Unit IV

6 Project Time Management

OPENING CASE

Sue Johnson was the project manager for a consulting company contracted to provide a new online registration system at a local college. This system absolutely had to be operational by May 1, so students could use it to register for the fall semester. Her company's contract had a stiff penalty clause if the system was not ready by then, and Sue and her team would get nice bonuses for doing a good job on this project and meeting the schedule. Sue knew that it was her responsibility to meet the schedule and manage scope, cost, and quality expectations. She and her team developed a detailed schedule and network diagram to help organize the project.

Developing the schedule turned out to be the easy part; keeping the project on track was more difficult. Managing people issues and resolving schedule conflicts were two of the bigger challenges. Many of the customers' employees took unplanned vacations and missed or rescheduled project review meetings. These changes made it difficult for the project team to follow their planned schedule for the system because they had to have customer sign-off at various stages of the systems development life cycle. One senior programmer on Sue's project team quit, and she knew it would take extra time for a new person to get up to speed. It was still early in the project, but Sue knew they were falling behind. What could she do to meet the operational date of May 1?

THE IMPORTANCE OF PROJECT SCHEDULES

Many information technology projects are failures in terms of meeting scope, time, and cost projections. Managers often cite delivering projects on time as one of their biggest challenges and the main cause of conflict.

Perhaps part of the reason schedule problems are so common is that time is easily and simply measured. You can debate scope and cost overruns and make actual numbers appear closer to estimates, but once a project schedule is set, anyone can quickly estimate schedule performance by subtracting the original time estimate from how long it really took to complete the project. People often compare planned and actual project completion times without taking into account approved changes in the project. Time is also the one variable that has the least amount of flexibility. Time passes no matter what happens on a project.

Individual work styles and cultural differences may also cause schedule conflicts. You will learn in Chapter 9, Project Human Resource Management, about the Myers Briggs Type Indicator. One dimension of this team-building tool deals with peoples' attitudes toward structure and deadlines. Some people prefer detailed schedules and emphasize task completion. Others prefer to keep things open and flexible. Different cultures and even entire countries have different attitudes about schedules. For example, some countries close businesses for several hours every afternoon to have siestas. Others countries may have different religious or secular holidays at certain times of the year when not much work will be done. Cultures may also have different perceptions of work ethic—some may value hard work and strict schedules while others may value the ability to remain relaxed and flexible.

With all these possibilities for schedule conflicts, it's important to use good project time management so that project managers can help improve performance in this area. Project time management, simply defined, involves the processes required to ensure timely completion of a project. Achieving timely completion of a project, however, is by no means simple. There are six main processes involved in project time management:

Defn

1. Activity definition involves identifying the specific activities that the project team members and stakeholders must perform to produce the project deliverables. An activity or task is an element of work normally found on the work breakdown structure (WBS) that has an expected duration, a cost, and resource requirements. The main outputs of this process are an activity list, activity attributes, milestone list, and requested changes.
2. Activity sequencing involves identifying and documenting the relationships between project activities. The main outputs of this process include a project schedule network diagram, requested changes, and updates to the activity list and attributes.
3. Activity resource estimating involves estimating how many resources—people, equipment, and materials—a project team should use to perform project activities. The main outputs of this process are activity resource requirements, a resource breakdown structure, requested changes, and updates to activity attributes and resource calendars.
4. Activity duration estimating involves estimating the number of work periods that are needed to complete individual activities. Outputs include activity duration estimates and updates to activity attributes.
5. Schedule development involves analyzing activity sequences, activity resource estimates, and activity duration estimates to create the project schedule. Outputs include a project schedule, schedule model data, a schedule baseline, requested changes, and updates to resources requirements, activity attributes, the project calendar, and the project management plan.
6. Schedule control involves controlling and managing changes to the project schedule. Outputs include performance measurements, requested changes, recommended corrective actions, and updates to the schedule model data, the schedule baseline, organizational process assets, the activity list and attributes, and the project management plan.

Figure 6-1 summarizes these processes and outputs, showing when they occur in a typical project.

You can improve project time management by performing these processes and by using some basic project management tools and techniques. Every manager is familiar with some form of scheduling, but most managers have not used several of the tools and techniques unique to project time management, such as Gantt charts, network diagrams, and critical path analysis.

Planning
Process: **Activity definition**
Outputs: Activity list, activity attributes, milestone list, requested changes
Process: **Activity sequencing**
Outputs: Project schedule network diagram, requested changes, updates to the activity list and attributes
Process: **Activity resource estimating**
Outputs: Activity resource requirements, resource breakdown structure requested changes, and updates to activity attributes resource calendars
Process: **Activity duration estimating**
Outputs: Activity duration estimates, updates to activity attributes
Process: **Schedule development**
Outputs: Project schedule, schedule model data, schedule baseline, requested changes, and updates to resource requirements, activity attributes, the project calendar, project management plan

Monitoring and Controlling
Process: **Schedule control**
Outputs: Performance measurements, requested changes, recommended corrective actions, and updates to the schedule model data, schedule baseline, organizational process assets, activity list and attributes, the project management plan

Project Start → **Project Finish**

Figure 6-1. Project Time Management Summary

ACTIVITY DEFINITION

Project schedules grow out of the basic documents that initiate a project. The project charter often mentions planned project start and end dates, which serve as the starting points for a more detailed schedule. The project manager starts with the project charter and develops a project scope statement and WBS, as discussed in Chapter 5, Project Scope Management. The project charter should also include some estimate of how much money will be allocated to the project. Using this information with the scope statement, WBS, WBS dictionary, project management plan, and information on organizational process assets, the project manager and project team begin developing a detailed list of activities and their attributes, a milestone list, and requested changes, if applicable.

The activity list is a tabulation of activities to be included on a project schedule. The list should include the activity name, an activity identifier or number, and a brief description of the activity. The activity attributes provide more schedule-related information about each activity, such as predecessors, successors, logical relationships, leads and lags, resource requirements, constraints, imposed dates, and assumptions related to the activity. The activity list and activity attributes should be in agreement with the WBS and WBS dictionary. Information is added to the activity attributes as it becomes available, such as logical relationships and resource requirements that are determined in later processes. Many project teams use an automated system to keep track of all of this activity-related information.

