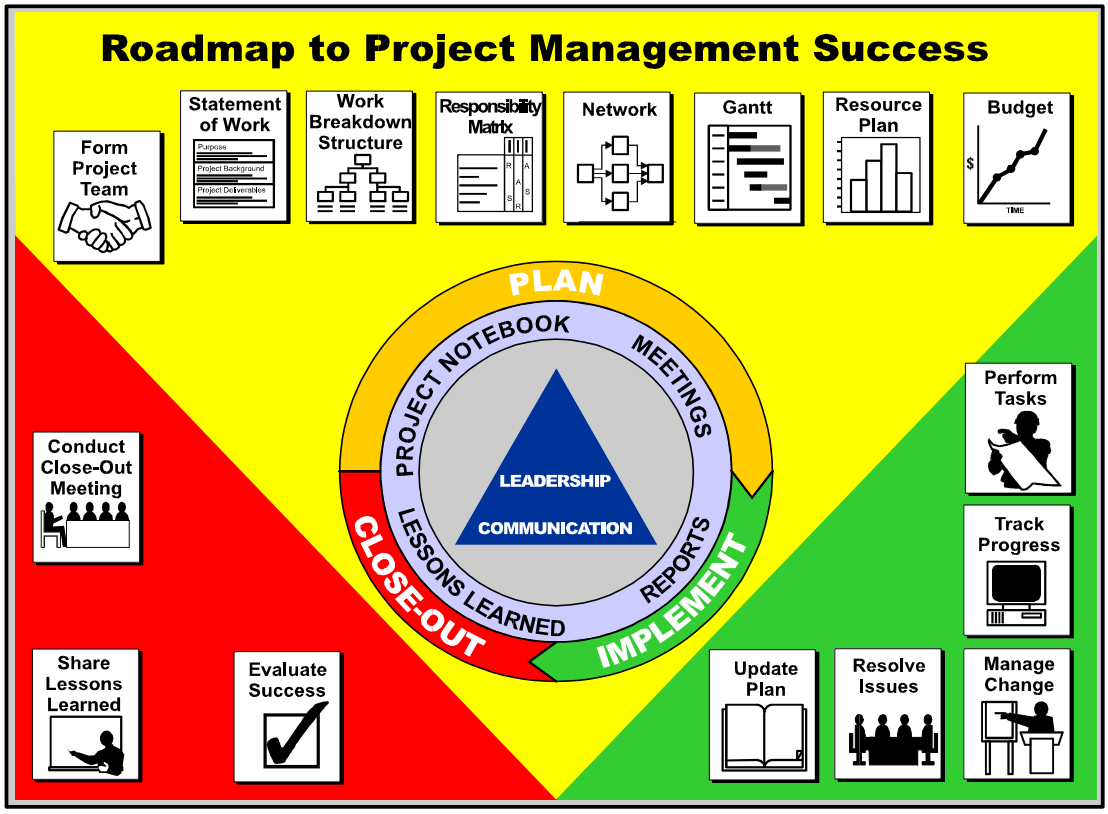
Project Management
Tools and Techniques



An Introductory Course
in
Project Management Foundations

Developed by:

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Section 1 – Introduction

This manual provides an overview of project management practices adopted by the Project Management Institute (PMI). It is intended to be an orientation manual for project team members, project engineers, project leads and prospective project managers. It can also be used as a refresher on project management concepts for personnel who have attended formal training sessions on project management. However, this manual is *not* a substitute for formal project management training.

Objectives

Upon completion of this training, the participant will be able to

1. Discuss the goals of project management.
2. Define project management terminology.
3. Describe the role of the project manager
4. Define the lifecycle phases of a project.
5. Explain the purpose and use of the project management notebook.
6. Identify and discuss the major elements of the project plan.
7. Discuss the responsibilities of the project stakeholders.
8. Apply project management techniques to control and monitor project progress.
9. List the contents of a project progress report.
10. Describe the need for a formal project change control.
11. List the objectives of the project close-out process.

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Section 2 – Project Management Overview

Project Management has been identified as a core competency by many corporations. The need for quality project management is clearly identified in company Quality Manuals as required by ISO 9000.

Knowing that project management is necessary is one thing; knowing **how** project management is successfully accomplished is quite another. A project manager should be able to move from one business unit to the next within a company without having to learn a completely new approach to project management each time. This is why businesses have established a formal project management process. This process applies to all projects, for both internal and external customers, in such a way so that there is a single set of basic tools for all projects. The generic approach to project management as developed by the Project Management Institute (PMI) will be presented in this course.

This section discusses the following:

- What is project management?
- Key definitions
- Benefits of a formal project management approach
- Roadmap to project management success

What is Project Management?

Project management is a discipline that enables projects to be successfully completed. It is a standardized approach to managing, monitoring, controlling, and reporting project progress against resource, schedule, budget, and quality expectations.

PMI defines project management as follows:

> *"Project management is the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder needs and expectations."*

Benefits of Project Management

The overall benefits of project management include the following:

- Shortens project completion time while balancing cost and quality.
- Enhances staffing flexibility and can help accomplish more work with fewer resources.
- Provides timely information to multiple levels of the organization in consistent formats.
- Enhances the decision process based on facts and project information.
- Enhances the ability to accomplish the business objectives and goals.

What is a Project

Using project management techniques has a clear set of benefits; but, to what are these techniques applied? What is a project?

PMI defines a project as:

> *"A project is a temporary endeavor undertaken to create a unique product or service."*

There must be a set of characteristics that define a project. For example:

- Has a goal and/or meets a specific need defined by the customer.
- Is a set of related activities that are non-recurring.
- Has a definite beginning and end.
- Has a set of clearly defined deliverables.
- Consumes resources in accomplishing the objectives.
- Needs to be managed.

The individual assigned this daunting task is the project manager. A project manager is:

> *"The person who is responsible for the project and will be held accountable for its success or failure."*

A good project manager can be thought of as a general manager; a manager that brings a number of skills to accomplish work. Project managers must be capable of addressing the technical aspects of the project, deal with the human resource issues that arise during the course of work, and interface with the customer to ensure customer satisfaction.

Project managers are given the task of trying to accomplish project goals and objectives in the shortest time possible, for the lowest cost and of the highest quality. Balancing this "triple-constraint" is the key to project success. Figure 1 shows the concept of the triple constraint of project management.

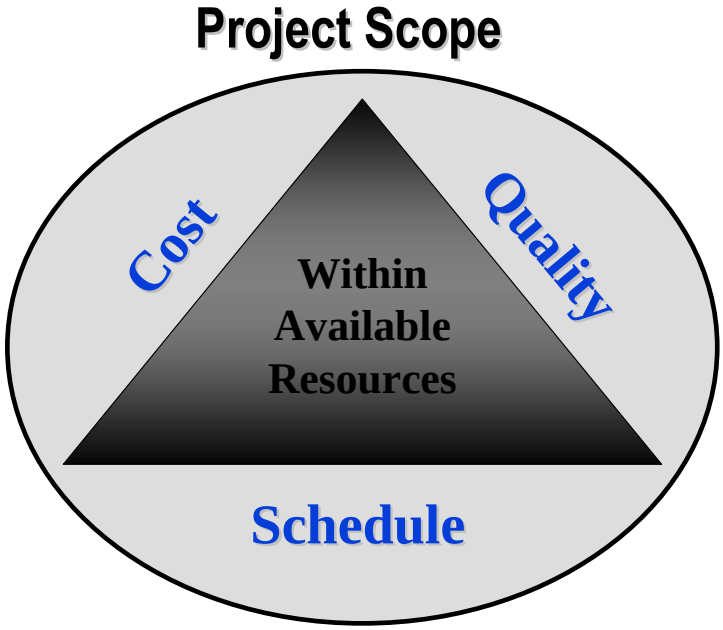

Figure 1 - Project Management Triple Constraint

There is no trick to balancing the triple constraint; it requires that the project manager use all the skill and knowledge gained through experience and applies the tools and methodologies of the trade. There are four key items to making this work:

1. A clear understanding of the customer's priorities.
2. "People" skills.
3. Thorough planning.
4. An organized and structured process.

The Project Lifecycle

As with all things, there is a lifecycle or standard approach to managing project work. Project managers who are successful at managing projects use proven project management techniques and follow a structured approach. PMI describes the project lifecycle as having five major components as shown in Figure 2. The lifecycle phases are:

- Initiation
- Planning
- Execution
- Control
- Closeout

Source: PMBOK

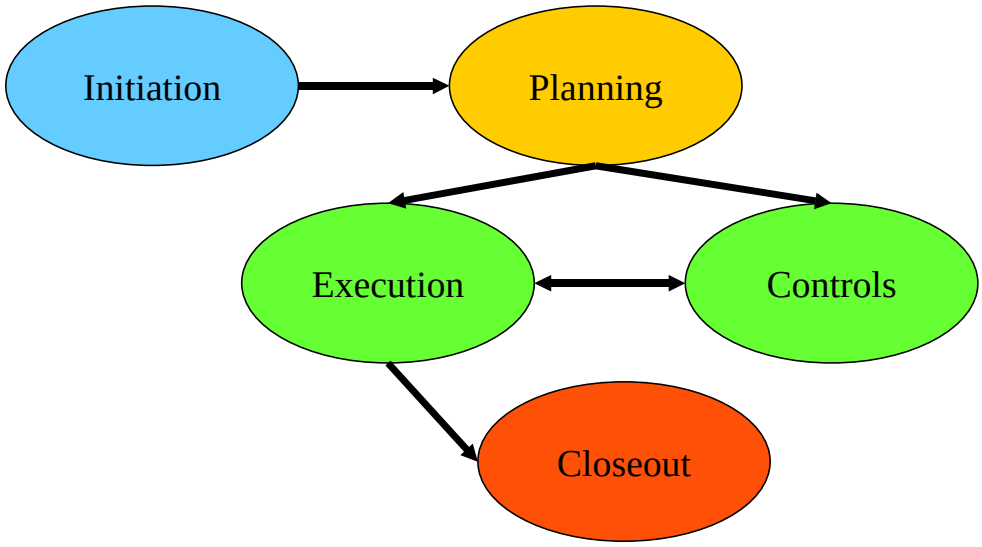

Figure 2 - Project Lifecycle

Roadmap to Project Management Success

The project lifecycle is the big picture of project management; however, it provides no details as to how to function within each phase of the project. One useful tool in implementing a project management process known as the *Roadmap to Project Management Success.* This roadmap identifies the structure and guidelines a project manager needs to be successful. It also provides guidance to the project manager concerning the right tools for the right task.

The overall goals of the Roadmap to Project Management Success are to

- Meet the customer's expectations of quality, schedule, and budget.
- Work within the organizational constraints of policies, procedures, and resources (personnel, material, equipment, and facilities).
- Continuously improve the process by making better use of lessons learned, leadership skills, and human resources.

Figure 3 shows the Roadmap to Project Management Success.

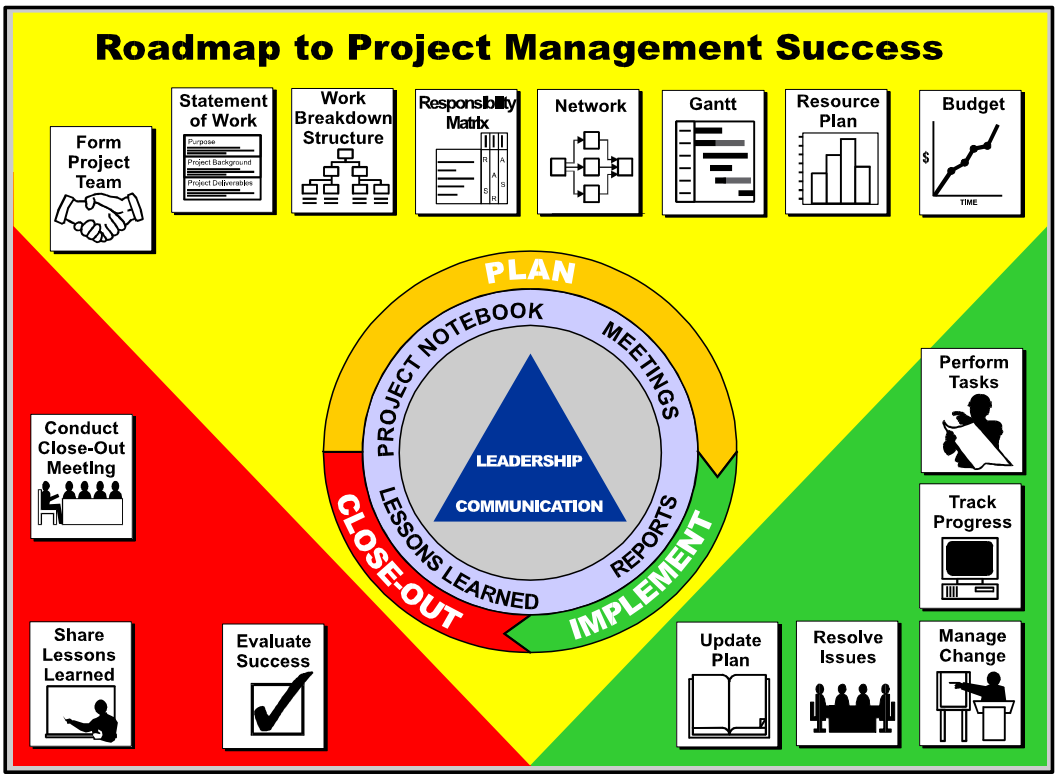

Figure 3 - Roadmap to Project Management Success

There are three phases depicted on the Roadmap and all are important to successful project completion:

- Planning phase
- Implementation phase
- Close-out phase

Each phase will be discussed in more detail later in this manual, but a brief introduction of the phases is given here.

Planning Phase

The most important phase for project success is the planning phase. During this phase, the project manager performs the following:

- Forms the project team
- Determines the project deliverables and the measurable success indicators
- Determines the tasks that need to be completed during the implementation phase
- Schedules those tasks
- Allocates human resources
- Sets a project budget

Implementation Phase

The implementation phase follows the planning phase and is the phase in which project execution occurs. The goals of the implementation phase include the following:

- Complete all the tasks identified in the planning phase.
- Track and report project status, using organizational and decision-making tools, such as progress reports, tracking systems, and project notebook.
- Create effective project communications by conducting progress reviews and problem-solving meetings.

