Reducing Project Duration

In skating over thin ice our safety is in our speed
—Ralph Waldo Emerson

Imagine the following scenarios:

—After finalizing your project schedule, you realize the estimated completion date is two months beyond what your boss publicly promised an important customer.
—Five months into the project, you realize that you are already three weeks behind the drop dead date for the project.
—Four months into a project top management changes its priorities and now tells you that money is not an issue. Complete the project ASAP!

What do you do?

This chapter addresses strategies for reducing project duration either prior to setting the baseline for the project or in the midst of project execution. Choice of options is based on the constraints surrounding the project. Here the project priority matrix introduced in Chapter 4 comes into play. For example, there are many more options available for reducing project time if you are not resource constrained than if you cannot spend more than your original budget. We will begin first by examining the reasons for reducing project duration followed by a discussion of different options for accelerating project completion. The chapter will conclude with the classic time-cost framework for selecting which activities to “crash.” Crash is a term that has emerged in the Project Management lexicon for shortening the duration of an activity or project beyond when it can be normally done.

Rationale for Reducing Project Duration

There are few circumstances in which a project manager or owner would not wish to reduce the time to complete a project. Reducing the time of a critical activity in a project can be done but almost always results in a higher direct cost; thus, the manager faces a cost-time trade-off problem—is the reduction in time worth the additional cost? Cost-time situations focus on reducing the critical path that determines the project completion date.

There are many good reasons for attempting to reduce the duration of a project. One of the more important reasons today is time to market. Intense global competition and rapid technological advances have made speed a competitive advantage. To succeed, companies have to spot new opportunities, launch project teams, and bring new products or services to the marketplace in a flash. Perhaps in no industry does speed matter as much as in the electronics industry. For example, a rule of thumb for moderate- to high-technology firms is that a six-month delay in bringing a product to market can result in a gross profit loss of market share.
Speed has been critical in business ever since the California Gold Rush. The cell-phone industry is a good example of an intensely competitive business that places a premium on speed. In 2005 Motorola came out with the RAZR, its ultrathin cell phone with camera and music player. Samsung Group answered seven months later with the Blade. Then on February 1, 2006, Motorola released SLVR, a phone that is even more svelte than its predecessor. Nokia entered the fray with N80, which added Wi-Fi Web browsing to the product mix. "It's like having a popular night-club. You have to keep opening new ones. To stay cool, you have to speed up," says Michael Greason, president of market researcher Diffusion Group, Inc.

In order to survive, Motorola, Nokia, and other cell-phone manufacturers have become masters at project management. They have been able to cut the market release time of new phones from 12–18 months to 6–9 months. What is at stake is over 500 million in forecasted sales of new cell phones each year.

* Steve Hamm, "Is Your Company Fast Enough?" BusinessWeek, March 27, 2006, pp. 68–76.
On January 17, 1994, a 6.8-magnitude earthquake struck the Los Angeles basin, near suburban Northridge, causing 60 deaths, thousands of injuries, and billions of dollars in property damage. Nowhere was the destructive power of nature more evident than in the collapsed sections of the freeway system that disrupted the daily commute of an estimated 1 million Los Angelinos. The Northridge earthquake posed one of the greatest challenges to the California Department of Transportation (CalTrans) in its nearly 100-year history. To expedite the recovery process, Governor Pete Wilson signed an emergency declaration allowing CalTrans to streamline contracting procedures and offer attractive incentives for completing work ahead of schedule. For each day that the schedule was beaten, a sizable bonus was to be awarded. Conversely, for each day over the deadline, the contractor would be penalized the same amount. The amount ($50,000 to $200,000) varied depending on the importance of the work.

