manager rolling up their sleeves and joining in on the work as needed, but everyone on the project team must take a leadership role. They need to own their responsibilities and manage the tasks assigned to them. The last thing anyone wants is a team of robots who can't make a move without being directed.

That said, there is a project leader, and their job is different than that of the team they manage. They have to straddle many worlds being both technically organizationally adept, able to engage effectively across boundaries, connecting talent with key challenges. Think of a project leader as the consummate integrator. They help others succeed.

What Makes a Good Project Leader?

Project leadership is difficult work, and while most project managers are adept at leveraging the tools and processes of the trade, there's no single body of knowledge to learn and pass a test on when it comes to leading successfully. It's the ultimate school where learning by doing is the only way forward. However, if you look at the way successful leaders work there are commonalities. What most leaders share is these following 10 attributes:

- They are grounded and centered
- They are aware and mindful
- They create solutions
- They are analytical
- They can evaluate risk
- They can generate a sense of urgency
- They are insightful
- They build cohesion
- They motivate people
- They achieve results

Ideas to Strengthen as a Project Leader

A good place to start is with project leaders you respect, who have experience and have lead projects in ways that you wish to emulate. Seeking out help from a mentor is recommended, because they can add a depth of dimension to the process that all the books in the world can never touch. Another thing to do is keep in mind these six concepts that are like a leadership workout. Practice them and you'll strengthen your leadership muscles.

1. Mind the Gap: Take time to explore the gap between navigating and leveraging the tools of the trade and leading others. It's leadership in a classic sense, with the goal to bring to life a group of individuals that coalesce as a team and pursue high performance. Easy words, tough tasks, but worth the investment in time and attention.

2. Reframe Your Challenge: It's Not the Project, It's the Team. The issue you face isn't project execution, it's team development. If you take care of the team and ensure that you form and frame the right environment, the team will take care of the initiative.
3. Let the Team Define Your Role: Perform a pre-post mortem on your role as leader. Ask your team: "At the end of this project when we are successful, what will you say that I did?" Listen carefully and you will hear many of the raw ingredients of high performance teams. From alignment on the purpose of the project to treating team members with respect to ensuring fair and even accountability to setting expectations high to not micro-managing, this question will prompt a torrent of important answers. Take notes. These define the raw content of your job description as project leader.
4. Let the Team Define Your Role: Perform a pre-postmortem on your role as leader. Ask your team: "At the end of this project when we are successful, what will you say that I did?" Listen carefully and you will hear many of the raw ingredients of high-performance teams. From alignment on the purpose of the project to treating team members with respect to ensuring fair and even accountability to setting expectations high to not micro-managing, this question will prompt a torrent of important answers. Take notes. These define the raw content of your job description as project leader.
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14.12 Project Leader Qualities

Leaders inspire others to share their vision, they motivate others to act on that vision, encourage others and help them overcome obstacles in pursuit of that vision. Here is a list of some of the core values of a strong leader.

- Communication: The ability to disseminate information and listen actively.
- Motivation: Getting people to want to do what you need them to do.
- Delegation: Knowing that you can't do everything and trusting others to help you carry the load by completing assigned tasks.
- Positivity: Keeping a positive attitude, regardless of the situation, helps with morale.
- Trustworthiness: People aren't going to listen to you or do what you ask if you don't first instill a sense of trust.
- Creativity: There will always be problems that can't be solved by rote; you must think creatively and be open to taking chances. Employ divergent thinking to find unique solutions.
- Feedback: Leadership doesn't take place in a vacuum. Listen to your team, stakeholders, advisors, mentors, etc., and take their opinions seriously.
- Responsibility: You can't expect people to follow you if you're not taking responsibility for the bigger picture and your behavior.
- Commitment: You also cannot expect to lead others if you are not committed to the project.
- Flexibility: Things change, and rigidity can ruin a project, so you must be willing to adapt and not hold too tightly to anything.

14.13 Wrike and other Project Management Tools

Project management tools are specially designed to assist an individual or team in managing their projects and tasks effectively. The term "PM tools"' usually refers to project management software you can either purchase or use for free online.

In today's fast-paced business environment, project management has become a critical component for organizations to ensure success. Effective project management involves planning, organizing, and managing resources to achieve specific goals within a defined timeline. However, managing projects manually can be challenging, time-consuming, and lead to errors.

Project management software has emerged as a solution to these challenges, providing a wide range of features and functionalities.

The Wrike project management tool is a full-scale solution for automated workflow planning, data visualization, resource allocation, and more. It's available as both a mobile and desktop app, accommodating both local and remote team members, and it's a highly useful collaboration tool for both large and small teams.