Close-out Phase

The last phase is the close-out phase. During this phase, the project manager performs the following:

- Conducts a close-out meeting
- Ensures that all deliverables have been delivered and that all measurable success indicators have been met
- Documents and shares lessons learned
- Ensures that the project documentation is up-to-date and complete

The close-out phase is also important because it positions future project managers to save time and money. By reviewing previous lessons learned, project managers can avoid many of the same problems and "do it right the first time."

Goals of the Project Roadmap

The goals of the *Roadmap to Project Management Success* are:

- Provide a means for meeting customer expectations.
- Work within a given organization or business constraint.
- Provide a baseline for continuous improvement of the process.
- Control the cost of change.

As Figure 4 shows, the cost of change grows as the project nears completion and must be kept under control.

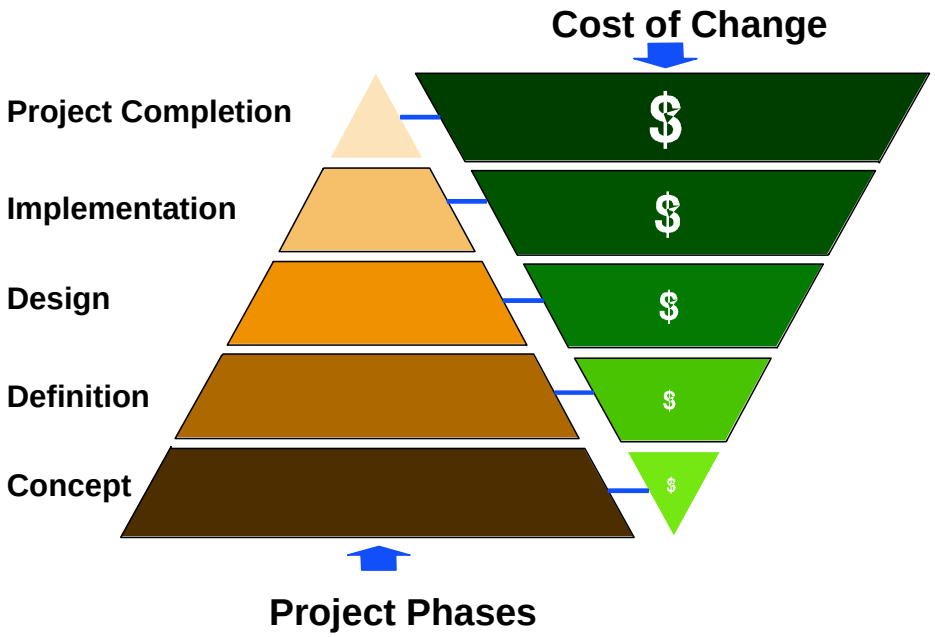

Figure 4 - Cost of Change

Section 3 – Project Stakeholders

When a new project is initiated, several key players are identified, each with a specific responsibility. These individuals are called stakeholders. First and foremost is the customer whose needs and expectations are uppermost in priority. Other stakeholders include the

- Project sponsor
- Project manager
- Project team

Other project stakeholders are:

- Senior management
- Internal cross-functional organizations
- External suppliers/vendors

Each of these individuals or groups has the opportunity to gain in some way from the work performed as a part of this project. Likewise, they can be negatively impacted if the project is unsuccessful. If any individual or group can gain or lose based upon the results of the project then they have a stake in the project.

Customer's Role

The customer plays a very significant role in the achieving the success of the project. In addition to the specific support outlined in the Statement of Work (SOW), the customer is responsible for the following:

- Providing a point of contact
- Approving measurable success indicators (deliverables, schedule, budget)
- Approving changes
- Providing resources as required
- Participating in problem solving
- Obtaining necessary training
- Providing specifications
- Attending progress review meetings
- Participating in the close-out phase of the project

Project Sponsor

The project sponsor is a member of the leadership team who serves as the sanctioning point for any project and oversees, but does not manage, project activities. The responsibilities of the project sponsor include the following:

- Runs interference and serves as a mediator for organizational issues
- Ultimately resolves team conflict
- Negotiates with the project manager on phases to be used on the project, associated criteria that must be fulfilled, and subsequent detail Work Breakdown Structures of the project
- Serves as the ultimate "situational leader"
- Conducts project reviews
- Supports the project manager and team members in areas of conflict, risk, timing, resources, and deliverables

Project Manager

The project manager has the ultimate responsibility/accountability for the success or failure of the project. This individual closely manages all project activities to ensure that the project is on schedule and at or under budget. Specific responsibilities include the following:

- Assesses/manages risk (and reports to senior leadership as necessary)
- Sets and communicates schedules
- Manages the budget
- Manages team development and conflict
- Serves as key customer interface (along with the client manager)
- Leads, directs, coaches, and supports the project team
- Delegates tasks to project team
- Prepares and presents progress reports to customer and senior leadership

In order to successfully fulfill these responsibilities, the project manager must able to

- ✓ Serve as leader/team builder
- ✓ Balance technical/cost/schedule/ requirements
- ✓ Evaluate problems and implement solutions
- ✓ Communicate effectively
- ✓ Negotiate and resolve conflicts

Project Team

The project team consists of the project manager and other individuals who are required to produce the project deliverables. The team may include consultants, engineers, instructors, writers, editors, graphic artists, and desktop publishers. Typically, the individuals serving on the project team will have responsibility for specific tasks, but in addition, they may assist with the following responsibilities:

- ➢ Manage specific activities within the project that relate directly to their area of expertise
- ➢ Oversee schedules and budgets within their area of the project
- ➢ Collect project information and update the project notebook
- ➢ Provide input for and participate in project reviews

Organizational Breakdown Structure

Project teams are formed by reaching into an organization and selecting or having resources to support the work. The type of organization has a great deal to do with how project teams are formed and how they work. There are three basic types of organizations:

- ➢ Functional organization
- ➢ Matrix organization
- ➢ Projectized organization

Table 1 lists the strengths and weaknesses of the various organization types with regard to project management.

Table 1 - Management Organization Comparison

Project Characteristics	Functional Organization	Matrix Organizations			Projectized Organization
		Weak	Balanced	Strong	
Project manager's authority	Little to none	Limited	Low to moderate	Moderate to high	Almost total
Percent of the organizations personnel assigned full time to the project	Virtually none	0% - 25%	15% - 60%	50% - 90%	85% - 100%
Project manager's role	Part-time	Part-time	Full-time	Full-time	Full-time
Common titles for project managers	Project Coordinator or Project Leader	Project Coordinator or Project Leader	Project Manager or Project Officer	Project Manager or Program Manager	Project Coordinator or Project Leader
Project management administrative staff	Part-time	Part-time	Part-time	Full-time	Full-time

Most project management texts recommend the matrix or projectized organization as the one of choice for a company or business unit that focuses on project work. The **matrix structure** was developed to take advantage of the benefits of the functional and product organization structures. In this organization, specific project managers are identified who report to a high level manager. Projects are supported by personnel from functional groups. Since all of the disadvantages of the matrix structure can generally be avoided with senior management support and clear communications (a strong matix), it is the recommended structure for effective implementation of project management.

Independent of the primary organizational structure implemented by a company, a tool that can be used to assist in forming the project team is called **the project organizational breakdown structure** (OBS). The purpose of the project OBS is to identify the specific organizational units required to support the project. Once this is done, specific team members needed from each organization can be identified. It is very similar to a company organizational chart but is developed for the project. Figure 5 is an example of an OBS.

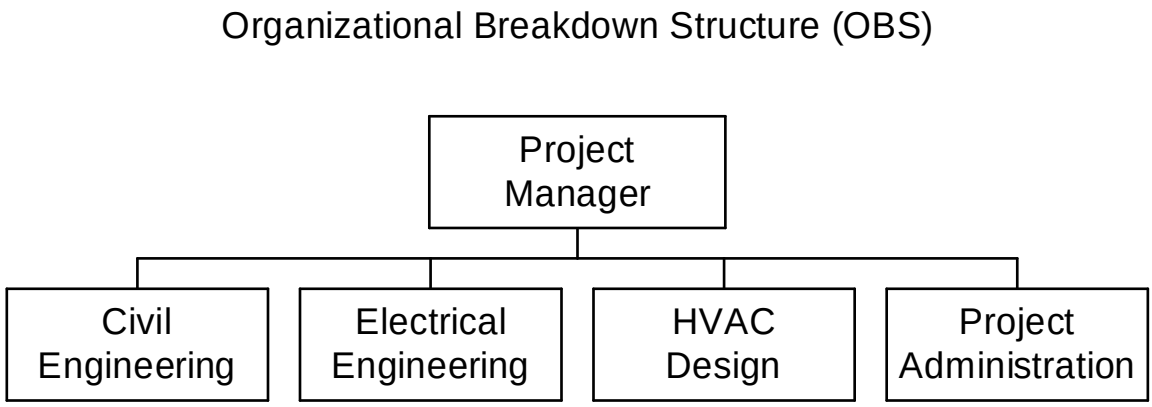

Figure 5 - Project Organizational Breakdown Structure

Once the core resources or Subject Matter Experts (SME) are assigned to a project, the project manager organizes the team by function within the OBS as shown in Figure 5.

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Section 4 – The Project Lifecycle: Planning

Planning

As mentioned in a previous section, there the Roadmap to Project Management Success addresses three phases of the project lifecycle:

- Project planning phase
- Project implementation phase
- Project close-out phase

To ensure that the project manager addresses the crucial areas in each phase of the project, it is recommended that a generic Project Management Checklist be developed. A sample checklist can be found in Appendix B.

Project planning is the most vital phase of any project because without it, time, money, and resources will surely be wasted. If insufficient time is spent on planning the project, multitude problems can occur during later phases of the project. Therefore, the project manager must take the time and energy necessary to see that all aspects of the planning stage are addressed.

During the planning phase, one of the project manager's main concerns is to establish the customer's needs and expectations. To do this, the project manager develops a ***project plan***. The project plan is written to

- Ensure understanding and acceptance of the project's goals and the means to achieve them.
- Defines the outcomes and commitments for the project
- Establishes the guidelines and standards for all project activities
- Provide a baseline for evaluating and reporting progress
- Act as a basis for change control.

Project Notebook

Once the project plan is completed, the project director should review and approve the plan. Part of the project plan is the ***project notebook***, which the project manager begins in the planning phase and updates throughout the project. The notebook represents a documented history of the project and is an excellent communication tool for the project team, especially when personnel changes occur. Following is a suggested project notebook file outline.

Suggested Project Notebook Outline

Pre-Project

- Proposal
- Contract Pricing Proposal (CPP)
- Contract Pricing Analysis (CPA)
- Client communications
- Work at Risk (WAR) form
- Purchase order
- Contract review sheet

Project Planning

- Statement of Work
- Work Breakdown Structure
- Responsibility charts (RASIC)
- Schedule
- Budget

Project Implementation

- Quality commitment letter
- Progress reports
- Contract book pages
- Invoices
- Timesheet detail report
- Meetings (agendas/minutes)
- Decision matrix
- Client communications

Project Close-out

- Final evaluation of measurable success indicators
- Close-out meeting (agenda/minutes)
- Final project report
- Reference letters
- Lessons learned
- Customer satisfaction survey

The project planning phase consists of the following key elements:

- Statement of Work
- Work Breakdown Structure
- Responsibility matrix
- Project schedule
- Resource plan
- Project budget
- Plan completion

Statement of Work

The ***Statement of Work***, which is the first planning document prepared, describes the purpose, history, deliverables, and measurable success indicators for a project. The project manager must prepare this document first because it establishes and defines customer expectations. In addition, it identifies the support required from the customer and outlines the contingency plans for possible events that could negatively impact the project. Because the Statement of Work defines the scope of the project, the project manager must take care to write it clearly so that the boundaries of the project are known in advance and clearly established. By doing so, effective change management can be established.

A good Statement of Work will answer the following questions:

- What is the purpose or goal of the project?
- Why is this project being done?
- Who is the initial customer?
- Who is the end user, or final customer?
- What are the tangible end products, or deliverables, to be delivered to the customer?
- What technical support is needed for the deliverables?
- What is the budget?
- What is the final date for the deliverables?
- What are the measurable success indicators?
- What kind of support is required from the customer?
- What contingency plans are in place?

Figure 6 is a sample of a generic ***Statement of Work***.

Statement of Work			
Date:		**Immediate Customer:**	
Contributors:		**Final End User:**	
Project Title:			
Purpose:			
Project Background:			
Project Deliverables:			
Measurable Success Indicators:			
Customer Support:			
Risk Plans:			

Figure 6 - Sample Statement of Work

Work Breakdown Structure

After completing a Statement of Work, which defines the scope of the project, the project manager creates a ***Work Breakdown Structure (WBS)*** to define the work that needs to be done. The project manager uses the WBS as the primary tool for organizing the project work. The WBS provides a hierarchical format that assists the project manager in the following:

- Structuring the work into major components and subcomponents
- Verifying conformance with all objectives
- Implementing a system of project responsibility commitments
- Developing a system for reporting and summarizing project progress

The WBS provides the vehicle that accurately reflects how the work will be done in order to deliver the overall product. It consists of elements (in boxes) and their associated tasks (with lines) shown at different levels that represent the work that must be accomplished. Figure 7 shows a representative WBS.