The incentive scheme proved to be a powerful motivator for the freeway reconstruction contractors. C. C. Myers, Inc., of Rancho Cordova, California, won the contract for the reconstruction of the Interstate 10 bridges. Myers pulled out all stops to finish the project in a blistering 66 days—a whopping 74 days ahead of schedule—and earning a $14.8 million bonus! Myers took every opportunity to save time and streamline operations. They greatly expanded the workforce. For example, 134 ironworkers were employed instead of the normal 15. Special lighting equipment was set up so that work could be performed around the clock. Likewise, the sites were prepared and special materials were used so that work could continue despite inclement weather that would normally shut down construction. The work was scheduled much like an assembly line so that critical activities were followed by the next critical activity. A generous incentive scheme was devised to reward teamwork and reach milestones early. Carpenters and ironworkers competed as teams against each other to see who could finish first.

Although C. C. Myers received a substantial bonus for finishing early, they spent a lot of money on overtime, bonuses, special equipment, and other premiums to keep the job rolling along. CalTrans supported Myers's efforts. With reconstruction work going on 24 hours a day, including jackhammering and pile-driving, CalTrans temporarily housed many families in local motels. CalTrans even erected a temporary plastic soundwall to help reduce the construction noise traveling to a nearby apartment complex. The double-layer curtain, 450 feet long and 20 feet high, was designed to reduce construction noise by 10 decibels.

Despite the difficulties and expense incurred by around-the-clock freeway building, most of Los Angeles cheered CalTrans’s quake recovery efforts. The Governor’s Office of Planning and Research issued a report concluding that for every day the Santa Monica Freeway was closed, it cost the local economy more than $1 million.

of about 35 percent. In these cases, high-technology firms typically assume that the time sav­
ings and avoidance of lost profits are worth any additional costs to reduce time without any
formal analysis. See the Snapshot from Practice: Cell-Phone Wars for more on this.

Another common reason for reducing project time occurs when unforeseen delays—for example, adverse weather, design flaws, and equipment breakdown—cause substantial
delays midway in the project. Getting back on schedule usually requires compressing the
time on some of the remaining critical activities. The additional costs of getting back on
schedule need to be compared with the consequences of being late. This is especially true
when time is a top priority.

Incentive contracts can make reduction of project time rewarding—usually for both
the project contractor and owner. For example, a contractor finished a bridge across a lake
18 months early and received more than $6 million for the early completion. The avail­
ability of the bridge to the surrounding community 18 months early to reduce traffic grid­
lock made the incentive cost to the community seem small to users. In another example,
in a continuous improvement arrangement, the joint effort of the owner and contractor
resulted in early completion of a river lock and a 50/50 split of the savings to the owner
and contractor. See Snapshot from Practice: Northridge Earthquake for a situation in
which a contractor went to great lengths to complete a project as quickly as possible

“Imposed deadlines” is another reason for accelerating project completion. For example, a
politician makes a public statement that a new law building will be available in two years. Or
the president of a software company remarks in a speech that new advanced software will be
available in one year. Such statements too often become imposed project duration dates—
without any consideration of the problems or cost of meeting such a date. The project dura­
tion time is set while the project is in its “concept” phase before or without any detailed
scheduling of all the activities

In addition, quality is sometimes compromised
to meet deadlines. More important, the se increased costs of imposed duration dates are sel­
dom recognized or noted by project participants.

Sometimes very high overhead costs are recognized before the project begins. In these
cases it is prudent to examine the direct costs of shortening the critical path versus the
overhead cost savings. Usually there are opportunities to shorten a few critical activities at
less than the daily overhead rate. Under specific conditions (which are not rare), huge sav­
ings are possible with little risk.

Finally there are times when it is important to reassign key equipment and/or people to
new projects. Under these circumstances, the cost of compressing the project can be com­
pared with the costs of not releasing key equipment or people.

Options for Accelerating Project Completion

Managers have several effective methods for crashing specific project activities when
resources are not constrained. Several of these are summarized below.