Wrike is a project management and collaboration tool that allows to manage projects from start to finish.

- It has a clean, easy-to-use interface and features like time-tracking and resource management.
- Like other tools, Wrike can integrate with other tools like Slack and Gmail.
- Offers spreadsheet-based User Interface (UI).
- Best-in-class project tracking features.

Asana: This is a great option for small businesses, because it offers features like task management, time tracking, and file sharing. One can create projects and assign tasks to team members. It even has a built-in calendar so one can plan the upcoming workload.

Asana is a software-as-a-service platform designed for team collaboration and work management. The teams can create projects, assign tasks, set deadlines, and communicate directly within Asana. It also includes reporting tools, file attachments, calendars, and goal tracking. In 2022, Asana released features for team organization; this included My Goals, Automatic Progress Updates, and integrations for Google Workspace and Figma.

Features of Asana:

- Visualize the work the way one wants: Asana is built for everyone, not just spreadsheet users, so one can plan and structure work anyone wants.
- Involves boards, list, timelines, and calendar.
- Break work into manageable pieces for the team.
- Break up a task into smaller parts or show additional steps to complete an overall task.
- Helps to visualize significant checkpoints in a project to measure and share progress.
- Give tasks a clear owner, so everyone knows who's responsible.
- Use an embedded timer or manually track the time spent on tasks to support resourcing and view project progress.
- Add files from the computer, Dropbox, Box, or Google Drive to any task or conversation.
- Helps to sync tasks across projects: Keep the same task in multiple projects to see work in different contexts without duplicating efforts.
- Analyze the task dependencies: Task dependencies make it clear which tasks are ready to start, and which tasks are waiting on others.
- Offers portfolios, dashboards, calendar views etc.

ClickUp: ClickUp is a cloud-based software for managing projects, teams, and tasks. ClickUp is a popular project management tool suitable for all types of businesses and team sizes across various industries looking to collaborate on the cloud. One can create projects, organize tasks, assign tasks to team members, track progress, and much more. ClickUp also offers integrations with other popular apps, including Trello, Jira, Google Docs, and Slack.

ClickUp comes with hundreds of features that can be customized for any work need—with more added every week. And they're all free, forever. ClickUp's unique hierarchy helps to create the perfect structure that scales with the needs. Each level of ClickUp gives more flexibility and control to organize everything from small teams to enterprise companies. It offers effective communication and collaboration tools, alerts, assigning tasks and reporting statuses, and setting the view grid. ClickUp's free plan is limited to 100 uses of custom fields, the paid versions offer unlimited uses and more space. One can create marketing campaigns, manage development sprints and create the ideal workflow for the project.

Notes: Click Up is a highly versatile and powerful project management tool that can be used by both teams and individuals. It combines important business application features and consolidates company project data into a single online solution.

Features of ClickUp

- Time Management: Identifying what needs to be done is the first step towards managing your time effectively. Thus, it is crucial to build a system for prioritizing your work. ClickUp is all about organizing tasks to help you meet your long-term objectives, as well as prioritizing tasks that must be completed first. The project managers and business owners can easily take advantage of ClickUp's time management features, which help optimize workflows by encouraging more seamless communication.
- Mobile Compatibility: Quick action is made easy with ClickUp mobile. Users can access ClickUp on any device, keeping them updated on projects wherever they are. The ClickUp mobile experience provides the same value to its users as desktop, without compromising on quality or user-friendliness. Through the app, users can organize tasks, edit them easily, interact with their team, view all of their to-dos at once and stay informed thanks to push notifications.
- Tagged Comments: When someone is tagged in a comment, their name will be highlighted in their notification feed. They also automatically become a "watcher," a user who gets notified whenever there are changes in the task. This helps team members prioritize the most important action items and increases oversight of critical project tasks. The users can group, filter and assign tasks in their preferred order using the tag functionality. Tags make it easy to share task information across your workspace, which improves overall workflow.
- Views & Collaboration: With ClickUp, users can choose from nine different view types, including list, board, table, box, calendar view, Gantt, activity, timeline and workload view. ClickUp encourages collaboration through team reporting, real-time editing, real-time syncing, comment editing, mentions and multiple assignees. The software also supports emojis, screenshot editing, comment assignment, discussions, setting comment reminders, sharing and quoting.
- Free Use: The most basic version of ClickUp is available for free and is surprisingly robust. When compared to its competitors, even advanced features and views, like Gantt Charts and automations, are included in ClickUp's free plan.

