**Project management** is mainly concerned with the processes of planning such a project, organizing the necessary resources, leading the individuals responsible for carrying out the project, monitoring its progress, and implementing its deliverables. The challenge of project management is to bring about the goals and objectives of a project within the constraints of time, scope, and budget. The larger the project, or the more complex it is or uncertain its environment, the more necessary and challenging is the task of project management. There are many project management methods available to assist project managers, a number of which are discussed.

INITIATION

Regardless of scope or complexity, all projects go through a similar sequence of stages during their life. Dividing the work into stages helps the project manager plan and organize resources for each stage, to gauge whether the project goals are being achieved, and to justify decisions to continue, modify, or end the project. The phases are initiation, planning, execution, monitoring and controlling, and closure.

All projects start with an idea for a product, a service, or a change (such as process improvement) that will produce an identifiable benefit. In the **initiation stage**, the nature and scope of a project are defined. This is normally documented and communicated to others through a project *terms of reference* document, also known as a *project charter*. The project charter describes what the project will accomplish.

Following the initiation stage is the **planning stage**. In this stage, the project is broken down into smaller modules, the sequence of activities is defined, and the resources needed for each are identified. This information is recorded in a project plan document. Careful project planning is an important component of managing project risk—uncertain events or outcomes can have an impact on success.

In the **execution stage**, work is carried out to deliver the product, service, or desired outcome. Most of the effort and cost related to the project is expended at this stage. Once the work has begun, the project manager is also responsible for ongoing control of the project.

In the **monitoring and control stage**, regular progress reports and constant assessment of issues and risks are carried out. The project manager should be regularly comparing the project plan document with its actual progress so that the expected benefits will be realized.

Finally, when the work on the project comes to an end, the project has reached the **closure stage**. At this stage, the project manager should ensure that the client is satisfied with the outcome and agrees that the work is done. The project manager should also review and document lessons learned so that future projects can benefit from this information.

It is important to note that not all projects will pass through every stage, since some will be terminated along the way. Some projects will pass through the planning, execution, and monitoring and controlling stages several times if unexpected events require that it “go back to the drawing board.” Each industry may use different names to describe the stages of a project lifecycle and will have different issues that need to be managed carefully. It is therefore important to become acquainted with industry-specific practices and conventions. For example, in the oil and gas industry, projects involving gas fields, pipelines, and natural gas plants can be worth billions of dollars and extend over 20 years or more. For a project of this scale, a key process that needs to be managed carefully is the Environmental and Social Health Impact Assessment. Making sure that the approval requirements are mapped out early and carefully, and that the project plan allows sufficient time and budget for the approvals process, can help avoid later delays that could cost millions of dollars. While every industry will have its own set of project management issues that need to be carefully addressed, overall project management processes are very similar across industries, no matter what the stages are called and what issues tend to dominate. This chapter provides only an overview. More resources on industry-specific project management topics can be found through professional groups such as the Project Management Institute and in general purpose or industry-specific textbooks on project management. There is also a large amount of information about project management on the internet.

All projects start with an idea for a product, a service, or a change that will produce benefits

for a group or organization. When an idea gets to the point where management is considering its implementation, a sponsor is identified. The **project sponsor** is normally a person or group that has the resources to complete the project and acts as the project champion, leading the process of developing a project charter document. The charter defines the project in such a way that it can be understood by a broad audience, yet it must provide enough information so that an appropriate project manager can be chosen. The project charter should include:

• Background: What are the reasons for creating the project, and who will benefit from it?

• Objectives: What are the key project goals? Are they expressed in specific and measurable terms?

• Methodology: What methodology will be taken to complete the project?

• Justification: Is the project feasible? Does it meet an identifiable need? Do its benefits outweigh the costs? This section of the project charter may refer to other documents such as a feasibility study or needs analysis.

• Requirements: What are the required features and functions of the product or service (or desired outcome)?

• Constraints: What are the restrictions that limit the project in terms of time, budget, and requirements?

• Assumptions: What major project-related factors are considered to be true?

• Risks: What uncertain events or outcomes could have an effect on one or more objectives of the project? What impact might each have? Can the risks be controlled?

• Deliverables: What outcomes from the project are necessary to achieve the stated objectives?