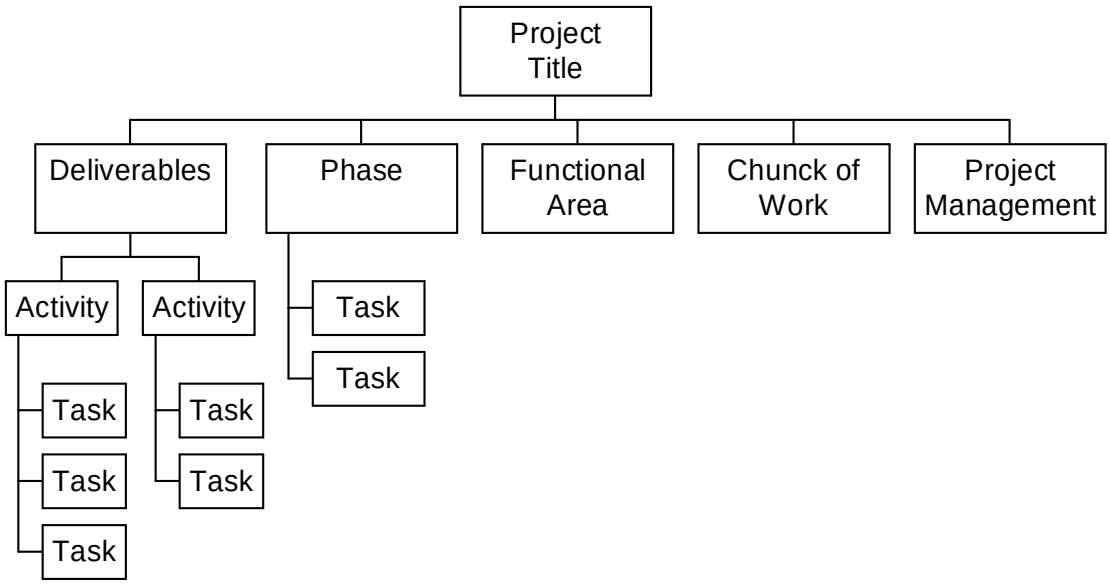

Figure 7 - Sample Work Breakdown Structure

On the first level, there is only one box, which describes the end product. This is sometimes referred to as the "work objective" or "project title."

The second level represents the elements that must be addressed in order to deliver the final product. These elements could be individual deliverables, project phases, or just logical chunks of work. Project management is also shown at this level. Depending on the level of detail required, this level may consist of several sublevels. Elements on level 2 are defined by nouns.

Level 3 identifies the activities and tasks that must be completed in order to achieve those things defined on level 2. These tasks, which are stated with an action verb, are shown in progressive levels of detail so that all aspects of the work are clearly defined.

Figure 8 shows a sample WBS that illustrates the progressive levels of detail for building a car.

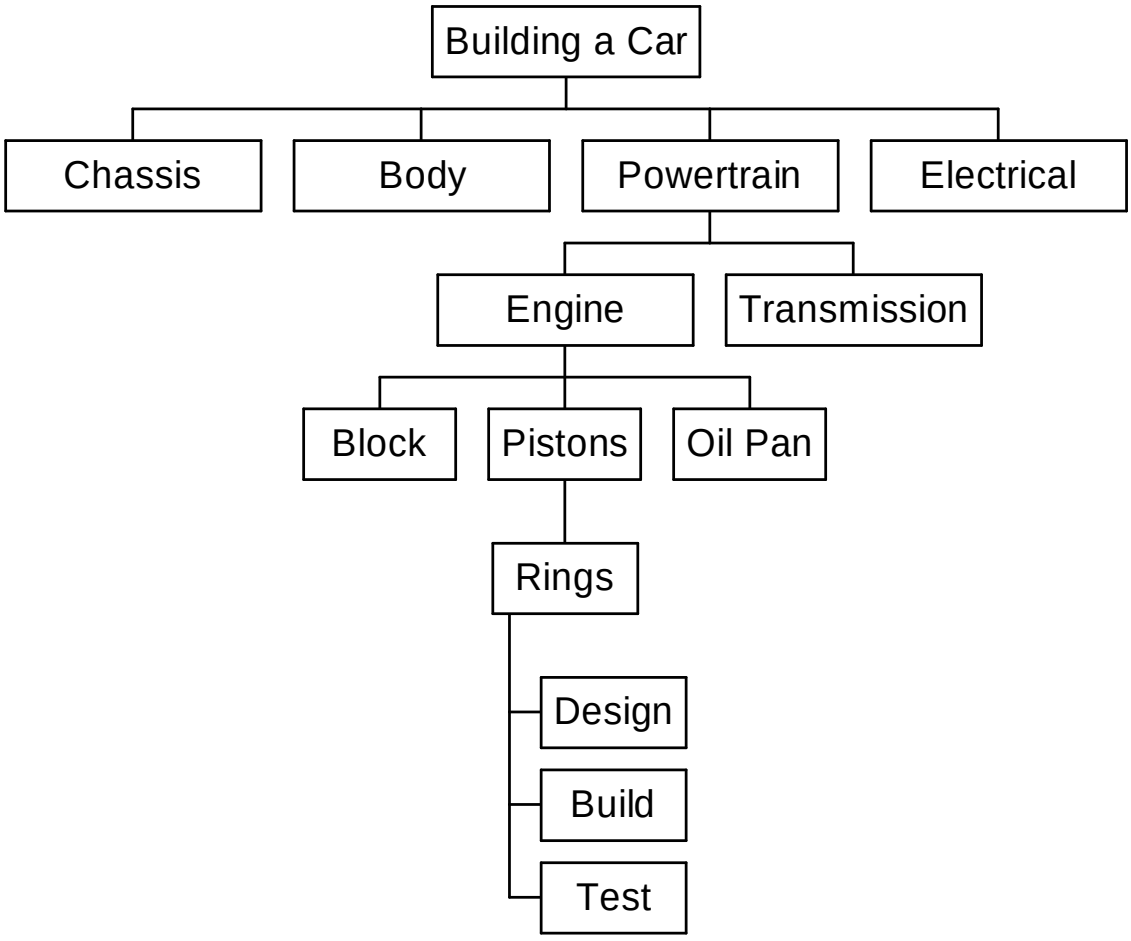

Figure 8 - Automotive WBS

When developing a WBS, the project manager can obtain sufficient detail if he/she answers the following questions for each activity:

- **WHO** is the responsible individual or organization for the activity?
- How much **TIME** will the activity take?
- What **COST** is associated with accomplishing the activity?
- How can **PROGRESS** be easily tracked?
- What STEPS are needed to accomplish the task?

The overriding purpose of the WBS is to define all the work that must be accomplished during a project to a level of detail that can be easily estimated, assigned, and tracked. The order or sequence of work is not considered at this time. At the lowest level of the WBS, the detail elements of work will become tasks in the Network Diagram that the project manager develops during project scheduling.

Responsibility Assignment Matrix

The ***Responsibility Assignment Matrix (RAM)*** is the tool project managers use to define the specific roles and responsibilities of each member of the project team with regards to the work activities identified by the WBS (see Figure 9). The project manager can also use this chart to build team commitment and establish clear responsibility. Just as the WBS defines the activities that need to be accomplished, the Responsibility Matrix identifies the individuals who will be involved in accomplishing those activities. This matrix provides an easy format to identify level of involvement of each individual in every project activity.

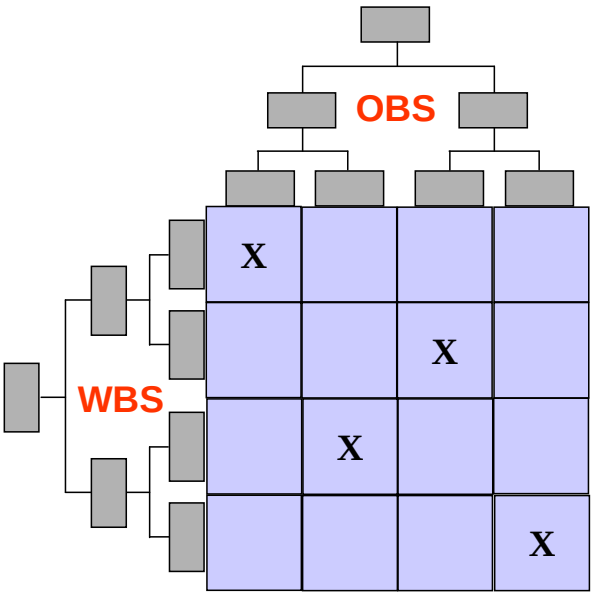

Figure 9 - OBS/WBS Relationship

The Responsibility Matrix depicts WBS activities on one axis and the project team members on the other. The project manager than fills in the center of the matrix, using letters to designate the level of involvement of each team member on a particular activity. Because the letters R, A, S, I, and C are used to designate levels of involvement, this matrix is sometimes referred to as a **RASIC** chart.

The specific letters represent the following:

R = Responsibility This individual or group is accountable for ensuring that each task is completed on time, is within budget, and has the expected quality.

A = Approves This individual or group has the final say in accepting the product or deliverable or authorizing the continuation of the project.

S = Supports This individual or group does the work to accomplish the task or provides assistance in doing the work. The level of effort is defined in the resource loading.

I = Informed This individual or group must receive all pertinent information regarding the specific task. This information should include the status of the task (started, completed, delayed), the content, or any approvals received.

C= Consulted This individual or group is an additional resource of information or assistance and needs to be involved in decisions regarding the content or status of the task.

Basic points to remember when developing a RASIC chart include the following:

- There must be one R and one A for each activity.
- Multiple Rs for the same activity make it unclear as to who is actually accountable for the work.
- Every activity on the WBS, even to the lowest level, must be included.
- The names of the individuals should be indicated on the chart.
- A good team-building technique is to delegate to each team member some responsibility for completing a task to give each person a sense of ownership in the project.

Figure 10 shows a representative RAM.

MARKETING STUDY	PROJECT MANAGER	CUSTOMER	TEAM MEMBER	SENIOR MANAGEMENT	SUPPORT STAFF
IDENTIFY POTENTIAL MARKET	C		S	R	
IDENTIFY SURVEY POPULATION	C	R	S	I	
DEVELOP SURVEY	R	I	S	I	
TEST SURVEY ON SAMPLE	R	I	S		S
FINALIZE SURVEY	R	A	S	I	S
CONDUCT SURVEY	R	I	S	I	S
COLLECT SURVEY	R	I	S		
ANALYZE DATA			R/S		I
REPORT RESULTS AND SUGGESTION	R	A	S	A	S

LEGEND
R - RESPONSIBLE A - APPROVE S - SUPPORT (DOES THE WORK) I - INFORM C - CONSULT

Figure 10 - Representative RAM

Project Schedule

Once all the work has been identified in the WBS and the Responsibility Chart drawn up, the project manager develops a schedule. Developing a schedule involves the following activities:

- Estimating how long each activity should take
- Determining the sequence of tasks
- Calculating the start and finish times for each activity

This section discusses the following:

- ✓ Methods for estimating time
- ✓ Network diagrams
- ✓ Gantt charts

Methods for Estimating Time

Accurately estimating the length of time for each activity in a project is crucial to the success of the project. There are two methods for estimating time:

- Deterministic
- Probabilistic

Deterministic time estimates are used for activities that

- ✓ Are well-defined
- ✓ Are similar to activities that have been done before
- ✓ Allow for high confidence in the project manager's ability to estimate the time accurately

Furthermore, project managers develop deterministic estimates by using the following:

- Previous experience
- Lessons learned
- Documentation from previous projects

Probabilistic time estimates are used for activities that

- ✓ Are **not** well-defined
- ✓ Have no similar activity experience
- ✓ Allow for little or no confidence in the project manager's ability to estimate time

Probabilistic time estimates use statistical methods to determine the length of time an activity should take.

Network Diagrams

After the time estimate for each activity has been determined, the project manager uses a network diagram to develop the actual calendar schedule. Network diagrams show a logical sequencing of the project's activities in terms of

- The planned flow of effort for each activity
- The relationship between individual activities

Figure 11 shows the relationship between the WBS and the network diagram for a project.

The project manager then uses the completed diagram to determine the total duration of the project.

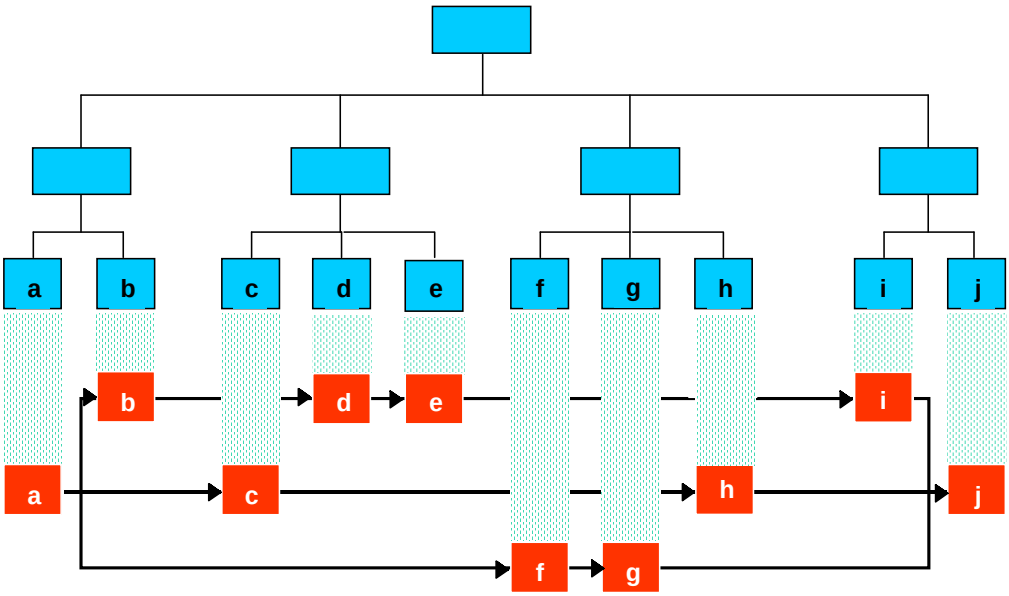

Figure 11 - WBS to Network Diagram Linkage

The network planning process describes a project as a network of activities or tasks that have specific relationships between each other. Using this process, the project manager can analyze and schedule each task using a set of calculations and procedures known as the ***Critical Path Method (CPM)***, which determines the series of tasks in a project that will take the longest amount of time.

The most well-known network diagram is the precedence diagram, which uses boxes to represent activities and arrow lines to show the connection between the activities. This is often referred to as Activity-On-Node (AON) diagrams. An alternative for of network diagram is the arrow diagram or Activity-On-Arrow (AOA) method. Figure 12 shows the same project in both the AOA and AON network diagram formats.