Options When Resources Are Not Constrained

Adding Resources

The most common method for shortening project time is to assign additional staff and
equipment to activities. There are limits, however, as to how much speed can be gained by
adding staff. Doubling the size of the workforce will not necessarily reduce completion
time by half. The relationship would be correct only when tasks can be partitioned so
In the face of increasing time-to-market pressures, many bio-tech firms are turning to outsourcing to expedite the drug development process. Panos Kalaritis, vice president of operations for Irix Pharmaceuticals, says that outsourcing process development can accelerate a drug's evolution by allowing a pharmaceutical company to continue research while a contractor works on process optimization. Susan Dexter of Lonza Biologics identified different types of outsourcing contracts including agreements for product development, clinical trial supplies, in-market or commercial supplies, and technology transfer. Often, she said, a given project can encompass more than one of the above stages over a period of several years.

Using a contractor, said Paul Henricks, business manager for Patheon Inc., gives the client company access to specialized knowledge and infrastructure as well as flexible resources and capacity. The sponsoring company can also manage risks by sharing responsibilities through outsourcing.

"Communication is key to a successful outsourcing relationship," said Dan Gold, vice president of process development for Covance, which was formerly Corning Bio. "Contractors and sponsors should both assign project managers, and the two must work together to maintain, track, and document project completion. There must be a concerted effort on the part of both parties to work as partners to complete the project."


Outsourcing Project Work

A common method for shortening the project time is to subcontract an activity. The subcontractor may have access to superior technology or expertise that will accelerate the completion of the activity. For example, contracting for a backhoe can accomplish in two hours what it can take a team of laborers two days to do. Likewise, by hiring a consulting firm that specializes in ADSI programming, a firm may be able to cut in half the time it would take for less experienced, internal programmers to do the work. Subcontracting also frees up resources that can be assigned to a critical activity and will ideally result in a shorter project duration. See Snapshot from Practice: Outsourcing Bio-Tech. Outsourcing will be addressed more fully in Chapter 12.

Scheduling Overtime

The easiest way to add more labor to a project is not to add more people, but to schedule overtime. If a team works 50 hours a week instead of 40, it might accomplish 25 percent more. By scheduling overtime you avoid the additional costs of coordination and communication encountered when new people are added. If people involved are salaried workers, there may be no real additional cost for the extra work. Another advantage is that there are fewer distractions when people work outside normal hours.
Overtime has disadvantages. First, hourly workers are typically paid time and a half for overtime and double time for weekends and holidays. Sustained overtime work by salaried employees may incur intangible costs such as divorce, burnout, and turnover. The latter is a key organizational concern when there is a shortage of workers. Furthermore, it is an oversimplification to assume that, over an extended period of time, a person is as productive during his or her eleventh hour at work as during his or her third hour of work. There are natural limits to what is humanly possible, and extended overtime may actually lead to an overall decline in productivity when fatigue sets in.

Overtime and working longer hours is the preferred choice for accelerating project completion, especially when the project team is salaried. The key is to use overtime judiciously. Remember a project is a marathon not a sprint! You do not want to run out of energy before the finish line.

Establish a Core Project Team

As discussed in Chapter 3, one of the advantages of creating a dedicated core team to complete a project is speed. Assigning professionals full time to a project avoids the hidden cost of multitasking in which people are forced to juggle the demands of multiple projects. Professionals are allowed to devote their undivided attention to a specific project. This singular focus creates a shared goal that can bind a diverse set of professionals into a highly cohesive team capable of accelerating project completion. Factors that contribute to the emergence of high-performing project teams will be discussed in detail in Chapter 11.

Do It Twice—Fast and Correctly

If you are in a hurry, try building a “quick and dirty” short-term solution, then go back and do it the right way. For example, the Rose Garden stadium in Portland, Oregon, was supposed to be completely finished in time for the start of the 1995–1996 National Basketball Association (NBA) season. Delays made this impossible, so the construction crew set up temporary bleachers to accommodate the opening-night crowd. The additional costs of doing it twice are often more than compensated for by the benefits of satisfying the deadline.

Options When Resources Are Constrained

A project manager has fewer options for accelerating project completion when additional resources are either not available or the budget is severely constrained. This is especially true once the schedule has been established. Below are some of these options.