Freedcamp: Freedcamp is a web-based project management tool designed specifically for people who need help managing multiple projects at once. It features task lists, calendars, file sharing, and other features needed by teams who want to collaborate on a project simultaneously.

Hive: This is a very simple and easy-to-use project management tool that's great for teams of any size. It offers time tracking, progress reporting, and task management features. Hive is a project management platform that was designed with users in mind, providing a user-friendly interface. One can also integrate Hive with other tools like Slack, Google Drive, and Jira.

Features of Hive

- Hive Goals for keeping the team aligned on project objectives.
- Time tracking for recording task completion.
- Native messaging app for team collaboration and communication.
- Project summaries for providing a quick overview on project details and status.
- Automation capabilities for streamlining manual processes and workflows.

The outstanding versatility and scalability make Hive work for different types of users. For example, it offers excellent collaboration tools, such as a built-in messaging app, that would work for small or large teams. In addition, it has powerful reporting and analytics tools that work for enterprises or smaller organizations looking to gain insights from project data.

Scoro

This is another popular project management tool with many great features like Gantt charts, resource planning, and issue tracking. One can also add comments on tasks, assign tasks to specific users or teams, and collaborate with them through chat.

Trello

Trello is a popular free project management app for managing projects and collaborating with teams. With Trello, one can manage projects across teams or solo efforts using cards representing tasks or ideas for future projects. The tool offers flexible sharing options so team members can collaborate on specific cards from anywhere.

Features of Trello

- Views: View the team's projects from every angle.
- Automation: Automate tasks and workflows with Butler automation.
- Power-Ups: Power up the teams by linking their favorite tools with Trello plugins.
- Templates: Give the team a blueprint for success with easy-to-use templates from industry leaders and the Trello community.
- Integrations: Find the apps the team is already using or discover new ways to get work done in Trello.

ProofHub

ProofHub is a robust project management tool designed to simplify and optimize project management processes for maximizing productivity. It serves as a centralized platform that effectively facilitates all aspects of managing a project, from planning, prioritizing, and assigning tasks to tracking and collaborating on them in a user-friendly, intuitive manner.

Its comprehensive suite of tools helps teams stay organized, productive, and ahead of deadlines, ultimately yielding better results, happier employees, and remarkable organizational growth.

Features:

All-in-one platform: ProofHub provides an all-in-one platform to centralize every aspect of management for your projects and eliminate the need to juggle through multiple apps to get things done. Plus, with everything conveniently organized at one place, you can quickly retrieve any relevant information, enhancing productivity and efficiency.

Task assignment and prioritization: To effectively distribute the workload among your team members, ProofHub allows you to create tasks and subsequent subtasks and assign them correspondingly to one or multiple team members. Additionally, you can set daily agendas and priority levels to stay ahead of deadlines.

Multiple task views: ProofHub allows you to track and optimize project progress with the flexibility of four different views: Table, Board, Gantt Chart, and Calendar. Switching between these views allows you to focus on specific tasks while maintaining a comprehensive overview of all tasks and deadlines.

Internal communication: With ProofHub's robust in-built chat feature, you can collaborate with your team members in real-time without having to shuffle through long email threads. Also, it saves you from the cost and compliance risks associated with relying on third-party integrations. Additionally, features like discussions and notes allow you to document every piece of information during the planning and brainstorming.

Proofing and file sharing: ProofHub's proofing feature comes with several markup tools to highlight and communicate the desired changes you want on your creative assets. This allows you to avoid mistakes while saving the hassle of physically being present with your designers. Additionally, you can easily share, store, and access files related to your project on ProofHub through drag and drop.

User-friendly interface: ProofHub comes with an intuitive and customizable interface that allows you to manage your project the way you see fit. You can set the dashboard with details that are relevant to specific work or jump directly to the location you want with the jump tube. Additionally, with the search option, you can find any file or resource with a single click. These options also allow for the seamless onboarding of new team members and getting them on the same page, no matter how big your projects are.

Access control: With the custom roles feature of ProofHub, you can maintain control over sensitive information by setting custom access permissions for different sections of ProofHub.

Basecamp

Basecamp is a comprehensive project management tool that is ideal for teams working remotely. The built-in collaboration tools, such as group chat, message boards, and team schedules, make communication and coordination much easier. However, the price tag is a bit steep compared to other project management software. It's important to note that some essential features, like multiple project views and task priorities, are missing from Basecamp. Despite its limitations, it's still a useful project management solution for remote teams, especially if they prioritize seamless collaboration and communication.

Features:

- Message boards, schedules, to-do lists
- Document and file storage
- Easy-to-use and simple interface
- Tag team members easily

Monday.com

Monday.com is one of the popular project management tools with flexible dashboards, CRM capabilities, product management and a guest view feature for real-time collaboration. It allows users to sign up by industry, tailoring the experience to specific fields.