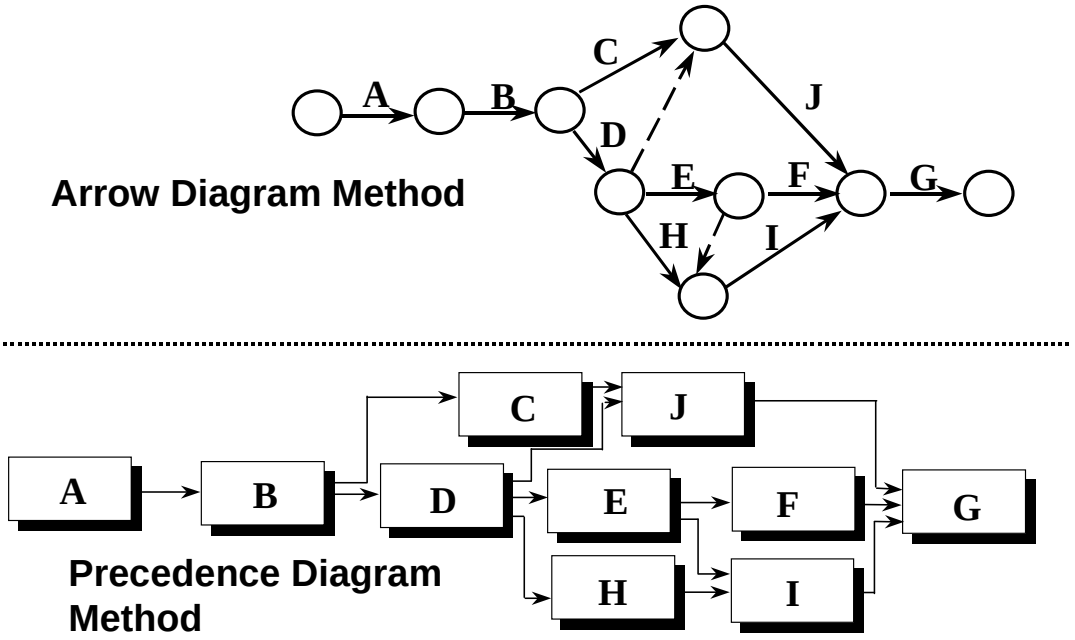

Figure 12 - AOA and AON Comparison

Network Diagram Example

A project manager has determined that the project is comprised of 10 activities with the following relationships:

- *A is the first activity*
- *B, C, and D are dependent on A*
- *E and F are dependent on B*
- *G is dependent on C*
- *H is dependent on C and D*
- *I is dependent on F and G*
- *J is dependent on E, I, and H*
- *J is the last task*

Figure 13 shows this example as a precedence diagram.

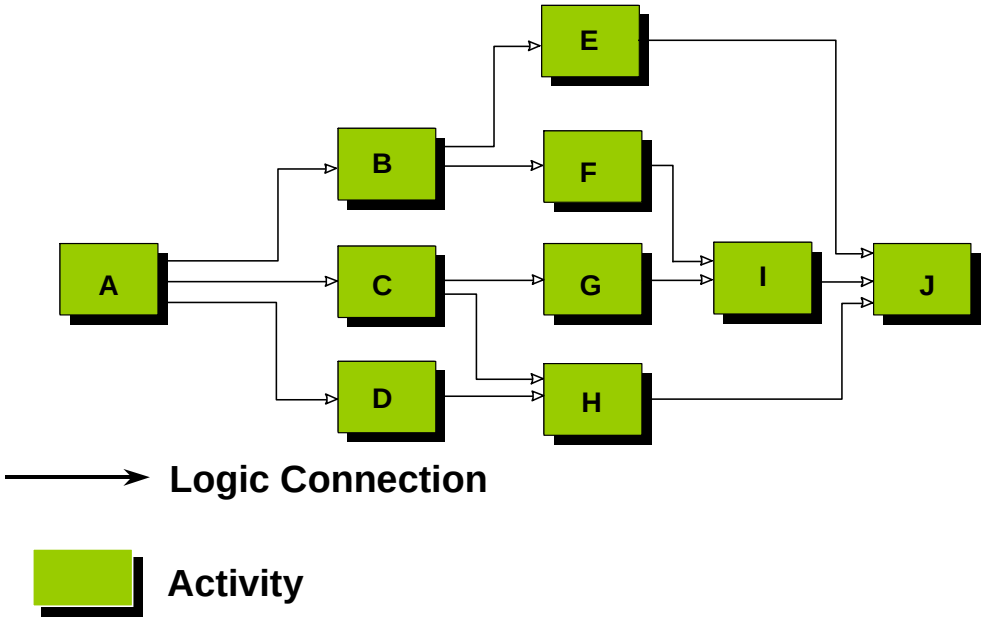

Figure 13 - Project Network Diagram Example

The precedence diagram shown in Figure 13 has ten activities, which are represented with the letters A through J. The diagram shows the order of work and should be read from left to right. Therefore activity A is done first and is followed by activities B, C and D, which are performed simultaneously. Work for activity H starts after activity C and D are finished and so on.

Each sequence of logically connected activities is called a ***network path***. In the example shown, the network has five paths:

1. A ➔ B ➔ E ➔ J
2. A ➔ B ➔ F ➔ I ➔ J
3. A ➔ C ➔ G ➔ I ➔ J
4. A ➔ C ➔ H ➔ J
5. A ➔ D ➔ H ➔ J

One of these paths is called the critical path and represents that path through the network that has the longest duration.

For this example, assume the following data:

Activity	Duration (months)
A	2
B	1
C	3
D	1
E	4
F	3
G	2
H	1
I	2
J	1

To determine the critical path, the project manager must calculate the duration of each path. This is done by adding the duration of each activity on the path together. In the example used, the network would have the following results:

Path	Duration (weeks)
A(2)+B(1)+E(4)+J(1)	= 8
A(2)+B(1)+F(3)+I(2)+J(1)	= 9
A(2)+C(3)+G(2)+I(2)+J(1)	= 10
A(2)+C(3)+H(1)+J(1)	= 7
A(2)+D(1)+H(1)+J(1)	= 5

The numbers shown in parenthesis are the activity's duration; therefore, the critical path would be A➔C➔G➔I➔J because that is the path with the longest duration. Using the CPM, the project manager could also determine that the project should last 10 weeks.

The project manager must know the critical path because if any activity along the critical path is delayed, the completion date of the entire project will be delayed. For example, if activity C takes 5 weeks to complete instead of 3, the project would be extended to 12 weeks instead of 10. However, if activity B took 3 weeks instead of 2, there would be no effect on the length of the project because activity B is not on the critical path. Built into each time duration should be some **slack**, which is the amount of time an activity can be delayed without impacting the project's final end date.

There is always a need to know when a project has reached a certain point or achieved a ***milestone***. An activity with a duration of 0 is called a ***milestone***, which is a unit of accomplishment, such as the start or finish of an activity. For example, an activity could be added to the beginning and end of the project and given a duration of 0; thus, activity A_1 may represent the project start milestone, and activity J_1 may represent the project's finish.

In addition to the above, the project manager can use CPM calculations to determine each activity's earliest and latest start and completion times. The complete network diagram for this example is shown in Figure 14.

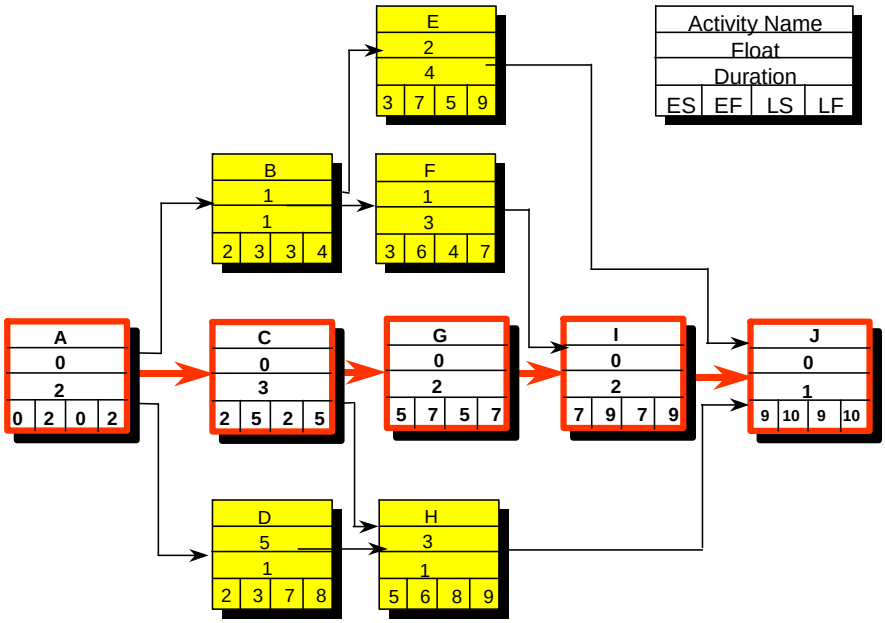

Figure 14 - Critical Path Solution

Gantt Charts

While CPM and network diagrams are tools for calculating project schedules, the Gantt chart is used to display the completed schedule. This chart has a calendar, or time line, on its X-axis and the activities on its Y-axis. A bar represents the duration of an activity and is placed on the chart to show the start/end times for each activity. Project milestones are shown as diamonds or some other common symbol.

The advantages to using a Gantt chart are that it is simple to construct, easy to interpret, and good for management reporting. When constructing a Gantt chart, the project manager should remember that the data on the chart should only represent the level of detail needed by the audience. Therefore, the project manager should provide only summary data for the client and upper management but detail data for project team members.

Figure 15 depicts the finished Gantt Chart for the project example.

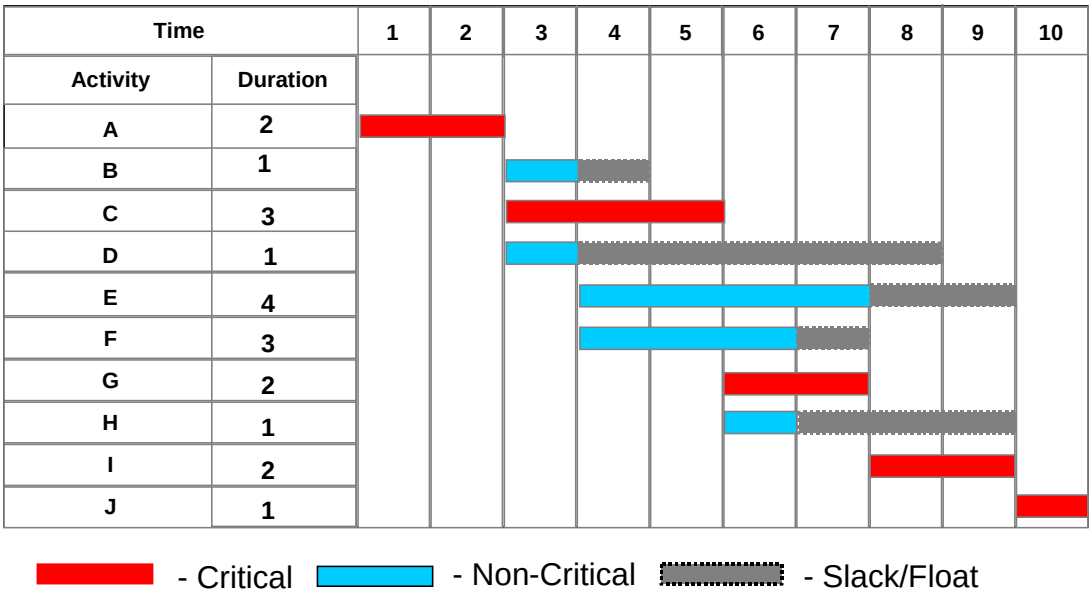

Figure 15 - Sample Gantt Chart

Resource Plan

In addition to the personnel needed to accomplish the work on a project, the project manager must identify and obtain the non-labor resource needs, such as

- Lab time
- Test facilities
- Prototype parts/systems
- Equipment
- Materials
- Facilities for instruction
- Printing needs

Unless these resources are available at the appropriate time and in the right amounts, the project schedule will suffer the same delays as it would were the personnel not available. Therefore, **a schedule is not complete until all the resources necessary to complete the project have been committed or assigned**.

When the project manager estimates the length of time for activities within a project, he/she may make assumptions regarding the number of people available as well as the skill level of those people. However, if personnel with less experience or lower skill levels are assigned, the time estimations will have to be adjusted accordingly. Similarly, if fewer people are available than what was originally estimated to be needed, the duration of an activity may have to change.

The same holds true for non-labor resources. The vendor considered in the original estimation of time and costs may not be available, or the time it takes to receive materials may have changed. Several unanticipated constraints and limitations may exist regarding resource availability, causing the project manager to recalculate the project schedule. In such cases, it is paramount that the project manager does the recalculations; otherwise, the project may begin with an unrealistic or impossible deadline.

Project Budget

Once the project manager has determined the schedule and identified and committed the resource requirements, he/she is ready to determine the project budget. Two key elements affect the level of detail in a budget: time and availability of information. Figure 16 shows this budgeting relationship.

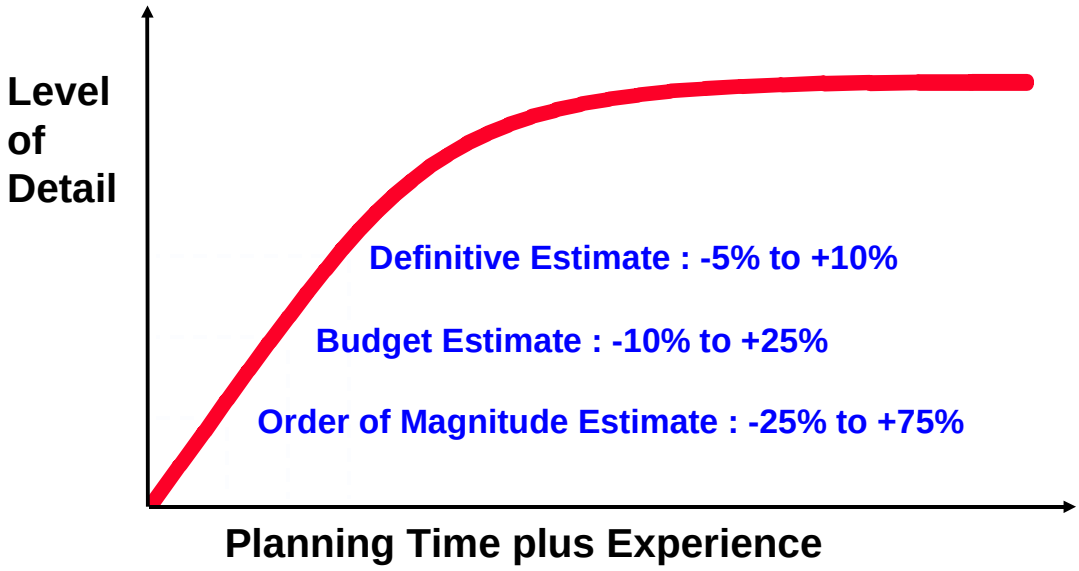

Figure 16 - Levels of Budget

This budgeting relations are affected in the following ways:

- When very little time is available, the project manager may actually base the budget on a wild guess (Order of Magnitude).
- If the project manager is allowed more time and has more experience, a fairly accurate budgetary estimate can be developed.
- The most detailed and most accurate budget can be developed when a highly experienced project manager is given sufficient time and extensive financial information.