Fast-Tracking

Sometimes it is possible to rearrange the logic of the project network so that critical activities are done in parallel (concurrently) rather than sequentially. This alternative is a good one if the project situation is right. When this alternative is given serious attention, it is amazing to observe how creative project team members can be in finding ways to restructure sequential activities in parallel. As noted in Chapter 6, one of the most common methods for restructuring activities is to change a finish-to-start relationship to a start-to-start relationship. For example, instead of waiting for the final design to be approved, manufacturing engineers can begin building the production line as soon as key specifications have been established. Changing activities from sequential to parallel usually requires closer coordination among those responsible for the activities affected but can produce tremendous time savings.

Critical-Chain

Critical-chain project management (CCPM) is designed to accelerate project completion. As discussed in Chapter 8, the jury is still out in terms of its applicability. Still CCPM
On March 13, 1999, Habitat for Humanity New Zealand built a fully operational, four-bedroom house in Auckland in 3 hours, 44 minutes, and 59 seconds from floor to roof complete with curtains, running showers, lawn, and fence. In doing so they became the fastest house builders in the world.

“We made a significant decimation of the record,” said Habitat New Zealand’s Chief Executive Graeme Lee. “The previous record of 4 hours, 39 minutes, 8 seconds, held by a Habitat chapter in Nashville, USA, was made with a three-bedroom home, and we built one with four bedrooms and used only 140 volunteers on the site.” The rules provide for construction to commence from an established floor platform. The house is complete when it meets the local building code, and the family can move in.

The project took 14 months to plan. CCPM principles were applied using ProChain Software to finalize project schedule. The critical-chain was recalculated 150–200 times and then analyzed to optimize the resulting new sequence of operations. This reiterative process was used to progressively develop the fastest plan.

One of the keys to efficiency was the use of “Laserbilt” pre-fabricated walls made from 36mm particleboard using technology that had been invented by a company in New Zealand. Another time saver was the use of a crane which lowered the wooden roof frame (built on adjacent land) onto the four walls.

Once the roof was on the walls, roofing iron was put on. Meanwhile, the wall sheathing was attached to outside walls and windows fitted, with painters almost painting the face of the hammers as sheath nailing was completed. Inside, vinyl was laid first in the utility areas while painters started in the bedrooms. After the vinyl, the bathrooms were fitted and curtains hung. On the outside, while the roofing was being installed, decks and steps were constructed, a front path laid, mail box and clothesline installed, wooden fence constructed around the perimeter, three trees planted, and lawns leveled and seeded.

Post-project assessment revealed that even further time could have been gained. The management rule was to be “One tradesperson in one room at one time,” but enthusiasm took over and people were doing whatever they could wherever they could, especially toward the end. The project manager estimated that if greater discipline had been exercised and if people moved out of the house as soon as they had completed their task, another 15 minutes would have been shaved from the record.

Habitat for Humanity is an international charitable organization that builds simple, affordable houses and sells them on a no-interest, no-profit basis to needy families.

principles appear sound and worthy of experimentation if speed is essential. At the same
time, it would be difficult to apply CCPM midstream in a project. CCPM requires con­
siderable training and a shift in habits and perspectives that take time to adopt. Although
there have been reports of immediate gains, especially in terms of completion times, a
long-term management commitment is probably necessary to reap full benefits. See the
Snapshot from Practice: The Fastest House in the World for an extreme example of
CCPM application.

Reducing Project Scope

Probably the most common response for meeting unattainable deadlines is to reduce or
scale back the scope of the project. This invariably leads to a reduction in the functional­
ity of the project. For example, the new car will average only 25 mpg instead of 30, or the
software product will have fewer features than originally planned. While scaling back the
scope of the project can lead to big savings in both time and money, it may come at a cost
of reducing the value of the project. If the car gets lower gas mileage, will it stand up to
competitive models? Will customers still want the software minus the features?