A milestone on a project is a significant event that normally has no duration. It often takes several activities and a lot of work to complete a milestone, but the milestone itself is like a marker to help in identifying necessary activities. Milestones are also useful tools for setting schedule goals and monitoring progress. For example, milestones on a project like the one in the opening case might include completion and customer sign-off of documents, such as design documents and test plans; completion of specific products, such as software modules or installation of new hardware; and completion of important process-related work, such as project review meetings, tests, and so on. Not every deliverable or output created for a project is really a milestone. Milestones are the most important and visible ones. For example, the term milestone is used in several contexts, such as in child development. Parents and doctors check for milestones, such as a child first rolling over, sitting, crawling, walking, talking, and so on. You will learn more about milestones later in this chapter.

Activity information is a required input to the other time management processes. You cannot determine activity sequencing, resources, or durations, develop the schedule, or control the schedule until you have a good understanding of project activities.

Recall the triple constraint of project management—balancing scope, time, and cost goals—and note the order of these items. Ideally, the project team and key stakeholders first define the project scope, then the time or schedule for the project, and then the project's cost. The order of these three items reflects the basic order of the first four processes in project time management: activity definition (further defining the scope), activity sequencing (further defining the time), and activity resource and activity duration estimating (further defining the time and cost). These four project time management processes are the basis for creating a project schedule.

The goal of the activity definition process is to ensure that the project team has complete understanding of all the work they must do as part of the project scope so they can start scheduling the work. For example, a WBS item might be "Produce study report." The project team would have to understand what that means before they can make schedule-related decisions. How long should the report be? Does it require a survey or extensive research to produce it? What skill level does the report writer need to have? Further defining that task will help the project team determine how long it will take to do and who should do it.

The WBS is often dissected further during the activity definition process as the project team members further define the activities required for performing the work. For example, the task "Produce study report" might be broken down into several subtasks describing the steps involved in producing the report, such as developing a survey, administering the survey, analyzing the survey results, performing research, writing a draft report, editing the report, and finally producing the report.

As stated earlier, activities or tasks are elements of work performed during the course of a project; they have expected durations, costs, and resource requirements. Activity definition also results in supporting detail to document important product information as well as assumptions and constraints related to specific activities. The project team should review the activity list and activity attributes with project stakeholders before moving on to the next step in project time management. If they do not review these items, they could produce an unrealistic schedule and deliver unacceptable results. For example, if a project manager simply estimated that it would take one day for the "Produce study report" task and had an intern or trainee write a 10-page report to complete that task, the result could be a furious customer who expected extensive research, surveys, and a 100-page report. Clearly defining the work is crucial to all projects. If there are misunderstandings about activities, then requested changes may be required.

In the opening case, Sue Johnson and her project team had a contract and detailed specifications for the college's new online registration system. They also had to focus on meeting the May 1 date for an operational system so the college could start using the new system for the new semester's registration. To develop a project schedule, Sue and her team had to review the contract, detailed specifications, and desired operational date, create an activity list, activity attributes, and milestone list. After developing more detailed definitions of project activities, Sue and her team would review them with their customers to ensure that they were on the right track.

ACTIVITY SEQUENCING

After defining project activities, the next step in project time management is activity sequencing. Activity sequencing involves reviewing the activity list and attributes, project scope statement, milestone list, and approved change requests to determine the relationships between activities. It also involves evaluating the reasons for dependencies and the different types of dependencies.

Dependencies

A dependency or relationship relates to the sequencing of project activities or tasks. For example, does a certain activity have to be finished before another one can start? Can the project team do several activities in parallel? Can some overlap? Determining these relationships or dependencies between activities has a significant impact on developing and managing a project schedule.

There are three basic reasons for creating dependencies among project activities:

1 ■ Mandatory dependencies are inherent in the nature of the work being performed on a project. They are sometimes referred to as hard logic. For example, you cannot test code until after the code is written.

2 ■ Discretionary dependencies are defined by the project team. For example, a project team might follow good practice and not start the detailed design of a new information system until the users sign off on all of the analysis work. Discretionary dependencies are sometimes referred to as soft logic and should be used with care since they may limit later scheduling options. M D E

3 ■ External dependencies involve relationships between project and non-project activities. The installation of a new operating system and other software may depend on delivery of new hardware from an external supplier. Even though the delivery of the new hardware may not be in the scope of the project, you should add an external dependency to it because late delivery will affect the project schedule.

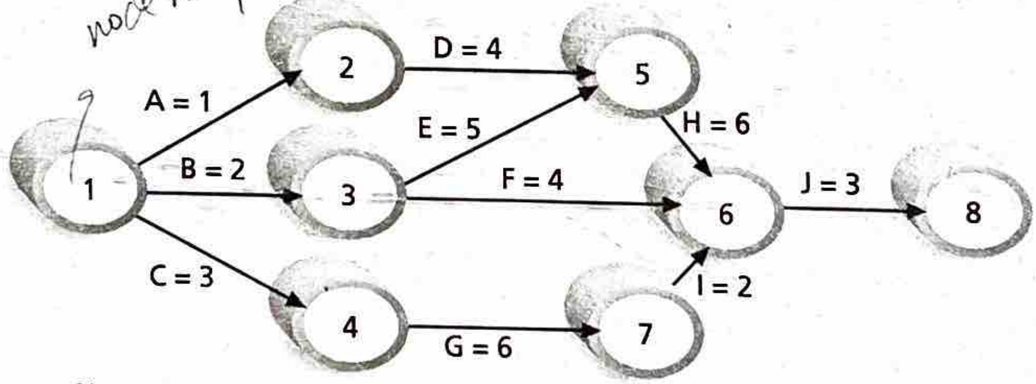
As with activity definition, it is important that project stakeholders work together to define the activity dependencies that exist on their project. If you do not define the sequence of activities, you cannot use some of the most powerful schedule tools available to project managers: network diagrams and critical path analysis.

Network Diagrams

→ AOA/ADM (Arrow Diagraming Method / Activity on arrow)
→ PDM (Precedence Diagraming method)

Network diagrams are the preferred technique for showing activity sequencing. A network diagram is a schematic display of the logical relationships among, or sequencing of, project activities. Some people refer to network diagrams as project schedule network diagrams or PERT charts. PERT is described later in this chapter. Figure 6-2 shows a sample network diagram for Project X, which uses the arrow diagramming method (ADM) or activity-on-arrow (AOA) approach.

node no: P



Note: Assume all durations are in days; A=1 means Activity A has a duration of 1 day.