For all projects, the very least that should be provided is a preliminary budget.

When developing a budget, the project manager must consider the following:

- ✓ Types of cost estimates
- ✓ The methods of obtaining cost data
- ✓ Key cost components

Types of Cost Estimates

As shown in Figure 16, there are three types of budget estimates:

- Order of Magnitude estimate
- Budget estimates
- Definitive estimates

A project manger uses an ***Order of Magnitude*** estimate to support decisions on the viability of a project. Estimating methods include the use of historical cost data for similar projects with adjustments for inflation and other factors. This estimate is not very accurate; therefore, the project manager can expect the actual cost to be within –25% to +75% of the actual project cost.

The ***Budgetary Estimate*** is used to determine if the time and resources should be invested in project planning. Estimating methods include the use of historical cost data and parametric modeling cost data. This type of estimate provides the improved accuracy, and a project manager can expect the actual costs will be within –10% to +25% of the definitive cost estimate.

Definitive Estimates support project implementation. Estimating methods include the use of historical cost data for each WBS element, written quotes for major cost items, and published data from vendors or contractors. This type of estimate provides the highest accuracy, and a project manager can expect the actual costs will be within –5% to +10%.

Methods of Obtaining Cost Data

There are many ways to obtain accurate cost data:

- Experience from past projects
- Functional subject matter experts
- Lessons learned
- Vendor quotes or bids
- Catalogs
- Cost estimating guides
- Buyers

Key Cost Components

When looking at cost components, the project manager must consider many different categories of costs; the two major cost categories being:

- Capital Items
- Expenses

Capital Costs

Capital items are typically thought of as major new equipment costs for installation as a part of a project.

Equipment Costs

Equipment costs may include items such as computers, printers, or training equipment. In addition to considering the equipment operating costs, the project manager should consider the best method of acquisition: buy, rent, or lease. Other costs that may be associated with equipment include the following:

- ✓ Special labor
- ✓ Fuel
- ✓ Maintenance
- ✓ Setup and installation
- ✓ Training

Facility Costs

Facilities costs are the direct costs associated with site preparation for production readiness. These costs can include the following:

- ✓ Line configurations
- ✓ Alterations to existing buildings/structures
- ✓ New process flows
- ✓ Relocation of utility hookups

Expenses

Expenses are broken down into two significant cost areas, direct and indirect costs.

The major **direct cost** components of any project include the following:

- ➢ Labor
- ➢ Materials
- ➢ Vendor/consultant costs

Labor Costs

Labor costs include the cost per hour for every person-hour it takes to complete the project. To estimate this cost, the project manager must consider the following:

- ✓ Salary/wages
- ✓ Shift differentials
- ✓ Training

Material Costs

Material costs include items, such as manuals or instructional tools, that must be available to complete the project. After determining the materials needed for the project, the project manager must consider the costs of the following:

- ✓ Actual material prices
- ✓ Freight/shipping charges
- ✓ Taxes
- ✓ Delivery schedule charges
- ✓ Storage and handling charges

Vendor/Consultant Costs

Vendor/Consultant costs are usually provided directly to the project manager from the vendor or consultant.

The primary **indirect costs** for a project are

- Overhead
- Contingencies

Overhead Costs

Overhead costs are the costs associated with doing business. Organizations might allocate these costs by department or by project; but, either way, the costs must be included in the project. Overhead costs can include the following:

- ✓ Utilities
- ✓ Rent
- ✓ Corporate services
- ✓ Indirect labor charges

Contingency Costs

Contingency costs include any unforeseen event that could impact the project. These are events that cannot be specified when the project manager is developing the budget. Planning for contingencies is a budgeting practice that provides special provisions for future costs. Occasionally, the total budget of a project is padded by a small percentage to provide for contingencies; however, great caution must be used in this instance. Contingencies are used to cover such things as:

- ✓ Weather delays
- ✓ Changes in design
- ✓ Price increases
- ✓ Estimating errors

However, contingency costs are not intended to cover the following:

- ✓ Changes in project goals
- ✓ Major schedule changes
- ✓ Economic downturns

Risk Planning

Before moving on to the implementation phase, project risk analysis and contingency planning should be done. Preliminary risk planning was done when the statement of work was written. However, at that time, only limited project information was available. Now, a more thorough analysis can be done based on the results of project planning. **One should also remember that risk management is not a one-time event. It is a continuous process that takes place throughout the project life cycle.**

Risk exists in all projects. There is always a chance that something can go wrong. Risk is any event that can negatively impact project scope, quality, cost, or schedule. Unavailability of resources and material costs that exceed estimates are two examples of risk. It is the project manager's role to manage risk.

The definition for risk management, as defined by PMI, is below:

> *"Risk Management is the art and science of identifying, analyzing and responding to risk factors throughout the life of the project and in the best interests of its objectives."*

Risk management begins in the planning phase of a project and continues until project close-out. New risks can occur and previously identified risks can be eliminated at any time during the project. An important aspect of project monitoring and control is the continuing assessment of project risk.

Typically, risk is the highest at the start of the project and gradually decreases as time goes on as shown in Figure 17.

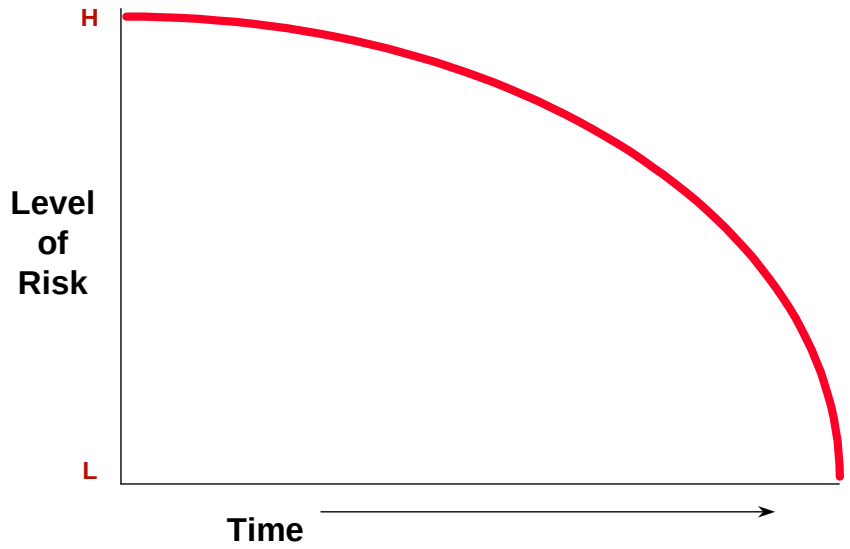

Figure 17 - Project Levels of Risk

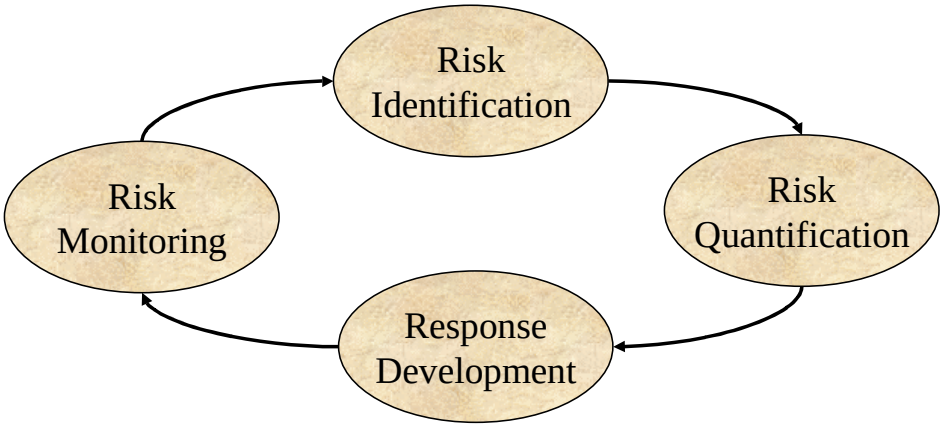

Figure 18 - Risk management Planning Cycle

Risk Identification

Risk identification is the process of reviewing all elements of the project plan and determining what risk events are reasonably likely to occur.

Some methods that can be used to assist in identifying risks are:

- Brainstorming
- Subject Matter Expert review
- Historical data
- Lessons learned

In addition, reviewing common sources of risk can also be helpful:

- ✓ Quality requirements
- ✓ Schedule constraints
- ✓ Cost limitations
- ✓ New technology
- ✓ Project complexity
- ✓ Third-party performance
- ✓ Contract terms (legal)

Risk Quantification

Risk quantification involves determining which risk events warrant response. Use of a risk prioritization matrix (Figure 19) can be helpful in assessing and prioritizing risks.

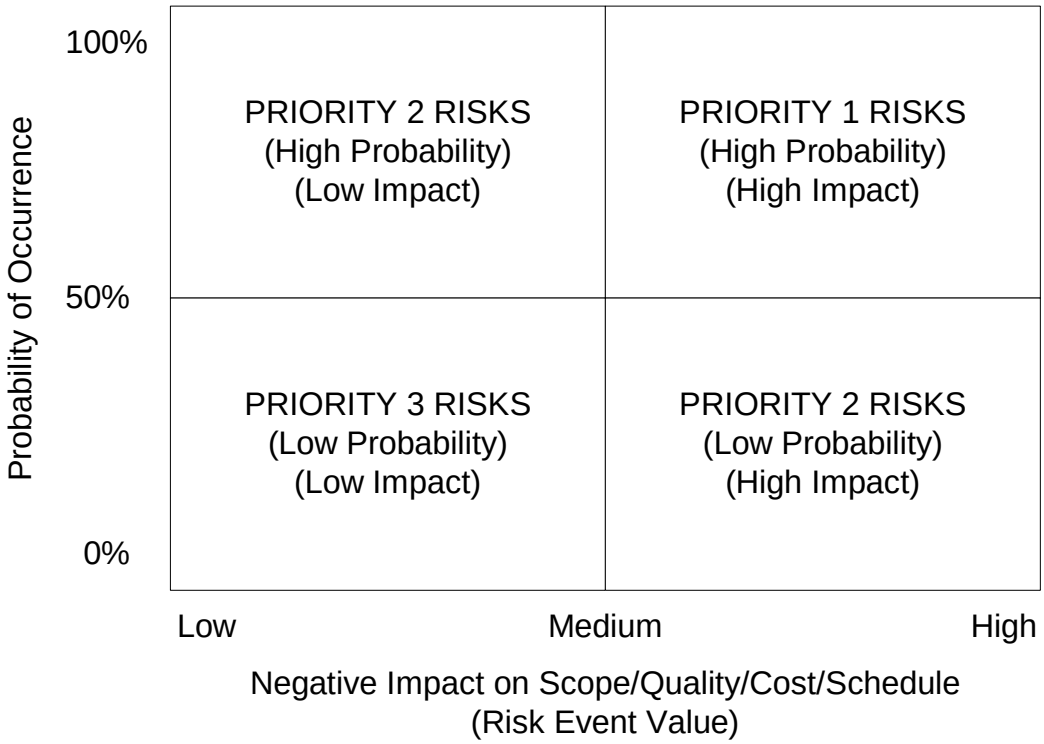

Figure 19 - Risk Prioritization Matrix

Risk Response Planning

Response development or contingency planning is both proactive and reactive.

- Proactive – Identifying steps that can be taken to **prevent** the risk from occurring. This is also called **risk avoidance**. These are steps you **will** take.
- Reactive – Identifying measures that will be taken to reduce the impact of the risk if it occurs. This is sometimes called **risk mitigation** or **retention**. These are steps you **may** take.

The risk prioritization matrix can assist in determining the risk management strategy to be used for a particular risk (Figure 20).

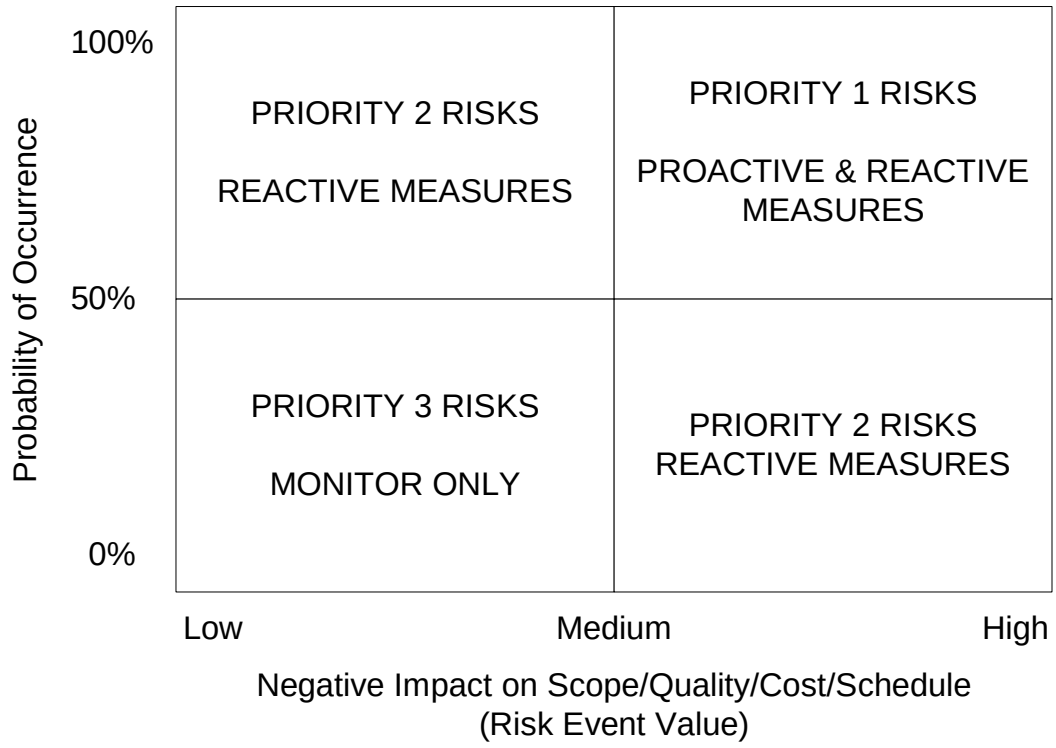

Figure 20 - Risk Response Planning

Risk Monitoring and Control

Risk monitoring and control involve executing the risk management plan (risk strategies identified) developed in order to respond to risk events over the course of the project. When changes occur, the basic cycle of identify, quantify, and respond is repeated.