The key to reducing a project scope without reducing value is to reassess the true spec­
cifications of the project. Often requirements are added under best-case, blue-sky scenarios
and represent desirables, but not essentials. Here it is important to talk to the customer
and/or project sponsors and explain the situation—you can get it your way but not until
February. This may force them to accept an extension or to add money to expedite the pro­
ject. If not, then a healthy discussion of what the essential requirements are and what items
can be compromised in order to meet the deadline needs to take place. More intense re­
examination of requirements may actually improve the value of the project by getting it
done more quickly and for a lower cost.

Calculating the savings of reduced project scope begins with the work breakdown struc­
ture. Reducing functionality means certain tasks, deliverables, or requirements can be
reduced or even eliminated. These tasks need to be found and the schedule adjusted. Focus
should be on changes in activities on the critical path.

Compromise Quality

Reducing quality is always an option, but it is rarely acceptable or used. If quality is sac­
rificed, it may be possible to reduce the time of an activity on the critical path.

In practice the methods most commonly used to crash projects are scheduling overtime,
outsourcing, and adding resources. Each of these maintains the essence of the original plan.
Options that depart from the original project plan include do it twice and fast-tracking.
Rethinking of project scope, customer needs, and timing become major considerations for
these techniques.

Project Cost–Duration Graph

Nothing on the horizon suggests that the need to shorten project time will change. The
challenge for the project manager is to use a quick, logical method to compare the bene­
fits of reducing project time with the cost. When sound, logical methods are absent, it is
difficult to isolate those activities that will have the greatest impact on reducing project
time at least cost. This section describes a procedure for identifying the costs of reducing
project time so that comparisons can be made with the benefits of getting the project com­
pleted sooner. The method requires gathering direct and indirect costs for specific project
durations. Critical activities are searched to find the lowest direct-cost activities that will
shorten the project duration. Total cost for specific project durations are computed and
then compared with the benefits of reducing project time—before the project begins or while it is in progress.

**Explanation of Project Costs**

The general nature of project costs is illustrated in Figure 9.1. The total cost for each duration is the sum of the indirect and direct costs. Indirect costs continue for the life of the project. Hence, any reduction in project duration means a reduction in indirect costs. Direct costs on the graph grow at an increasing rate as the project duration is reduced from its original planned duration. With the information from a graph such as this for a project, managers can quickly judge any alternative such as meeting a time-to-market deadline. Further discussion of indirect and direct costs is necessary before demonstrating a procedure for developing the information for a graph similar to the one depicted in Figure 9.1.

**Project Indirect Costs**

Indirect costs generally represent overhead costs such as supervision, administration, consultants, and interest. Indirect costs cannot be associated with any particular work package or activity, hence the term. Indirect costs vary directly with time. That is, any reduction in time should result in a reduction of indirect costs. For example, if the daily costs of supervision, administration, and consultants are $2,000, any reduction in project duration would represent a savings of $2,000 per day. If indirect costs are a significant percentage of total project costs, reductions in project time can represent very real savings (assuming the indirect resources can be utilized elsewhere).

**Project Direct Costs**

Direct costs commonly represent labor, materials, equipment, and sometimes subcontractors. Direct costs are assigned directly to a work package and activity, hence the term. The ideal assumption is that direct costs for an activity time represent normal costs, which typically mean low-cost, efficient methods for a normal time. When project durations are
imposed, direct costs may no longer represent low-cost, efficient methods. Costs for the imposed duration date will be higher than for a project duration developed from ideal normal times for activities. Because direct costs are assumed to be developed from normal methods and time, any reduction in activity time should add to the costs of the activity. The sum of the costs of all the work packages or activities represents the total direct costs for the project.

The major plight faced in creating the information for a graph similar to Figure 9.1 is computing the direct cost of shortening individual critical activities and then finding the total direct cost for each project duration as project time is compressed; the process requires selecting those critical activities that cost the least to shorten. (Note: The graph implies that there is always an optimum cost-time point. This is only true if shortening a schedule has incremental indirect cost savings exceeding the incremental direct cost incurred. However, in practice there are almost always several activities in which the direct costs of shortening are less than the indirect costs.)