Figure 6-2. Activity-on-Arrow (AOA) Network Diagram for Project X

Note the main elements on this network diagram. The letters A through J represent activities with dependencies that are required to complete the project. These activities come from the WBS and activity definition process described earlier. The arrows represent the activity sequencing or relationships between tasks. For example, Activity A must be done before Activity D; Activity D must be done before Activity H, and so on.

The format of this network diagram uses the activity-on-arrow (AOA) approach or the arrow diagramming method (ADM)—a network diagramming technique in which activities are represented by arrows and connected at points called nodes to illustrate the sequence of activities. A node is simply the starting and ending point of an activity. The first node signifies the start of a project, and the last node represents the end of a project.

Keep in mind that the network diagram represents activities that must be done to complete the project. It is not a race to get from the first node to the last node. *Every* activity on the network diagram must be completed in order for the project to finish. It is also important to note that not every single item on the WBS needs to be on the network diagram; only activities with dependencies need to be shown on the network diagram. However, some people like to have start and end milestones and to list every activity. It is a matter of preference. For projects with hundreds of activities, it might be simpler to include only activities with dependencies on a network diagram, especially on large projects. Sometimes it is enough to put summary tasks on a network diagram or to break down the project into several smaller network diagrams.

Assuming you have a list of the project activities and their start and finish nodes, follow these steps to create an AOA network diagram:

step1

1. Find all of the activities that start at Node 1. Draw their finish nodes, and draw arrows between Node 1 and each of those finish nodes. Put the activity letter or name on the associated arrow. If you have a duration estimate, write that next to the activity letter or name, as shown in Figure 6-2. For example, A = 1 means that the duration of Activity A is one day, week, or other standard unit of time. Also be sure to put arrowheads on all arrows to signify the direction of the relationships.

step2

2. Continue drawing the network diagram, working from left to right. Look for bursts and merges. Bursts occur when two or more activities follow a single node. A merge occurs when two or more nodes precede a single node. For example, in Figure 6-2, Node 1 is a burst since it goes into Nodes 2, 3, and 4. Node 5 is a merge preceded by Nodes 2 and 3.

step3

3. Continue drawing the AOA network diagram until all activities are included on the diagram.

step4

4. As a rule of thumb, all arrowheads should face toward the right, and no arrows should cross on an AOA network diagram. You may need to redraw the diagram to make it look presentable.

Even though AOA or ADM network diagrams are generally easy to understand and create, a different method is more commonly used: the precedence diagramming method. The precedence diagramming method (PDM) is a network diagramming technique in which boxes represent activities. It is particularly useful for visualizing certain types of time relationships.

Figure 6-3 illustrates the types of dependencies that can occur among project activities. After you determine the reason for a dependency between activities (mandatory, discretionary, or external), you must determine the type of dependency. Note that the terms activity and task are used interchangeably, as are relationship and dependency. See Appendix A to learn how to create dependencies in Microsoft Project 2007. The four types of dependencies or relationships between activities include:

- **Finish-to-start:** a relationship where the "from" activity or predecessor must finish before the "to" activity or successor can start. For example, you cannot provide user training until after software, or a new system, has been installed. Finish-to-start is the most common type of relationship, or dependency, and AOA network diagrams use only finish-to-start dependencies.

- **Start-to-start:** a relationship in which the "from" activity cannot start until the "to" activity or successor is started. For example, on several information technology projects, a group of activities all start simultaneously, such as the many tasks that occur when a new system goes live.
- **Finish-to-finish:** a relationship where the "from" activity must be finished before the "to" activity can be finished. One task cannot finish before another finishes. For example, quality control efforts cannot finish before production finishes, although the two activities can be performed at the same time.
- **Start-to-finish:** a relationship where the "from" activity must start before the "to" activity can be finished. This type of relationship is rarely used, but it is appropriate in some cases. For example, an organization might strive to stock raw materials just in time for the manufacturing process to begin. A delay in the manufacturing process starting should delay completion of stocking the raw materials. Another example would be a babysitter who wants to finish watching a young child but is dependent on the parent arriving. The parent must show up or "start" before the babysitter can finish his or her oversight.

FS
SS
FF
SF

Task dependencies

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

TA TB

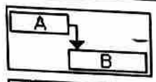
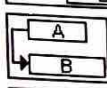
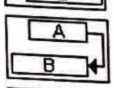
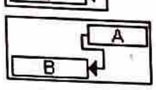
Task dependency	Example	Description
Finish-to-start (FS)		Task (B) cannot start until task (A) finishes.
Start-to-start (SS)		Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)		Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)		Task (B) cannot finish until task (A)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

Figure 6-3. Task Dependency Types

Figure 6-4 illustrates Project X using the precedence diagramming method. Notice that the activities are placed inside boxes, which represent the nodes on this diagram. Arrows show the relationships between activities. This figure was created using Microsoft Project, which automatically places additional information inside each node. Each task box includes the start and finish date, labeled Start and Finish, the task ID number, labeled ID, the task's duration, labeled Dur, and the names of resources, if any, assigned to the task, labeled Res. The border of the boxes for tasks on the critical path appears automatically in red in the Microsoft Project network diagram view. In Figure 6-4, the boxes for critical tasks have a thicker border.

The precedence diagramming method is used more often than AOA network diagrams and offers a number of advantages over the AOA technique. First, most project management software uses the precedence diagramming method. Second, the precedence diagramming method avoids the need to use dummy activities. Dummy activities have no duration and no resources but are occasionally needed on AOA network diagrams to show logical relationships between activities. They are represented with dashed arrow lines, and have zero for the duration estimate. Third, the precedence diagramming method shows different dependencies among tasks, whereas AOA network diagrams use only finish-to-start dependencies. You will learn more about activity sequencing using Project 2007 in Appendix A.