It is important to understand that even the most thorough and comprehensive analysis cannot identify all risks and probabilities correctly; control and iteration are required.

Risk Worksheet

As a means of documenting the project risk management plan, a standardized template can be used as shown in Figure 21.

Risk Worksheet

Project Manager: _____ **Date:** _____

Project Title: _____

Risk Description:

Risk Priority: **1** **2** **3** **(Circle the Priority)**

Probability %: **Risk Event Value (REV):**

Expected Monetary Value (EMV):

Impacts:

☐ **Quality** ☐ **Schedule**

☐ **Cost** ☐ **Scope**

Preventative Plan (Proactive Plan): **(For Priority 1 Risks)**

Contingency Plan (Reactive Plan): **(For Priority 1 and 2 Risks)**

Date of Last Review: _____ **Date of Last Review:** _____

Figure 21 - Risk Worksheet

Section 5 – The Project Lifecycle: Implementation

During this phase, the project manager has many responsibilities, including the following:

- Provides leadership for the project
- Conducts formal and informal progress report meetings
- Manages change
- Resolves issues
- Tracks project activities to ensure that they:
  - ✓ Are completed on time
  - ✓ Reach quality objectives
  - ✓ Stay within budget
- Maintain a project notebook that contains:
  - ✓ Progress reports
  - ✓ Contact logs
  - ✓ Minutes from all meetings
  - ✓ Lessons learned
  - ✓ Vendor and contractor information

This section discusses the following:

- Factors that ensure implementation success
- Project control
- Change management

Factors that Ensure Implementation Success

Successful project implementation depends on the following factors:

- Updating the project plan
- Staying within the scope of work specified in the project plan
- Getting authorization for changes
- Providing deliverables in stages
- Conducting project review meetings

- Frequently checking the work being performed in order to provide guidance and direction as needed
- Keeping up-to-date project information
- Reviewing project staff performance in order to assist when necessary

Project Control

Project control is based on the project manager's ability to establish an effective project plan with cost, time, and quality baselines. During the implementation phase, the project manager maintains control over the project by measuring, evaluation, and reporting actual performance against the established baselines. To keep control of the project, the project manager must understand that project implementation is a team effort and that he/she must rely on team members to successfully complete their assigned activities.

Greatly simplified, project control boils down to the project manager performing the following:

- Reviewing project team activities frequently
  - ✓ The project manager should conduct formal project reviews with the stakeholders on a monthly basis. At the same time, he/she should review and present project status reports for the previous month and discuss anticipated project progress over the next two months.
  - ✓ The project manager should address changes that occurred since the last review and cover all future issues and concerns.
  - ✓ The project manager should hold informal review meetings on a weekly or biweekly basis.
  - ✓ Finally, the project manager should cover the progress reviews for the last two weeks and discuss projections for progress during the coming two weeks.
- Providing the support the team members need to complete their activities
- Letting the team know the status of the project and what needs to be done next. If necessary, the project manager should prioritize the tasks for the team.

The most important aspect of project control is communication. Throughout the project, the project manager must inform the customer, leadership, and the project team of any problems or changes as soon as possible. By doing so, the project manager will see the following results:

- The team members will be encouraged to talk about problem areas and offer their input for a solution.
- The customer and the project team have the opportunity to share their input on how to handle problems or changes to the project.
- Determining how to handle problems or change in the project will become a team effort and not the sole responsibility of one person.

The two most important tools for monitoring and controlling the project's progress are the

- Project notebook
- Project progress reports

Project Notebook

During a project, the project manager will accumulate a large volume of documentation. A notebook can provide a place to organize that documentation for use as a quick reference. The project notebook, which is started in the planning phase, must be updated on a regular basis. During the implementation phase, the project manager must update and include the following information:

- Project plan, including the Statement of Work, the WBS, the schedule, and the budget
- Progress reports
- Contact logs
- Meeting minutes
- Contractual documents
- Other pertinent documents or information

Project Progress Reports

Progress reports are one of the best ways to track the progress of the project. The project manager uses the progress reports to monitor activities and compare them to the schedule and budget. The project manager should complete the progress reports on a monthly basis.

The major sections of a progress report include the following:

- Project description
- A summary of the progress made since the last report
- Outstanding issues that need to be addressed
- Meetings attended
- Reports and correspondence sent
- Action planned for the next period
- Project funding status
- A macro-level milestone chart comparing the percentage spent to the percentage completed

Figure 22 shows a sample Project Progress Report form.

Project Progress Report			
Customer:			**Date Submitted:**
Authorization Reference:			**Report Period:**
Project Description:			
Financial Administrator:		**Customer Representative:**	
Summary of Progress During Period:			
Milestones Achieved:			
Open Issues:	**Assigned to:**		**Date Due:**
Actions Planned for Next Period:			
Authorized/Established Limit:	**Expended During Period:**	**Expended to Date:**	**Remaining at End of Period:**
Project Manager:		**Project Director:**	

Figure 22 - Sample Project Report

Tracking Project Progress

Once project progress data has been collected and before a report can be written, the project manager can use several tools to measure performance against the baseline plan for quality, schedule, and cost. These tools include:

- Quality reviews
- Schedule performance
- Cost performance charts
- Earned Value Analysis

Quality Reviews

Special meetings should be held to ensure that deliverables will meet predefined customer expectations and quality standards. These reviews can be informal and include as few as two people: the presenter and the reviewer. Formal reviews may include several people such as subject matter experts and customer personnel if formal acceptance is being sought.

Probably one of the most important guidelines to remember about these meetings is that **the focus of the meeting should be on the deliverable or product and not on the producer.**

Topics of concern during quality reviews include:

- Product design
- Specifications
- Manuals
- Parts
- Computer program code

Schedule Performance

The application of Gantt charts can be extended by showing the original project plan baseline compared to the current plan (actual and forecast) in order to measure schedule performance.

Using the Gantt chart, the original baseline schedule is plotted for each activity. The baseline schedule for each activity is plotted below the actual performance of the tasks. In effect, two schedules are plotted in the Gantt chart: the original plan and the current plan. This method provides a very easy way to determine schedule status visually.

An example schedule performance Gantt chart is shown in Figure 23.

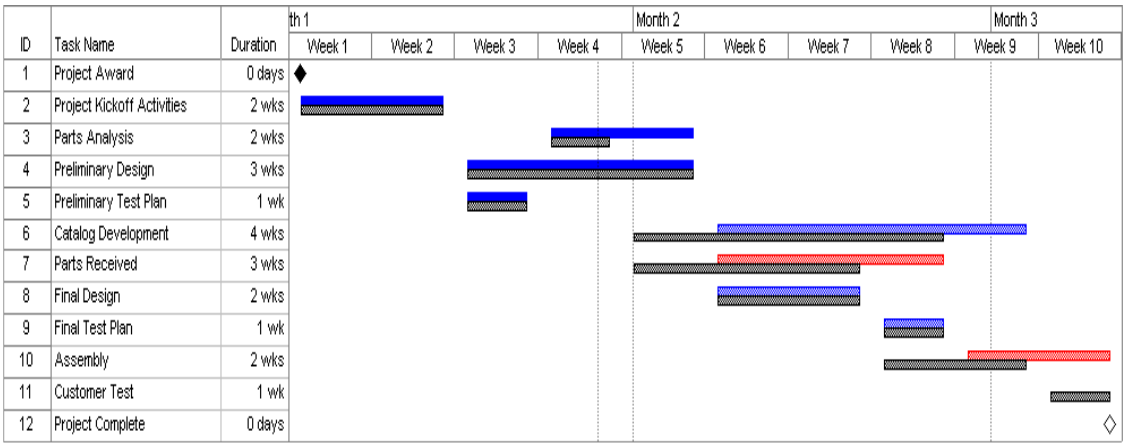

Figure 23 - Tracking Gantt Chart

Earned Value Analysis

Project cost performance can be displayed in tabular-format, visual-format (cost curves), or a combination of both. In these charts, budgeted dollars are compared with actual costs to date. Based on actual cost data, projections can then be made to forecast estimated actual cost at project completion. The most effective method for measuring project cost performance is called earned value analysis.

Earned value analysis is an extension of the performance measurement techniques discussed so far. This type of analysis emerged as part of the government's requirement for government subcontractors to have an approved approach for measuring project schedule and cost performance in terms of **money**, the universal measurement of project performance.

Earned value analysis requires organizational discipline in order to track data and provides accurate values for key project metrics. Reasonable baseline plans and project metrics must be developed. Project managers must have a clear understanding of the project and a thorough WBS and budget determination in order to use the system. Figure 24 illustrates a sample EVA management system approach.

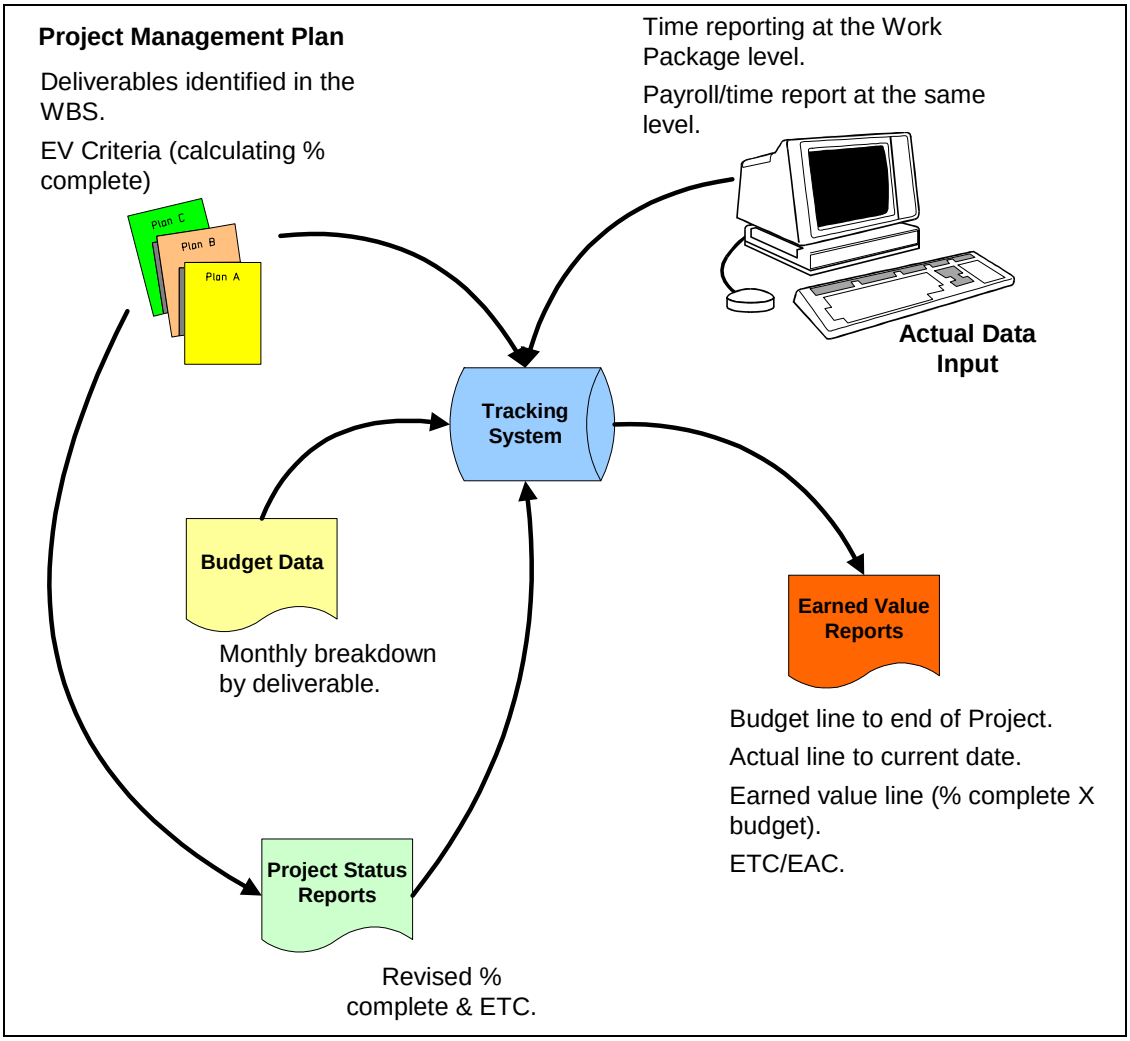

Figure 24 - Sample Earned Value Management System

Definitions

Table 2 - Earned Value Analysis Definitions

Term	Definition
Planned Value (PV)	This is the budget for what was scheduled to have been performed within the reporting period. This may also be called the budget plan, performance measurement baseline, or budgeted cost of the work scheduled (BCWS) for this period.
Actual Costs (AC)	The actual cost of work completed within a given reporting period. This includes only those costs related to work performed to date. It is sometimes referred to as the actual cost of the work performed (ACWP).
Budget at Completion (BAC)	The budget approved for the project. This is also called the performance measurement baseline for the project.
Estimate to Complete (ETC)	Estimate of what it will cost to finish the rest of the project or an individual work task.
Estimate at Completion (EAC)	Forecasted project cost determined at the end of each reporting period.
Earned Value (EV)	This is the budgeted cost for the work that has actually been performed within the given reporting period. Actual earned value is the sum of the budgets for all work that has been completed for the reporting period. **At the activity level, it is equal to the percent complete of an activity times its original budget.**

Earned Value Analysis Example

You are the project manager for the production of a new line of widgets. The project plan calls for the production of 2000 widgets in the next two months with a total project budget of $2,000.00. The estimates provided to management were to produce 1000 widgets per month at a cost of $1,000.00. At the end of the first month, the project output is 900 widgets and total costs are $1,100.00. Your manager has asked you for a report on the project.