The **project manager** is assigned the responsibility of fulfilling the objectives of the project. He or she is in charge of all aspects of the project, including the development of a plan, getting the project started, keeping it on track, and regularly reporting to the sponsor, management, and any other parties that have an interest (i.e., the stakeholders) in how the project is progressing.

When the project sponsor and management agree on the contents of the charter and have chosen an appropriate manager, this constitutes the formal start of the project.

**11.2.2 Planning**

Once the project has been approved to go into the planning phase, the project manager is responsible for developing a detailed project plan based on the project charter. The primary purpose of the **project plan** is to estimate the time, cost, and resources needed to complete the project as it is set out in the project charter. A thorough project plan can increase the likelihood that a project will be successful. It includes a number of components:

• The project scope: What is the overall goal of the project? What is the justification for the project? What are its deliverables? What are the product’s or service’s success criteria?

• The project team: Who will be responsible for carrying out the project? What skill sets are needed?

• A work breakdown structure: What is the nature and scope of each activity in the project? How are the activities related? Who will be responsible for each task

• A project schedule: How much time will each task take? In what sequence will tasks be done? When will each start and finish? What are the major milestones?

• A budget: What are the major cost drivers? What will be the costs, and when will they occur?

• A risk plan: What are the major risks associated with the project? What impact could each risk have? Can these risks be controlled? If so, how?

• A communications plan: What aspects of the project should be communicated? When and to whom should project updates be given?

The project plan will contain all the information the project manager will need to determine whether the project should continue to the next phase. Part of this decision will be based on a detailed economic evaluation, now possible because the resources needed for the project have been identified. The methods discussed in Chapters 4 through 10 are appropriate tools for the economic evaluation. The project manager is responsible for communicating the results of the economic evaluation to the sponsor and to management.

If the evaluation indicates that the project is economically justified, the sponsor usually approves a decision to move into the execution stage.

**11.2.3 Execution**

In this stage, the actual work of the project is done. Execution involves initiating the processes defined in the project plan and carrying through with them so that the project’s objectives are achieved. In this stage, the project manager is responsible for selecting a project team and then coordinating the people and resources necessary to produce the project deliverables. The deliverables are the outputs of the project as defined initially in the project charter and then identified in more detail in the project plan.

**11.2.4 Monitoring and Controlling**

The processes of monitoring and controlling take place throughout the execution stage. By monitoring and controlling a project, the project manager tracks progress so that potential problems can be identified quickly and action taken to correct them. The project manager measures progress against the project plan, and any changes or corrective actions that are taken are aimed at returning to the plan or modifying it in light of new circumstances. Monitoring and controlling activities include carrying out the following activities regularly as work on the project is completed:

• Reviewing the project activities: What is the status of each activity?

• Monitoring the project constraints: Where should we be (compared to the project plan) in terms of project costs, time, and scope?

• Identifying corrective actions: Are there problems or issues with the project? If so, what can be done to get back on track? Does the plan need to be revised?

• Implementing changes: What is the impact of plan changes? How can the changes be managed?

This phase of a project concludes when the project’s goals and objectives have been met. Note that a project could also be terminated prior to coming to a conclusion if priorities change, funds no longer exist, or the project is not meeting its objectives. If goals and objectives have been met, the project moves on to its final stage: closure

**11.2.5 Closure**

Closure occurs when all activities defined in the project charter document have been completed, the project is signed off with the project sponsor, and the project team has been disbanded. A project *closure report* is a helpful tool that documents the conclusion of the project and contains an assessment of how well the project performed against its original goals. It is also a worthwhile document in which to note lessons learned during the project as a learning mechanism for future projects. Finally, the project closure report documents that the sponsor has accepted the final deliverables. The project manager is responsible for developing the project closure report, managing the signoff process, and disbanding the project team.

There is a wide range of tools available to a project manager aimed at supporting all stages of effective project management. For example, there are tools to help structure and sequence the manager’s work and to provide guidance as to what issues need to be addressed at each stage. The tools covered in this section focus primarily on those used in planning a project, as this is the phase in which information gathered is used to analyze project viability.

We will look at three tools: the work breakdown structure (WBS), the Gantt chart, and the critical path method (CPM). The WBS is used to decompose a project into smaller, more manageable activities; the Gantt chart is used to sequence these activities; and CPM is used to schedule and control project activities.