Adv of PDM over AOA

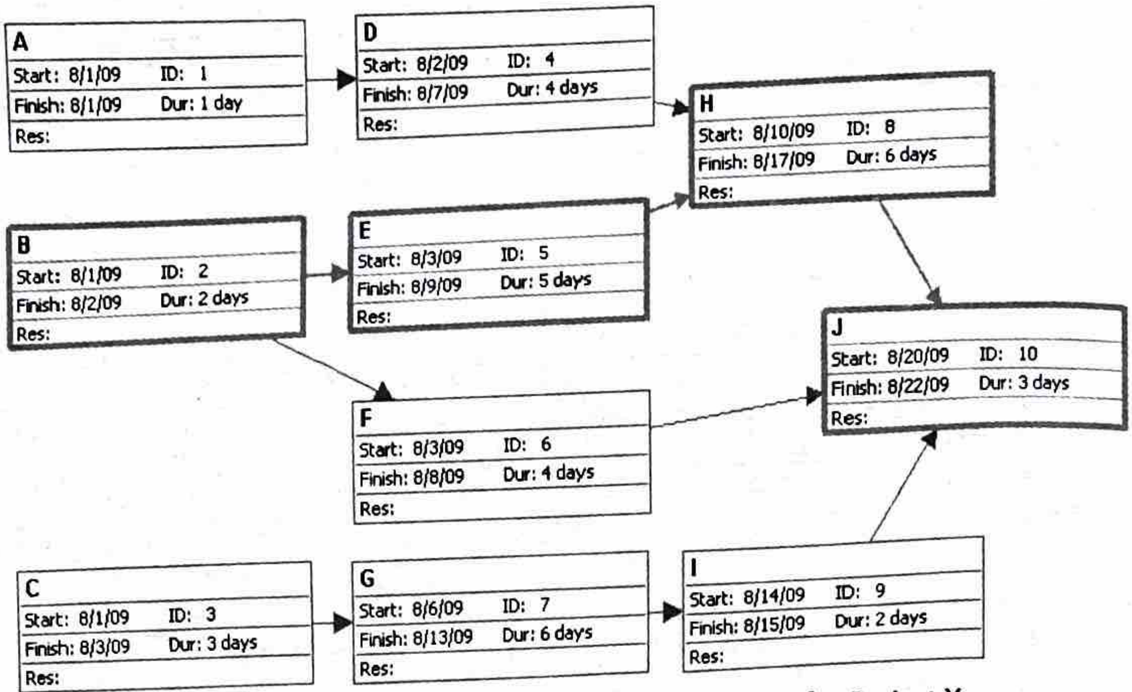


Figure 6-4. Precedence Diagramming Method (PDM) Network Diagram for Project X

ACTIVITY RESOURCE ESTIMATING

Before you can estimate the duration for each activity, you must have a good idea of the quantity and type of resources (people, equipment, and materials) that will be assigned to each activity. The nature of the project and the organization will affect resource estimating. Expert judgment, the availability of alternatives, and estimating data and software (discussed in more detail in Chapter 7, Project Cost Management) are tools available to assist in resource estimating. It is important that the people who help determine what resources are necessary include people who have experience and expertise in similar projects and with the organization performing the project.

Important questions to answer in activity resource estimating include:

IMP FACTORS:

- How difficult will it be to do specific activities on this project?
- Is there anything unique in the project's scope statement that will affect resources?
- What is the organization's history in doing similar activities? Has the organization done similar tasks before? What level of personnel did the work?
- Does the organization have people, equipment, and materials that are capable and available for performing the work? Are there any organizational policies that might affect the availability of resources?
- Does the organization need to acquire more resources to accomplish the work? Would it make sense to outsource some of the work? Will outsourcing increase or decrease the amount of resources needed and when they'll be available?

A project's activity list, activity attributes, project management plan, enterprise environmental factors, organizational process assets (such as policies regarding staffing and outsourcing), and resource availability information are all important input to answering these questions. During the early phases of a project, the project team may not know which specific people, equipment, and materials will be available. For example, they might know from past projects that there will be a mix of experienced and inexperienced programmers working on a project. They might also have information available that approximates the number of people or hours it normally takes to perform specific activities.

It is important to thoroughly brainstorm and evaluate alternatives related to resources, especially on projects that involve people from multiple disciplines and companies. Since most projects involve many human resources and the majority of costs are for salaries and benefits, it is often effective to solicit ideas from different people to help develop alternatives and address resource-related issues early in a project. The resource estimates should also be updated as more detailed information becomes available.

The main outputs of the resource estimating process include a list of activity resource requirements, a resource breakdown structure, requested changes, and updates to the activity attributes and resource calendars, if needed. For example, if junior employees will be assigned to many activities, the project manager might request that additional activities, time, and resources be approved to help train and mentor those employees. In addition to providing the basis for activity duration estimating, activity resource estimating provides vital information for project cost estimating (Chapter 7), project human resource management (Chapter 9), project communications management (Chapter 10), project risk management (Chapter 11), and project procurement management (Chapter 12). For example, a resource breakdown structure is a hierarchical structure that identifies the project's resources by category and type. Resource categories might include analysts, programmers, and testers. Under programmers, there might be types of programmers, such as Java programmers or COBOL programmers. This information would be helpful in determining resource costs, acquiring resources, and so on.

ACTIVITY DURATION ESTIMATING

After working with key stakeholders to define activities, determine their dependencies, and estimate their resources, the next process in project time management is to estimate the duration of activities. It is important to note that duration includes the actual amount of time worked on an activity *plus* elapsed time. For example, even though it might take one workweek or five workdays to do the actual work, the duration estimate might be two weeks to allow extra time needed to obtain outside information. The resources assigned to a task will also affect the task duration estimate. Do not confuse duration with effort, which is the number of workdays or work hours required to complete a task. A duration estimate of one day could be based on eight hours of work or eighty hours of work. Duration relates to the time estimate, not the effort estimate. Of course, the two are related, so project team members must document their assumptions when creating duration estimates and update the estimates as the project progresses. The people who will actually do the work, in particular, should have a lot of say in these duration estimates, since they are the ones whose performance will be evaluated on meeting them. If scope changes occur on the project, the duration estimates should be updated to reflect those changes. It is also helpful to review similar projects and seek the advice of experts in estimating activity durations.