How is the project doing?

Table 3 - EVA Example Values

EVA Parameter	EVA Amount
BAC	$2,000.00
PV	$1,000.00
AC	$1,100.00
EV	$900.00

Earned Value Calculations

The four values provided in are used in the predictive equations utilized in earned value analysis.

Variances

The two basic calculations are for cost variance (CV) and schedule variance (SV):

$$CV = EV - AC$$

$$SV = EV - PV$$

In the example,

$$CV = \$900 - \$1{,}100 = -\$200$$

$$SV = \$900 - \$1{,}000 = -\$100$$

Obviously, the project is slightly behind schedule and over budget.

Performance Indices

There are two performance indices that are used in the EVA process, the cost performance index (CPI) and schedule performance index (SPI):

$$CPI = EV/AC$$

$$SPI = EV/PV$$

In the example,

$$CPI = \$900/\$1{,}100 = 0.818$$

$$SPI = \$900/\$1000 = 0.900$$

When these indices are provided in a management report, it can be quickly determined that the project is behind schedule and over budget.

Percent Spent

The last of the quick indicators are percent spent and percent complete:

$$\%Complete = EV/BAC$$
$$\%Spent = AC/BAC$$

In this example,

$$\%Complete = \$900/\$2{,}000 = 45\%$$
$$\%Spent = \$1{,}100/\$2{,}000 = 55\%$$

Predictions

It is obvious that this project has some problems. EVA can be used to make some predictions about the future performance on the project. At the current rate of doing work and spending money to accomplish that work, the following may be estimated:

- Estimate at Completion (EAC)
- Estimate to Complete (ETC)
- Variance at Completion (VAC)
- Schedule Variance at Completion (SVC)

$$EAC = BAC/CPI$$
$$ETC = EAC - AC$$
$$VAC = BAC - EAC$$
$$SVC = \frac{\frac{BAC}{SPI} - BAC}{\text{Avg. Time Period PV}} \times 100$$

In this example,

$$EAC = \$2{,}000/0.818 = \$2{,}445.00$$
$$ETC = \$2{,}445 - \$1{,}100 = \$1{,}345.00$$
$$VAC = \$2{,}000 - \$2445 = -\$445$$

$$SVC = \frac{\frac{\$2{,}000}{0.900} - \$2{,}000}{\$1{,}000} \times 100 = 22.2\%$$

The project is late and overspent. If corrections are not made and the project continues on its present course, it will be over spent by $445 and be approximately 10 - 12 days late (22%).

Value of Earned Value Management

- Measures performance and progress with a single management control system.
- Improves the ability to forecast project performance.
- Forces management analysis.
- Helps to determine the need to re-plan.

Figure 25 shows the relationship between the various earned value analysis indicators.

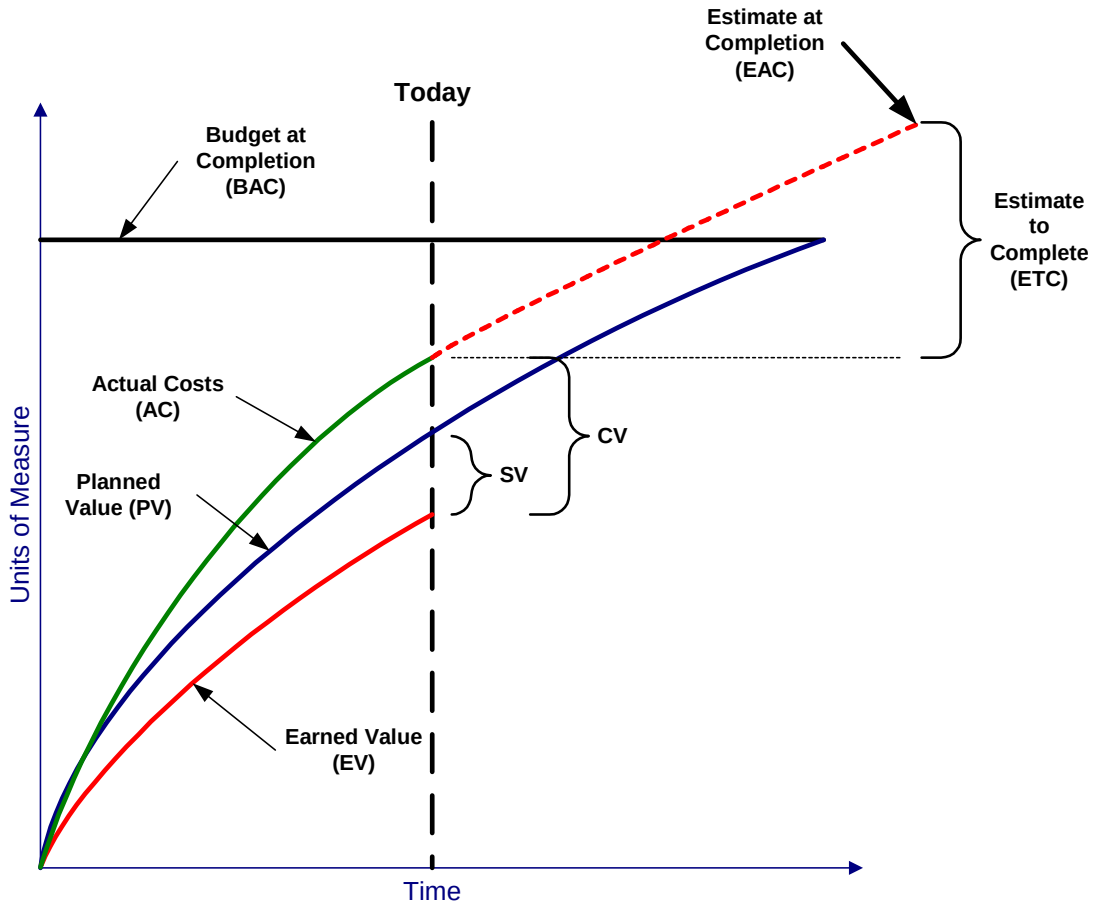

Figure 25 - Earned Value Indicator Relationships

Change Management

Ineffective change management is one of the leading causes of project failure. Change will occur on every project. The only difference is the extent of the change and how well the project team is prepared to address it.

Change management is when the project manager uses existing project information to make decisions when a change in the project occurs. The project plan, developed during the planning phase, can help the project manager anticipate the consequences of change and prepare a "what if" plan to handle those changes. In every situation, the project manager must be able to react quickly to changes, analyze the impact on the project, and select the best course of action.

Change Requests

Change can be classified into two major categories:

- Changes in project scope as a result of specific requests by the customer
- All other changes that may impact quality, cost, and/or schedule, which require some form of corrective action

Customer requested changes can be effectively managed by establishing and enforcing a documented process for handling the request. Figure 26 is an example of a simple change request process. The process basically address the following:

- Change request submission
  - *The change is documented and submitted to the project manager for review.*
- Change analysis and review
  - *The change is analyzed to determine feasibility and its impact on project quality, cost, schedule, and budget.*
- Approval and incorporation
  - *The project manager makes recommendations and the change is either approved or rejected. If approved, the change is incorporated into the project schedule.*
- Closure
  - *After the change is completed and accepted, the request is closed and filed in the project notebook.*

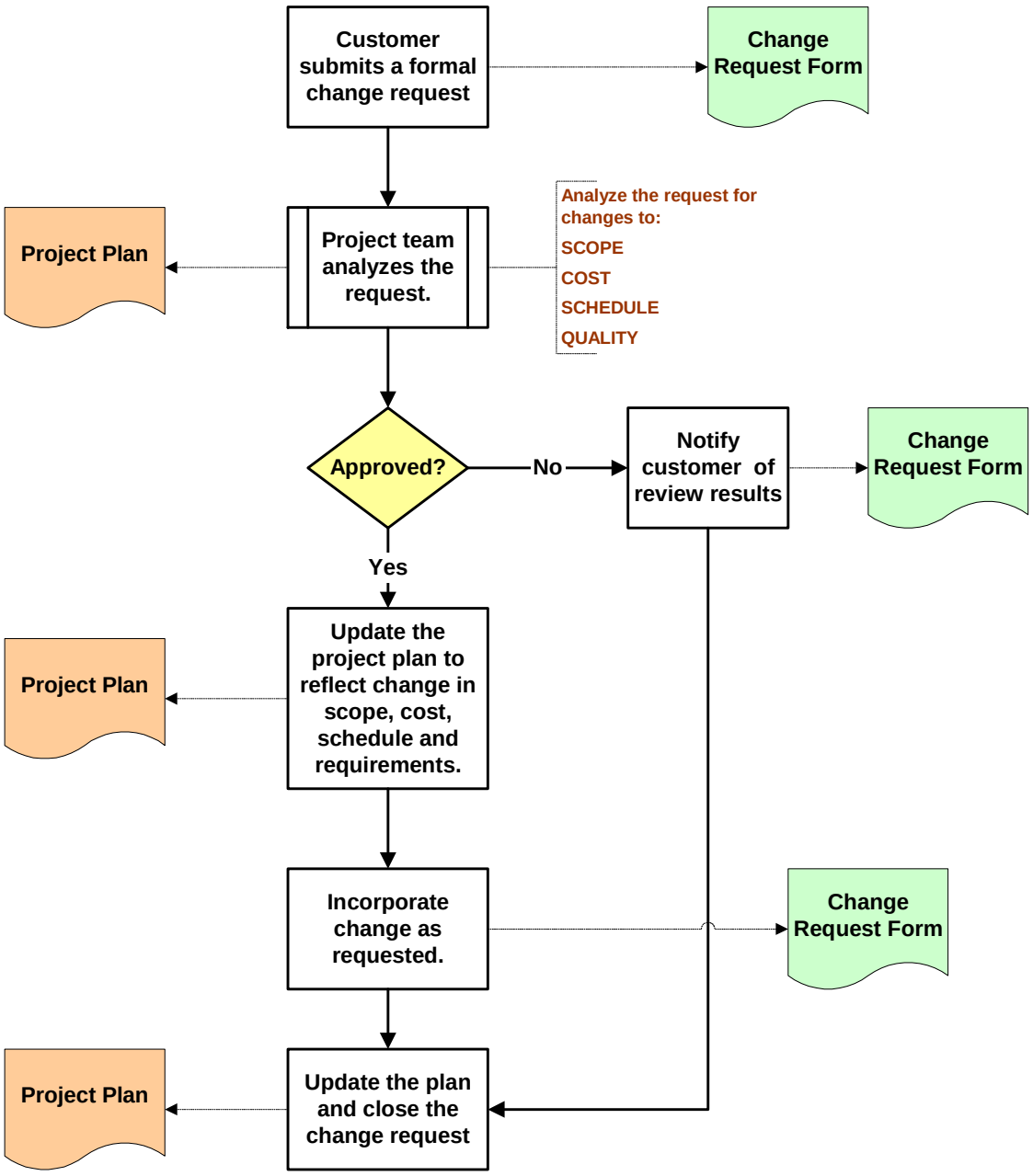

Figure 26 - Sample Change Process Flow

Depending on the type and nature of the changes, the project manager can handle changes, using one of two methods:

- Taking the problem directly to the team members
- Getting support and input from company leadership

Taking Problems Directly to Team Members

Problems that are small in nature should be taken directly to the team members for their input and solutions. Oftentimes, it is the people who are doing the bulk of the work who understands the problems the best and can find real solutions at minimal cost. This technique also gives the team a sense of ownership of the project.

In this case, the project manager should call a team meeting to explain the issue or change. At the meeting, he/she should

- Ask each team member how the change could impact his/her assigned tasks
- Ask for suggestions on a course of action

After receiving the input, the project manager should document the issue or proposed change in a progress report or memo, send the report to the appropriate personnel for approval, and then implement the change after approval is received.

Getting Support and Input from Company Leadership

In other cases, the project manager cannot effectively deal with change without the support and input of senior leadership. Sometimes, it may even be senior leadership that mandates the change.

Whatever the situation, the project manager must be able to present the right information so that leadership can make the best decision. When presenting corrective actions options, the project manager should include how the change will impact the each of the following:

- Budget
- Quality
- Schedule
- Other programs

In addition, the project manger should provide as many alternatives as possible to help those in leadership to understand more fully the results of whatever decision they make. Therefore, it is paramount that the project manager organizes the information well and presents his/her options clearly. One way to do this is to use a Decision Matrix, which is a tool that allows managers to weigh all the options and ask the right questions. The matrix, used in conjunction with the project plan, provides a summary of several options and their impact.

Figure 27 shows a sample Decision Matrix.

Decision Matrix				
Option	**Impact On**			**Risk**
	Schedule	**Budget**	**Quality**	
Describe course of action for this option	Quality impact on schedule	Quantify impact on budget	Describe course of action for this option	Indicate risk level as: H = High M = Medium L = Low
Example: Use overtime to complete the task that's behind schedule	Will get the project back on schedule	Will increase cost by 10%	No impact on quality	L
Example: Overlap work on later critical path activities by adding staff	Will get the project back on schedule	Will increase cost by 20%	New staff may not know or adhere to quality standards	H

Figure 27 - Decision Matrix

Section 6 – The Project Lifecycle: Closeout

The final phase of the Roadmap to Project Success is the close-out phase, during which time the project is brought to completion. The four major steps in the close-out phase are

- Measuring project success
- Conducting a close-out meeting
- Documenting the lessons learned
- Summarizing project experience

Measuring Project Success

Before providing the final deliverables to the customer, the project manager should ensure that all the customer's needs have been met. To do this, the project manager checks the deliverables against the project's success indicators.