There are three major steps required to construct a project cost-duration graph:

1. Find total direct costs for selected project durations.
2. Find total indirect costs for selected project durations.
3. Sum direct and indirect costs for these selected durations.

The graph is then used to compare additional cost alternatives for benefits. Details of these steps are presented here.

**Determining the Activities to Shorten**

The most difficult task in constructing a cost-duration graph is finding the total direct costs for specific project durations over a relevant range. The central concern is to decide which activities to shorten and how far to carry the shortening process. Basically, managers need to look for critical activities that can be shortened with the smallest increase in cost per unit of time. The rationale for selecting critical activities depends on identifying the activity's normal and crash times and corresponding costs. **Normal time** for an activity represents low-cost, realistic, efficient methods to completing the activity under normal conditions. **Crash time** represents the greatest time reduction possible under realistic conditions.
4. Slope represents cost per unit of time.
5. All accelerations must occur within the normal and crash times.

Knowing the slope of activities allows managers to compare which critical activities to shorten. The less steep the cost slope of an activity, the less it costs to shorten one time period; a steeper slope means it will cost more to shorten one time unit. The cost per unit of time or slope for any activity is computed by the following equation:

\[
\text{Cost slope} = \frac{\text{Rise}}{\text{Run}} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}} = \frac{CC - NC}{NT - CT} = \frac{\$800 - \$400}{10 - 5} = \frac{\$400}{5} = \$80 \text{ per unit of time}
\]

In Figure 9.2 the rise is the y axis (cost) and the run is the x axis (duration). The slope of the cost line is $80 for each time unit the activity is reduced; the limit reduction of the activity time is five time units. Comparison of the slopes of all critical activities allows us to determine which activity(ies) to shorten to minimize total direct cost. Given the preliminary project schedule (or one in progress) with all activities set to their early-start times, the process of searching critical activities as candidates for reduction can begin. The total direct cost for each specific compressed project duration must be found.

**A Simplified Example**

Figure 9.3A presents normal and crash times and costs for each activity, the computed slope and time reduction limit, the total direct cost, and the project network with a duration of 25 time units. Note the total direct cost for the 25-period duration is $450. This is an anchor point to begin the procedure of shortening the critical path(s) and finding the total direct costs for each specific duration less than 25 time units. The maximum time reduction of an activity is simply the difference between the normal and crash times for an activity.
For example, activity D can be reduced from a normal time of 11 time units to a crash time of 7 time units, or a maximum of 4 time units. The positive slope for activity D is computed as follows:

\[
\text{Slope} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}} = \frac{\$150 - \$50}{11 - 7} = \frac{\$100}{4} = \$25 \text{ per period reduced}
\]

The network shows the critical path to be activities A, D, F, G. Because it is impossible to shorten activity G, activity A is circled because it is the least-cost candidate; that is, its slope ($20) is less than the slopes for activities D and F ($25 and $30). Reducing activity A one time unit cuts the project duration to 24 time units but increases the total direct costs to $470 ($450 + $20 = $470). Figure 9.3B reflects these changes. The duration of activity
A has been reduced to two time units; the “x” indicates the activity cannot be reduced any further. Activity D is circled because it costs the least ($25) to shorten the project to 23 time units. Compare the cost of activity F. The total direct cost for a project duration of 23 time units is $495 (see Figure 9.4A).

Observe that the project network in Figure 9.4A now has two critical paths—A, C, F, G and A, D, F, G. Reducing the project to 22 time units will require that activity F be reduced; thus, it is circled. This change is reflected in Figure 9.4B. The total direct cost for 22 time units is $525. This reduction has created a third critical path—A, B, E, G; all activities are critical. The least-cost method for reducing the project duration to 21 time units is the combination of the circled activities C, D, E which cost $30, $25, $30, respectively, and increase total direct costs to $610. The results of these changes are depicted in Figure 9.4C. Although some activities can still be reduced (those without the “x” next to the activity time), no activity or combination of activities will result in a reduction in the project duration.