There are several inputs to activity duration estimating. Enterprise environmental factors, organizational process assets, the project scope statement, activity list, activity attributes, activity resource requirements, resource calendars, and the project management plan all include information that affect duration estimates. In addition to reviewing past project information, the team should also review the accuracy of the duration estimates thus far on the project. For example, if they find that all of their estimates have been much too long or short, the team should update the estimates to reflect what they have learned. One of the most important considerations in making activity duration estimates is the availability of resources, especially human resources. What specific skills do people need to do the work? What are the skill levels of the people assigned to the project? How many people are expected to be available to work on the project at any one time?

The outputs of activity duration estimating include updates to the activity attributes, if needed, and duration estimates for each activity. Duration estimates are often provided as a discrete number, such as four weeks, or as a range, such as three to five weeks, or as a three-point estimate. A three-point estimate is an estimate that includes an optimistic, most likely, and pessimistic estimate, such as three weeks for the optimistic, four weeks for the most likely, and five weeks for the pessimistic estimate. The optimistic estimate is based on a best-case scenario, while the pessimistic estimate is based on a worst-case scenario. The most likely estimate, as it sounds, is an estimate based on a most likely or expected scenario. A three-point estimate is required for performing PERT estimates, as described later in this chapter, and for performing Monte Carlo simulations, described in Chapter 11, Project Risk Management. Other duration estimating techniques include analogous and parametric estimating and reserve analysis, as described in Chapter 7, Project Cost Management. Expert judgment is also an important tool for developing good activity duration estimates.

SCHEDULE DEVELOPMENT

Schedule development uses the results of all the preceding project time management processes to determine the start and end dates of the project. There are often several iterations of all the project time management processes before a project schedule is finalized. The ultimate goal of schedule development is to create a realistic project schedule that provides a basis for monitoring project progress for the time dimension of the project. The main outputs of this process are the project schedule, schedule model data, a schedule baseline, requested changes, and updates to resource requirements, activity attributes, the project calendar, and the project management plan. Some project teams create a computerized model to create a network diagram, enter resource requirements and availability by time period, and adjust other information to quickly generate alternative schedules. See Appendix A for information on using Project 2007 to assist in schedule development.

Several tools and techniques assist in the schedule development process:

1 ■ A Gantt chart is a common tool for displaying project schedule information.
2 ■ Critical path analysis is a very important tool for developing and controlling project schedules.
3 ■ Critical chain scheduling is a technique that focuses on limited resources when creating a project schedule.
4 ■ PERT analysis is a means for considering schedule risk on projects.

The following section provides samples of each of these tools and techniques and discusses their advantages and disadvantages. (See the *PMBOK® Guide Third Edition* to learn how these main techniques and others are broken into additional categories.)

1 Gantt Charts

Gantt charts provide a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in a calendar format. Gantt charts are sometimes referred to as bar charts since the activities' start and end dates are shown as horizontal bars. Figure 6-5 shows a simple Gantt chart for Project X created with Microsoft Project. Figure 6-6 shows a Gantt chart that is more sophisticated based on a software launch project. Recall that the activities on the Gantt chart should coincide with the activities on the WBS, which should coincide with the activity list and milestone list. Notice that the software launch project's Gantt chart contains milestones, summary tasks, individual task durations, and arrows showing task dependencies.

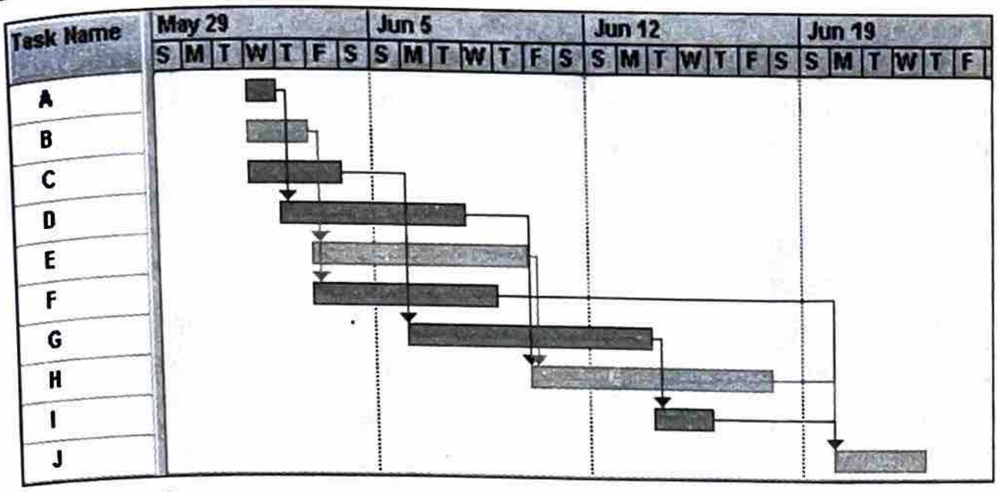


Figure 6-5. Gantt Chart for Project X

Notice the different symbols on the software launch project's Gantt chart (Figure 6-6):

- The black diamond symbol represents a milestone. In Figure 6-6, Task 1, "Marketing Plan distributed," is a milestone that occurs on March 17. Tasks 3, 4, 8, 9, 14, 25, 27, 43, and 45 are also milestones. For very large projects, top managers might want to see only milestones on a Gantt chart. Microsoft Project allows you to filter information displayed on a Gantt chart so you can easily show specific tasks, such as milestones.