In many instances, deliverables are supplied to the customer throughout the project. In this case, the project manager must make checks throughout the project that the deliverables meet the quality and customer specifications before they are turned over to the customer. By using the Statement of Work as a checklist, the project manager can measure project success by reviewing the following:

- Project purpose
- Deliverables
- Measurable success indicators

In other cases, the success of the project cannot be fully realized until well after the project is over.

Conducting Close-out Meetings

After verifying that the measurable success indicators have been met, the project manager conducts the close-out meeting. Attendees at the close-out meeting should be the project stakeholders. Before holding the close-out meeting, the project manager should perform the following:

- Prepare and circulate the agenda to all participants, notifying them of the following:
  - ✓ Time and location
  - ✓ Topics to be covered

- ✓ Expected length of the meeting
- ✓ Expected participants at the meeting
- ✓ Any items that participants need to bring to the meeting

- Ensure that all remaining deliverables are ready for delivery.
- Ensure that release date documentation is available for interim deliverables.
- Update the project schedule to reflect the actual project.
- Total the current project costs.
- Ensure that all additions/changes to engineering standards and specifications have been identified and documented.
- Ensure that the documentation for all authorized project changes (scope, budget, resources, schedule) are available.

The typical close-out meeting agenda includes the following:

- Reviewing the Statement of Work for the project
- Reviewing the actual deliverables and showing how the project met its measurable success indicators
- Summarizing what was done well
- Identifying areas for improvement
- Requesting recommendations for future improvements
- Determining whether additional tasks, such as providing the customer with documentation or creating reproducible masters, are necessary to complete the project
- Listing additional tasks, responsible people, and due dates
- Documenting lessons learned for the project notebook

It is also advantageous to hold an informal close-out meeting with the project team members. At this meeting, the team should perform the following:

- Identify what went right on the project
- Identify what went wrong on the project
- List ideas for improvement
- List ways to ensure that those things that went right happen again on future projects

Documenting Lessons Learned

Throughout a project, the project manager will encounter new challenges and opportunities. To help other project managers when they encountered similar circumstances, the project manager should summarize the lessons learned and the follow-up changes that occurred during the course of the project and put these into the project notebook. In addition, the project manager should include the issues discussed during the close-out meeting.

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APPENDIX A – GLOSSARY[1]

Activity	The smallest unit of work, a task; it requires time and resources to complete.
Activity Float	Activity float is the amount of time units that an activity may be delayed without impacting the end of the project. (See *Total Float*)
Actual Cost (AC)	The total cost of an activity, task, product, process, or project that were completed to date.
Arrow Diagram Method	A network diagram in which activities are represented by arrows and nodes represent the start/finish of activities.
Bottom Up (Brainstorming)	A technique used to develop a Work Breakdown Structure whereby all tasks associated with a project are identified and then logically grouped according to similarities or the resulting product when all tasks have been completed.
Budget at Completion	The total project budget estimated in the planning phase.
Burden	An aggregate cost consisting of all indirect costs incidental to plant operations. Also referred to as overhead.
Corrective and Preventive Action	The systematic process whereby a project team is able to prevent and correct deviations from a project plan.

[1] Portions of this glossary are reprinted from the *A Guide to the Project Management Body Of Knowledge* with permission of the Project Management Institute.

Cost Estimating	The process that integrates all areas of cost accumulation which relates to a product, process, or project. This multi-disciplined approach utilizes all aspects of costs including material, labor, burden, labor related, and facilities cost. This technique involves a combination of historical, actual, and future costs to arrive at the most accurate definition.
Cost Variance	The difference between expected costs of doing work and the actual cost of the work.
Critical Path	That sequence of activities that will delay the project completion date if any activity along the path is not completed on time. The critical path determines how much time is necessary to successfully complete a project. If a task on the critical path is delayed, the entire project will be delayed.
Critical Path Method	Technique used in project scheduling to calculate early and late start and finish times in order to determine which path of activities is critical.
Deliverables	Outputs of project.
Depreciation	Is an annual charge against income which reflects a loss in value of equipment due to its use.
Detailed Cost Estimate	A cost estimate used to support project planning and implementation. Also known as Final Cost Estimate.
Direct Labor	The labor cost which is directly associated with the development of a given product. Direct labor is also referred to as productive labor.
EAC	See *Estimate at Completion*.
Early Finish (EF)	The earliest possible ending date of an activity.
Early Start (ES)	The earliest possible starting date of an activity.
Earned Value (EV)	The amount of money you planned on spending for the activities that were completed to date.

Earned Value Analysis	A method of measuring project performance which integrates cost and schedule. It compares the amount of work that was scheduled to occur with what actually happened (to determine if the project is on schedule) and the budget for the work that occurred with the actual cost (to determine if the project is over or under budget).
Estimate at Completion	The projected total project cost determined at some point during project implementation.
Final Cost Estimate	A cost estimate used to support project planning and implementation. Also known as Detailed Cost Estimate.
Float (Slack)	The amount of time an activity can be delayed before it increases the total duration of the project. Zero float time implies that the activity has no room for delay. Also known as slack time.
Forecast	An estimate and/or prediction of future events and conditions predicated on information available at the time the forecast/prediction is made.
Free Float	The number of time units an activity may be delayed without affecting the early start of a succeeding task.
Gantt Chart (Bar Chart)	A graphical representation of a project schedule which shows the relationships within given time constraints among project tasks. A Gantt chart has a calendar or time line on the x-axis and lists activities on the y-axis. A bar is used to represent duration of the activity and is placed on the chart to show accurate start/stop times.
General and Administrative Costs	Costs necessary to plant operation but not associated with providing services or developing products. Examples are executives salaries, public relations, and R&D.
Histogram	A graph with vertical bars usually indicating quantities or costs of resources used for specific time intervals.

Labor Burden	An aggregate cost consisting of all indirect labor costs incidental to operations. Also referred to as indirect labor. Examples: janitorial, maintenance, etc.
Lag Time	The logical relationship between the start and/or finish of one activity, and the start and/or finish of another. It may include a predicted delay of the start of another activity, or allow a successor to start prior to 100% completion of the predecessor activity.
Late Finish (LF)	The latest possible date an activity can end (and still complete the project on time).
Late Start (LS)	The latest possible date an activity can start (and still complete the project on time).
Lead Time	See Lag Time.
"Success Triangle"	The elements of schedule, cost, and quality which must be considered in project planning, and met during project implementation.
Measurable Success Indicators	Concise, measurable information that identifies how well a project is to be completed.
Milestone	A project event that represents a checkpoint, a major accomplishment, or a deliverable result. For example, the start or finish of some activity.
Negative Float	The amount of time units a forecasted finish will exceed the scheduled late finish of an activity. (It reflects how late a task, logic string, and/or project is).
Network Diagram	A diagram which shows the logical sequencing of a project's activities in order to illustrate the plan ned flow of efforts through activities and the relationships between the activities.
Overhead	See *Burden.*
Percent Completion Chart	An extended application of the Gantt chart where shading is used to show the status of activity completion.

PERT Time Estimating	A probabilistic time estimate which uses a statistical method to determine the duration of an activity. It uses a weighted formula for estimating time based on three time estimates; optimistic, pessimistic, and most likely.
Planned Value (PV)	The cost associated with the original project schedule.
Precedence Diagram Method	A network diagram in which activities are represented by boxes which are connected by arrows.
Preliminary Cost Estimate	A cost estimate used to support decisions on the viability of a project.
Productive Labor	See *Direct Labor*.
Project	A temporary endeavor undertaken to create a unique product or service. A set of non-recurring related activities that have a definite beginning and end, have a goal to meet, and have clearly defined objectives and deliverables.
Resource	A person, piece of equipment, or material used to accomplish a project task.
Resource Leveling	The process of matching the number of required resources to the number of available resources.
Responsibility Assignment Matrix	A matrix-like chart used to keep track of responsibility among the project team. The project team members are charted against the project responsibilities.
Schedule Variance	The difference, in time or cost, of where a project is compared to where it should be, based on work performed.
S.M.A.R.T.	An acronym describing how measurable success indicators should be written. Consists of: Specific, Measurable, Attainable, Realistic, and Takes organizational policies and practices into account.

Statement of Work (SOW)	A detailed description of the project deliverables and the purpose for creating them. The SOW also includes information on how well the project must be completed in order to be successful.
SVAR	See *Schedule Variance*.
Task	A small, manageable element of work, also called an activity.
Top Down	A technique used to develop a Work Breakdown Structure whereby the end product is broken down into major elements which are in turn divided into sub-elements or activities.
Total Float	The number of time units an activity may be delayed from the early start without delaying the end of the project. (Note: When total float is used, the total float for succeeding tasks is subsequently used as well.)
Variances	Reports of differences between what a project should have cost and what it actually costs to complete. Can be due solely to cost factors, or to deviance from schedule.
"What if" Plan	Alternate plans made considering possibility of an event occurring which would alter the schedule, budget, or quality of a project, but would not end the project.
Work Breakdown Structure (WBS)	A systematic, graphical approach for dividing a project into tasks required to complete the project.

Appendix B – Project Checklists

Use the checklists in this appendix as an aid to developing the elements of your project plan and to prepare for your project closeout meeting.

Forming the Project Team Checklist

Be sure you have considered the following when you form your project team:

- ✓ Have project team members been identified?
- ✓ Have training needs been considered?
- ✓ Have responsibilities been assigned to customer, senior level management, project manager, and team members?
- ✓ Have resources been leveled?
- ✓ Has resource leveling been reflected in the project schedule (critical path of network diagram)?

Statement of Work Checklist

Be sure your statement of work answers the following questions:

- ✓ What is the purpose—the goal—of the project?
- ✓ Why is the project to be done?
- ✓ Who is the initial customer?
- ✓ Who is the end user (final customer)?
- ✓ What are the tangible end products (deliverables) to be delivered to the initial customer?
- ✓ Have the technical requirements for the deliverables been identified?
- ✓ What is the available budget?
- ✓ Have training needs been addressed?
- ✓ What kind of support is required from the customer?

Measurable Success Indicator Checklist

Check that **most** of the following questions can be answered "yes" for each of the project's measurable success indicators.

- ✓ Is it measurable and verifiable?
- ✓ Does it specify only the **what** and **when**, and not the **how** and **why**?
- ✓ Does it contain a specific action verb?
- ✓ Does it specify a single key result to be accomplished?
- ✓ Is it consistent with resources available or anticipated?
- ✓ Does it relate directly to project requirements?
- ✓ Can the project team members understand it in terms of their contribution?
- ✓ Is it realistic and attainable, and does it represent a challenge to the project team members?
- ✓ Can it be willingly agreed to by the customer, project manager, and the project team members without undue pressure?
- ✓ Does it address accountability when joint effort is required?
- ✓ Can it be communicated in discussion with others?
- ✓ Does it provide a maximum payoff on the required investment in time and resources (as compared to other success indicators that might be considered for obtaining the same results)?
- ✓ Is it consistent with basic company and organizational policy and practice?

Work Breakdown Structure Checklist

Check your project's work breakdown structure for the following:

- ✓ Are the project's deliverables addressed in the major elements?
- ✓ Are major elements and sub elements defined as nouns?
- ✓ Is project management included as a major element?
- ✓ Are project activities defined as verbs?
- ✓ Are project activities defined such that the work can be controlled?
- ✓ Are project activities defined such that authority, responsibility, and accountability can be assigned to an individual or a group?
- ✓ Are activities defined such that progress can be measured?
- ✓ Are activities identified such that duration and cost for each activity can be determined?
- ✓ Will the sum of activities for one element ensure that the element will be produced with the desired quality?
- ✓ Are there three or less levels, and no more than 20-30 activities?

Project Scheduling Checklist

Check your Gantt chart and network diagram to make sure you can answer "yes" to all of the following questions. Do they:

- ✓ List all the activities in the work breakdown structure?
- ✓ Identify the interdependencies between tasks?
- ✓ Provide a clearly defined start and end date for each task?
- ✓ Remain flexible enough to allow a change in the scope of effort?
- ✓ Appear to be easy to understand?
- ✓ Provide a means for keeping the information updated and current throughout the course of the project?

Project Budget Checklist

The project budget checklist is a guideline to be used to verify that certain tasks have been completed. This list is not all-inclusive and may vary from project to project. The checklist is not prepared by priority. Each project manager should establish the priority and sequence given to each job or task to be completed.

- ✓ Cost estimate
  - *Preliminary*
  - *Final detailed*
- ✓ Labor costs
  - *Salary*
  - *Hourly*
  - *Skilled*
  - *Unskilled*
- ✓ Material costs
  - *Direct*
  - *Indirect*
- ✓ Equipment costs and depreciation
  - *Equipment required (Lease, Buy)*
  - *Depreciation (Method, Useful life, Salvage)*
- ✓ Overhead costs
  - *Contract labor*
  - *Subcontractors*
  - *Indirect expenses*
  - *Taxes, insurance, etc.*
- ✓ Facilities alterations costs
  - *Expansion*
  - *Rearrangement*
  - *Relocation of utility outlets*
- ✓ Cost estimating data
  - *Engineering*
  - *Purchasing*

- ♦ *Accounting*
- ♦ *Manufacturing*

✓ Analysis

- ♦ *Historical*
- ♦ *Index*

✓ Contracts or external costs

✓ Management review and approval

✓ Construction costs

✓ Tooling costs

✓ General and administrative

✓ Engineering requirements

Resource Leveling Checklist

Be sure you have considered the following when you form your project team:

✓ Have project team members been identified?

✓ Have training needs been considered?

✓ Have responsibilities been assigned to the customer, senior level management, project manager, and team members?

✓ Have resources been leveled?

✓ Has resource leveling been reflected in the project schedule (critical path of network diagram)?

Project Closeout Meeting Checklist

Be sure the following items are taken care of before the project close-out meeting:

- ✓ Has an agenda been prepared and circulated to all potential attendees? It should notify them of the following:
  - *Time and location*
  - *Topics to be covered*
  - *Expected duration of the meeting*
  - *Items that they need to bring to the meeting*
- ✓ Are all remaining project deliverables ready for delivery?
- ✓ Is release date documentation available for interim deliverables?
- ✓ Has the project schedule been updated to reflect the actual project?
- ✓ Have current project costs been accumulated?
- ✓ Have all additions/changes to engineering standards and specifications been identified and documented?
- ✓ Is documentation for all authorized changes (scope, budget, resources, schedule, etc.) available?