**Project Management tools**

**11.3.1 Work Breakdown Structure**

A **work breakdown structure (**WBS) is used to organize all the work to be done in a project by decomposing the project into successively smaller units. At the lowest level, each unit of work or “**work package**” represents a specific project deliverable. Constructing a WBS helps identify the activities involved in a project and the resources that are necessary to complete each of them. It is also a good tool for recognizing and avoiding potential duplication of activities. As well as being a planning tool, a WBS can be updated over the course of a project, as necessary, to record changes to the plan. A WBS can be represented in a variety of ways. Two common depictions are a diagram that looks much like an organizational chart, and an indented list. In the diagram representation, the topmost level represents the project as a whole. Each successive layer below represents a finer level of detail in the WBS. In an indented list, each successive layer is indented from the layer above. The indented list format is commonly used for complex projects as it can more easily accommodate many thousands of items.

**EXAMPLE 11.1**

This example has to do with construction of a simple beam bridge. A beam bridge consists of a horizontal beam supported at each end by an abutment. A simple example of a beam bridge is a log or wooden plank placed across a stream. If the beam is long enough, it may need intermediate supports called piers.

**11.3.2 Gantt Charts**

A Gantt chart is a graph or bar chart that depicts the timing and sequence of project activities. It was first developed by the pioneering industrial engineer Henry Gantt to help plan and control production of ammunition during World War I. It is one of the simplest and most fundamental project scheduling tools available. A Gantt chart consists of a list of the work items and a diagram indicating when each item starts and ends. The WBS is a good basis to start a Gantt chart, as it estimates the time required to carry out each task but not the schedule of work. A Gantt chart indicates the sequence of activities required to complete a project and includes project milestones such as review and inspection. Once the overall schedule is set up, a project manager can use a Gantt chart to monitor project progress.

**11.3.3 The Critical Path Method**

Managers responsible for planning and controlling large projects have found CPM and PERT to be very helpful. Both are based on a network representation that is able to capture the interdependence of activities not well communicated through a Gantt chart. Although these methods were developed independently, they serve the same general purpose and have many similarities. CPM was initially developed for projects with certain task times that can be crashed, or shortened, through the use of additional resources and offers a method to make cost and time tradeoffs for a project. In contrast, PERT was developed to plan and control projects where task times are assumed to be uncertain. Since their initial use in the 1950s and 1960s, these two methods have evolved. They may be referred to together as PERT/CPM, and the combination draws on the strengths of each. This chapter will focus primarily on the CPM. In both CPM and PERT, project activities are represented by a network of nodes and arcs. In the **“activity on arc,” or AOA,** representation, arcs represent activities and nodes are used to capture interrelationships between activities, as illustrated in Figure 11.3. Figure 11.3 depicts a project with six activities where Activity 1 precedes Activities 2 and 3, Activity 4 follows Activity 2, and Activities 4 and 5 must be completed prior to the start of Activity 6. Activity 1 is represented by an arc connecting two nodes that mark the start and end of Activity 1. Once Activity 1 has been completed, Activities 2 and 3 can begin. Thus the node that represents the end of Activity 1 also represents the start of Activities 2 and 3. Activities 2 and 3 are drawn as two arcs coming from the node that marks the end of Activity 1. Next, since Activity 4 can start once Activity 2 has been completed, an arc denoting Activity 4 is drawn coming out of the node that indicates the end of Activity 2. Similarly, an arc denoting Activity 5 is drawn out of the node marking the end of Activity 3. Finally, since Activity 6 can begin only when both Activities 4 and 5 are done, the nodes marking the end of Activities 4 and 5 are joined together into one node denoting the event that both are completed. Thus Activity 6 is represented as an arc emanating from a single node that represents the end of Activities 4 and 5 (or the start of Activity 6).

**11.3.3.2 Project Crashing and Time–Cost Tradeoffs**

One of the strengths of the CPM method is that it provides managers with a mechanism for examining the possibility of reducing overall project completion time through the application of additional resources. This is referred to as **crashing** a project. Since resources such as overtime, extra equipment, and additional staff generally result in higher costs, project managers need to make a tradeoff between the extra costs associated with crashing and the reduced project completion time.