black – milestone

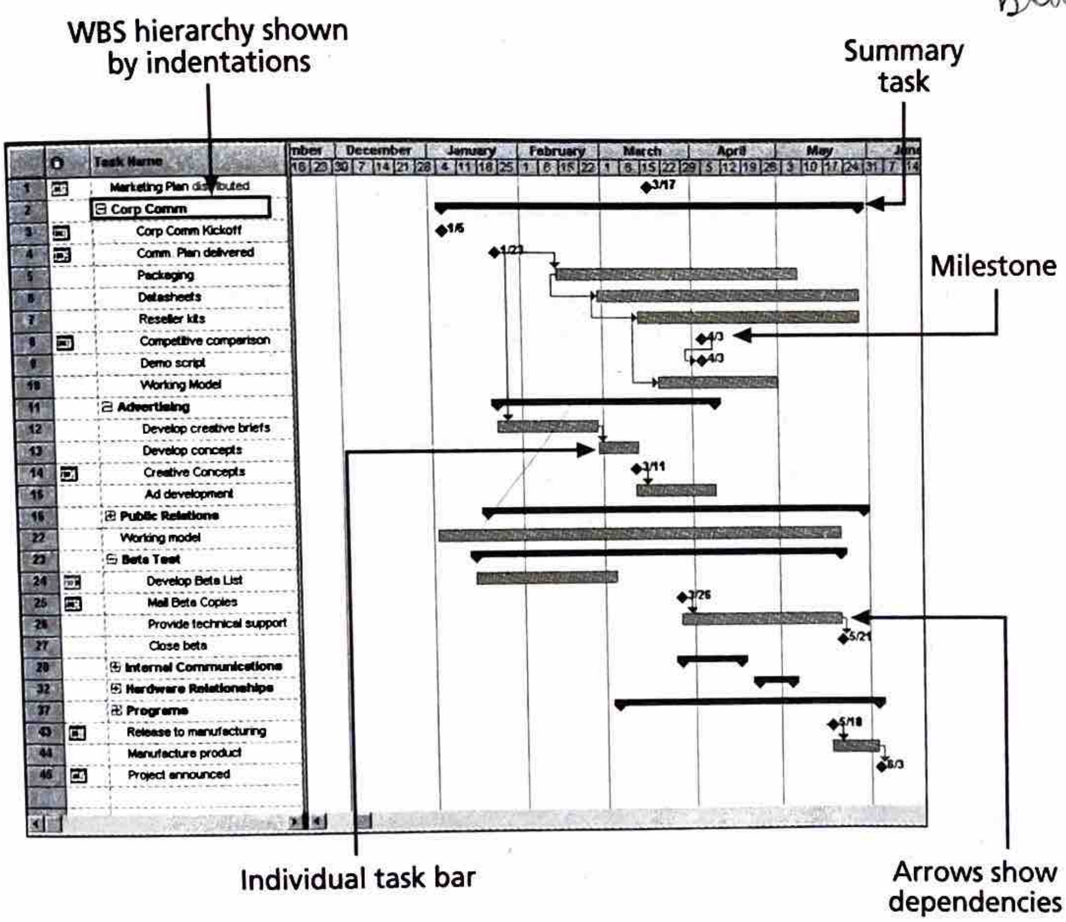


Figure 6-6. Gantt Chart for Software Launch Project

- The thick black bars with arrows at the beginning and end represent summary tasks. For example, Activities 12 through 15—"Develop creative briefs," "Develop concepts," "Creative concepts," and "Ad development"—are all subtasks of the summary task called "Advertising," Task 11. WBS activities are referred to as tasks and subtasks in most project management software.
- The light gray horizontal bars such as those found in Figure 6-6 for Tasks 5, 6, 7, 10, 12, 13, 15, 22, 24, 26, and 44, represent the duration of each individual task. For example, the light gray bar for Subtask 5, "Packaging," starts in mid-February and extends until early May.
- Arrows connecting these symbols show relationships or dependencies between tasks. Gantt charts often do not show dependencies, which is their major disadvantage. If dependencies have been established in Microsoft Project, they are automatically displayed on the Gantt chart.

Adding Milestones to Gantt Charts

Milestones can be a particularly important part of schedules, especially for large projects. Many people like to focus on meeting milestones, so you can create milestones to emphasize important events or accomplishments on projects. Normally, you create milestones by entering tasks with zero duration. In Microsoft Project, you can also mark any task as a milestone by checking the appropriate box in the Advanced tab of the Task Information dialog box. The duration of the task will not change to zero, but the Gantt chart will show the milestone symbol to represent that task based on is start date. See Appendix A for more information.

To make milestones meaningful, some people use the SMART criteria to help define them. The SMART criteria are guidelines suggesting that milestones should be:

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

For example, distributing a marketing plan is specific, measurable, and assignable if everyone knows what should be in the marketing plan, how it should be distributed, how many copies should be distributed and to whom, and who is responsible for the actual delivery. Distributing the marketing plan is realistic and able to be time-framed if it is an achievable event and scheduled at an appropriate time.

Best Practice

Schedule risk is inherent in the development of complex systems. Luc Richard, the founder of *www.projectmangler.com*, suggests that project managers can reduce schedule risk through project milestones, a best practice that involves identifying and tracking significant points or achievements in the project. The five key points of using project milestones include the following:

1. Define milestones early in the project and include them in the Gantt chart to provide a visual guide.
2. Keep milestones small and frequent.
3. The set of milestones must be all-encompassing.
4. Each milestone must be binary, meaning it is either complete or incomplete.
5. Carefully monitor the critical path.

Additional best practices Richard recommends for software development projects include the following:

- Monitor the project's progress and revise the plan.
- Build on a solid base; that means developing a system with less than a .1 percent defect rate.
- Assign the right people to the right tasks. Put the best developers on the critical tasks.
- Start with high-risk tasks.
- "Don't boil the ocean." In other words, if the entire project consists of high-risk tasks, then the project itself is high-risk and bound for failure.
- Integrate early and often, and follow practices like the daily build process.[1] (A daily build involves compiling the latest version of a software program each day to ensure that all required dependencies are present and that the program is tested to avoid introducing new bugs.)

baseline

Using Tracking Gantt Charts to Compare Planned and Actual Dates

You can use a special form of a Gantt chart to evaluate progress on a project by showing actual schedule information. Figure 6-7 shows a Tracking Gantt chart—a Gantt chart that compares planned and actual project schedule information. The planned schedule dates for activities are called the baseline dates, and the entire approved planned schedule is called the schedule baseline. The Tracking Gantt chart includes columns (hidden in Figure 6-7) labeled "Start" and "Finish" to represent actual start and finish dates for each task, as well as columns labeled "Baseline Start" and "Baseline Finish" to represent planned start and finish dates for each task. In this example, the project is completed, but several tasks missed their planned start and finish dates.