However, it has limitations such as limited task dependencies based on dates and essential features like Gantt charts, calendar views, automation, time tracking, and integrations being available only on higher-priced plans, which may not be suitable for smaller businesses or tight budgets.

Features:

- Centralized communication and document management
- Visual project management and tracking
- Analytics and reporting are well-executed

- Smartly integrated with Dropbox, Zapier, Google Drive, and similar sharing and management tools
- CRM tools that can expand as your small business grows.

Summary

- Project communication management is a crucial aspect of project management as it ensures all stakeholders are kept informed about the project's progress, issues, and changes, thereby facilitating effective decision making and collaboration.
- Project communication management is a collection of processes that help make sure the right messages are sent, received, and understood by the right people.
- Successful leadership depends on clear communication about goal, performance, responsibility, achievement, challenges, as well as customer feedback with the team members who generally belong to a diverse group of people.
- Regular reporting of the project's progress and status to the stakeholders is the decisive portion of efficacious project leadership. So, proper communication management, which consists of three processes, mitigates the risk of failure to some extent. These are some of the effective communications in project management.
- Project leadership is difficult work, and while most project managers are adept at leveraging the tools and processes of the trade, there's no single body of knowledge to learn and pass a test on when it comes to leading successfully.
- Productive project management can drive a company towards success, giving employees a clear, easy-to-follow path towards completing their work objectives in a highly efficient manner.

Keywords

Project Communication Management: The processes required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information.

Project management tools: Project management tools are specially designed to assist an individual or team in managing their projects and tasks effectively. The term "PM tools"' usually refers to project management software you can either purchase or use for free online.

Project Leader: A project leader is someone who leads a project, but that doesn't really get to the bottom of this seemingly simple title.

Decision Making: The decision-making process in project management can heavily influence the success employees feel as individuals (and as a team) or, unfortunately, create a litany of workflow issues and interpersonal misunderstandings.

SWOT analysis: SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. It can reveal areas that need improvement and what is likely to succeed.

Self Assessment

1. SWOT stands for ___________________.

A. Strengths, Weaknesses, Opportunities, and Threats

B. Software, Warison, Opportunities, and Threats

C. Software, Working, Open, and Through

D. Strong, Weak, Open, and Thorough

2. The decision-making process in project management cannot influence the success employees feel as individuals (and as a team).

A. True

B. False

3. Which of the following statement(s) is/are true for project management tools?

A. Project management tools are specially designed to assist an individual or team in managing their projects and tasks effectively.

B. PM tools usually refers to project management software you can either purchase or use for free online.

C. Project management software has emerged as a solution to providing a wide range of features and functionalities.

D. All the above.

4. Effective project management involves planning, organizing, and managing resources to achieve specific goals within a defined timeline.

A. True

B. False

5. Which of the following opts not the quality of a successful project leader?

A. Motivation

B. Dishonesty

C. Positivity

D. Flexibility

6. _________________ is a crucial aspect of project management as it ensures all stakeholders are kept informed about the project's progress, issues, and changes, thereby facilitating effective decision making and collaboration.

A. Change reciprocation

B. Project communication management

C. Configuration management

D. Report management

7. Asynchronous communication is also called as _____________ communication.

A. Indefinite

B. Field

C. Passive

D. Teamsync

8. The project manager has to manage the execution of the project communication management plan. The additional responsibilities can include:

A. Creation of messages for communication.

B. Transmission or distribution of communications.

C. Storage of any communication reports, files, or documents.

D. All the above.

9. Regular reporting of the project's progress and status to the stakeholders is the decisive portion of efficacious project leadership.

A. True

B. False

10. If all the members or parties are taking part in exchanging information at the same time, communication is called ____________ communication.

A. anonymous

B. reciprocation

C. synchronous

D. indefinite

Answers for Self Assessment

1.	A	2.	B	3.	D	4.	A	5.	B
6.	B	7.	C	8.	D	9.	A	10.	C

Review Questions

1. Discuss in detail about importance of effective communication?
2. What are the qualities a project leader must possess?
3. List the significance of decision making in project management.
4. Indicate the process of decision making in project management.
5. Enlist the project leadership qualities and importance.
6. Discuss the concept of effective project communication management.
7. How is project communication management carried out? List the process involved in it.
8. Discuss the various challenges of decision-making in project management.
9. What do you understand by project management tools. List the different project management tools.
10. Write a short note on:
    (a) Effective communication
    (b) Leadership

Further Readings

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