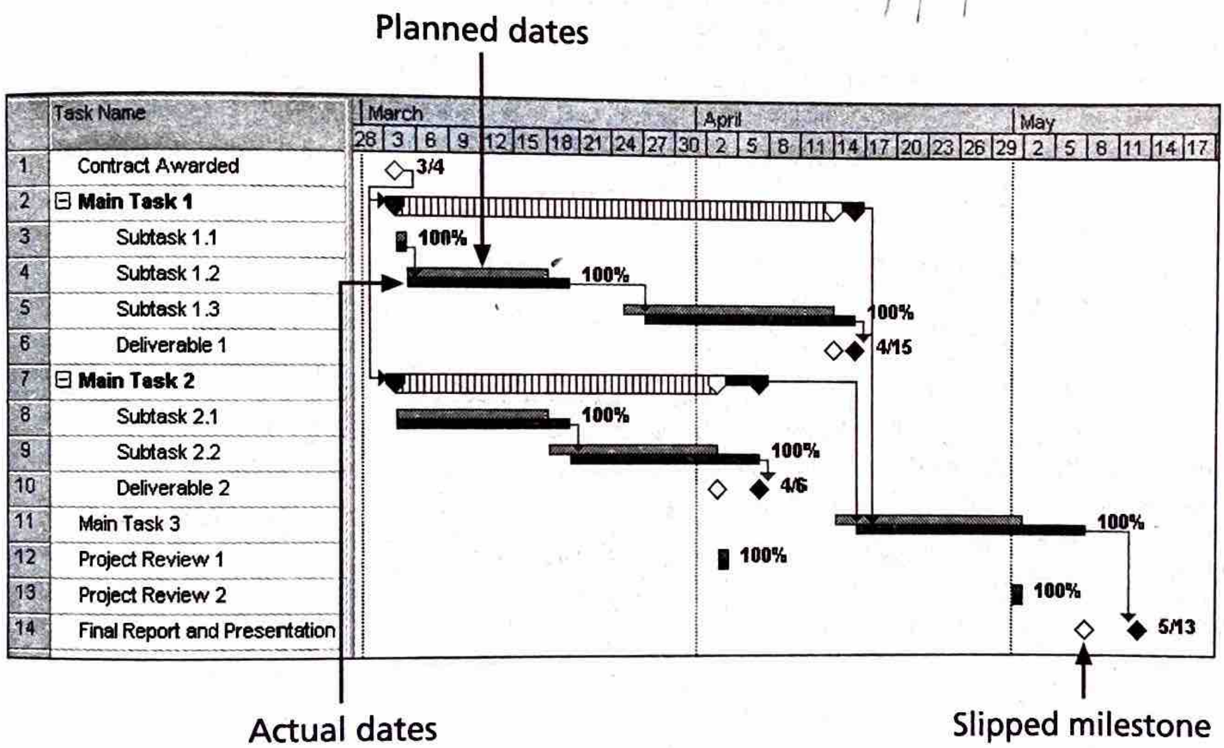


Figure 6-7. Sample Tracking Gantt Chart

To serve as a progress evaluation tool, a Tracking Gantt chart uses a few additional symbols:

- Notice that the Gantt chart in Figure 6-7 often shows two horizontal bars for tasks. The top horizontal bar represents the planned or baseline duration for each task. The bar below it represents the actual duration. Subtasks 1.2 and 1.3 illustrate this type of display. If these two bars are the same length, and start and end on the same dates, then the actual schedule was the same as the planned schedule for that task. This scheduling occurred for Subtask 1.1, where the task started and ended as planned on March 4. If the bars do not start and end on the same dates, then the actual schedule differed from the planned or baseline schedule. If the top horizontal bar is shorter than the bottom one, the task took longer than planned, as you can see for Subtask 1.2. If the top horizontal bar is longer than the bottom one, the task took less time than planned. A striped horizontal bar, illustrated by Main Tasks 1 and 2, represents the planned duration for summary tasks. The black bar adjoining it shows progress for summary tasks. For example, Main Task 2 clearly shows the actual duration took longer than what was planned.
- A white diamond on the Tracking Gantt chart represents a slipped milestone. A slipped milestone means the milestone activity was actually completed later than originally planned. For example, the last task provides an example of a slipped milestone since the final report and presentation were completed later than planned.
- Percentages to the right of the horizontal bars display the percentage of work completed for each task. For example, 100 percent means the task is finished, 50 percent means the task is still in progress and is 50 percent completed.

A Tracking Gantt chart is based on the percentage of work completed for project tasks or the actual start and finish dates. It allows the project manager to monitor schedule progress on individual tasks and the whole project. For example, Figure 6-7 shows that this project is completed. It started on time, but it finished a little late, on May 13 (5/13) versus May 8.

The main advantage of using Gantt charts is that they provide a standard format for displaying planned and actual project schedule information. In addition, they are easy to create and understand. The main disadvantage of Gantt charts is that they do not *usually* show relationships or dependencies between tasks. If Gantt charts are created using project management software and tasks are linked, then the dependencies *will* be displayed, but differently than they would be displayed on a network diagram. However, whether you prefer viewing dependencies on a Gantt chart or network diagram is a matter of personal preference.

Critical Path Method

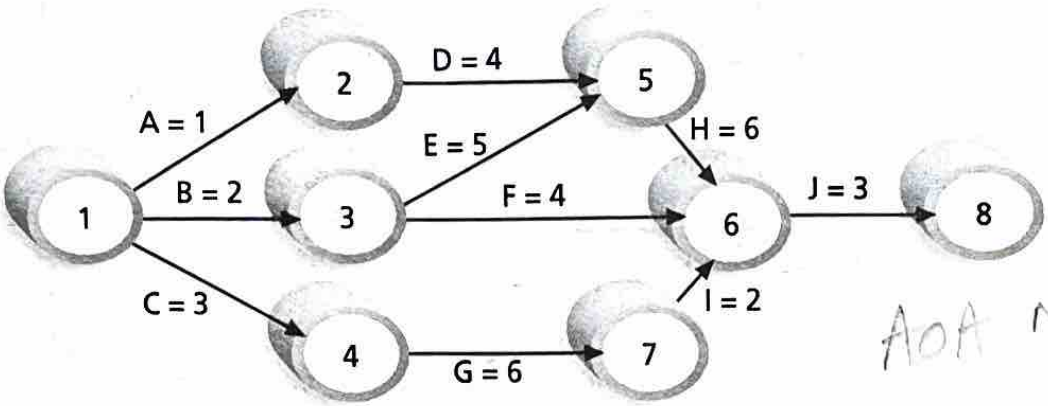
Analysis

Many projects fail to meet schedule expectations. Critical path method (CPM)—also called critical path analysis—is a network diagramming technique used to predict total project duration. This important tool will help you combat project schedule overruns. A critical path for a project is the series of activities that determine the *earliest* time by which the project can be completed. It is the *longest* path through the network diagram and has the least amount of slack or float. Slack or float is the amount of time an activity may be delayed without delaying a succeeding activity or the project finish date. There are normally several tasks done in parallel on projects, and most projects have multiple paths through a network diagram. The longest path or path containing the critical tasks is what is driving the completion date for the project. You are not finished with the project until you have finished *all* the tasks.

Calculating the Critical Path

To find the critical path for a project, you must first develop a good network diagram, which, in turn, requires a good activity list based on the WBS. Once you create a network diagram, you must also estimate the duration of each activity to determine the critical path. Calculating the critical path involves adding the durations for all activities on each path through the network diagram. The longest path is the critical path.

Figure 6-8 shows the AOA network diagram for Project X again. Note that you can use either the AOA or precedence diagramming method to determine the critical path on projects. Figure 6-8 shows all of the paths—a total of four—through the network diagram. Note that each path starts at the first node (1) and ends at the last node (8) on the AOA network diagram. This figure also shows the length or total duration of each path through the network diagram. These lengths are computed by adding the durations of each activity on the path. Since path B-E-H-J at 16 days has the longest duration, it is the critical path for the project.



AOA N/w dgm

Note: Assume all durations are in days.

Path 1:	A-D-H-J	Length = 1+4+6+3 = 14 days
Path 2:	B-E-H-J	Length = 2+5+6+3 = 16 days
Path 3:	B-F-J	Length = 2+4+3 = 9 days
Path 4:	C-G-I-J	Length = 3+6+2+3 = 14 days

Since the critical path is the longest path through the network diagram, Path 2, B-E-H-J, is the critical path for Project X.

Figure 6-8. Determining the Critical Path for Project X

What does the critical path really mean? The critical path shows the shortest time in which a project can be completed. Even though the critical path is the *longest* path, it represents the *shortest* time it takes to complete a project. If one or more of the activities on the critical path takes longer than planned, the whole project schedule will slip *unless* the project manager takes corrective action.

Project teams can be creative in managing the critical path. For example, Joan Knutson, a well-known author and speaker in the project management field, often describes how a gorilla helped Apple computer complete a project on time. Team members worked in an area with cubicles, and whoever was in charge of a task currently on the critical path had a big, stuffed gorilla on top of his or her cubicle. Everyone knew that person was under the most time pressure, so they tried not to distract him or her. When a critical task was completed, the person in charge of the next critical task received the gorilla.

Growing Grass Can Be on the Critical Path

– time dim

People are often confused about what the critical path is for a project or what it really means. Some people think the critical path includes the most critical activities. However, the critical path is concerned only with the time dimension of a project. The fact that its name includes the word *critical* does not mean that it includes all critical activities. For example, Frank Addeman, Executive Project Director at Walt Disney

Imagineering, explained in a keynote address at the May 2000 PMI-ISSIG Professional Development Seminar that growing grass was on the critical path for building Disney's Animal Kingdom theme park! This 500-acre park required special grass for its animal inhabitants, and some of the grass took years to grow. Another misconception is that the critical path is the shortest path through the network diagram. In some areas, such as transportation modeling, similar network diagrams are drawn in which identifying the shortest path is the goal. For a project, however, each task or activity must be done in order to complete the project. It is not a matter of choosing the shortest path.

Other aspects of critical path analysis may cause confusion. Can there be more than one critical path on a project? Does the critical path ever change? In the Project X example, suppose that Activity A has a duration estimate of three days instead of one day. This new duration estimate would make the length of Path 1 equal to sixteen days. Now the project has two longest paths of equal duration, so there are two critical paths. Therefore, there *can* be more than one critical path on a project. Project managers should closely monitor performance of activities on the critical path to avoid late project completion. If there is more than one critical path, project managers must keep their eyes on all of them.

The critical path on a project can change as the project progresses. For example, suppose everything is going as planned at the beginning of the project. In this example, suppose Activities A, B, C, D, E, F, and G all start and finish as planned. Then suppose Activity I runs into problems. If Activity I takes more than four days, it will cause path C-G-I-J to be longer than the other paths, assuming they progress as planned. This change would cause path C-G-I-J to become the new critical path. Therefore, the critical path can change on a project.

Using Critical Path Analysis to Make Schedule Trade-Offs

It is important to know what the critical path is throughout the life of a project so the product manager can make trade-offs. If the project manager knows that one of the tasks on the critical path is behind schedule, he or she needs to decide what to do about it. Should the schedule be renegotiated with stakeholders? Should more resources be allocated to other items on the critical path to make up for that time? Is it okay if the project finishes behind schedule? By keeping track of the critical path, the project manager and his or her team take a proactive role in managing the project schedule.

A technique that can help project managers make schedule trade-offs is determining the free slack and total slack for each project activity. Free slack or free float is the amount of time an activity can be delayed without delaying the early start date of any immediately following activities. The early start date for an activity is the earliest possible time an activity can start based on the project network logic. Total slack or total float is the amount of time an activity can be delayed from its early start without delaying the planned project finish date.

Project managers calculate free slack and total slack by doing a forward and backward pass through a network diagram. A forward pass determines the early start and early finish dates for each activity. The early finish date for an activity is the earliest possible time an activity can finish based on the project network logic. The project start date is equal to the early start date for the first network diagram activity. Early start plus the duration of the first activity is equal to the early finish date of the first activity. It is also equal to the early start date of each subsequent activity unless an activity has multiple predecessors. When an activity has multiple predecessors, its early start date is the latest of the early finish dates of those predecessors. For example, Tasks D and E immediately precede Task H in Figure 6-8. The early start date for Task H, therefore, is the early finish date of Task E, since it occurs later than the early finish date of Task D. A backward pass through the network diagram determines the late start and late finish dates for each activity in a similar fashion. The late start date for an activity is the latest possible time an activity might begin without delaying the project finish date. The late finish date for an activity is the latest possible time an activity can be completed without delaying the project finish date.