With the total direct costs for the array of specific project durations found, the next step is to collect the indirect costs for these same durations. These costs are typically a rate per
FIGURE 9.5
Summary Costs by Duration

<table>
<thead>
<tr>
<th>Project duration</th>
<th>Direct costs</th>
<th>Indirect costs</th>
<th>Total costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>450</td>
<td>400</td>
<td>$850</td>
</tr>
<tr>
<td>24</td>
<td>470</td>
<td>350</td>
<td>820</td>
</tr>
<tr>
<td>23</td>
<td>495</td>
<td>300</td>
<td>795</td>
</tr>
<tr>
<td>22</td>
<td>525</td>
<td>250</td>
<td>775</td>
</tr>
<tr>
<td>21</td>
<td>610</td>
<td>200</td>
<td>810</td>
</tr>
</tbody>
</table>

day and are easily obtained from the accounting department. Figure 9.5 presents the total direct costs, total indirect costs, and total project costs. These same costs are plotted in Figure 9.6. This graph shows that the optimum cost-time duration is 22 time units and $775. Assuming the project will actually materialize as planned, any movement away from this time duration will increase project costs. The movement from 25 to 22 time units occurs because, in this range, the absolute slopes of the indirect costs are greater than the direct cost slopes.

Using the Project Cost-Duration Graph

This graph, as presented in Figures 9.1 and 9.6, is valuable to compare any proposed alternative or change with the optimum cost and time. More importantly, the creation of such a graph keeps the importance of indirect costs in the forefront of decision making. Indirect costs are frequently forgotten in the field when the pressure for action is intense. Finally, such a graph can be used before the project begins or while the project is in progress. Creating the graph in the preproject planning phase without an imposed duration is the
first choice because normal time is more meaningful. Creating the graph in the project planning phase with an imposed duration is less desirable because normal time is made to fit the imposed date and is probably not low cost. Creating the graph after the project has started is the least desirable because some alternatives may be ruled out of the decision process. Managers may choose not to use the formal procedure demonstrated. However, regardless of the method used, the principles and concepts inherent in the formal procedure are highly applicable in practice and should be considered in any cost-duration trade-off decision.

Crash Times
Collecting crash times for even a moderate-size project can be difficult. The meaning of crash time is difficult to communicate. What is meant when you define crash time as “the shortest time you can realistically complete an activity”? Crash time is open to different interpretations and judgments. Some estimators feel very uncomfortable providing crash times. Regardless of the comfort level, the accuracy of crash times and costs is frequently rough at best, when compared with normal time and cost.

Linearity Assumption
Because the accuracy of compressed activity times and costs is questionable, the concern of some theorists—that the relationship between cost and time is not linear but curvilinear—is seldom a concern for practicing managers. Reasonable, quick comparisons can be made using the linear assumption. The simple approach is adequate for most projects. There are rare situations in which activities cannot be crashed by single time units. Instead, crashing is “all or nothing.” For example, activity A will take 10 days (for say $1,000) or it will take 7 days (for say $1,500), but no options exist in which activity A will take 8 or 9 days to complete. In a few rare cases of very large, complex, long-duration projects, the use of present value techniques may be useful; such techniques are beyond the scope of this text.

Choice of Activities to Crash Revisited
The cost-time crashing method relies on choosing the cheapest method for reducing the duration of the project. There are other factors that should be assessed beyond simply cost. First, the inherent risks involved in crashing particular activities need to be considered. Some activities are riskier to crash than others. For example, accelerating the completion of a software design code may not be wise if it increases the likelihood of errors surfacing downstream. Conversely, crashing a more expensive activity may be wise if fewer inherent risks are involved.

Second, the timing of activities needs to be considered. Crashing a critical activity early in the project may result in wasted money if some other critical activity is finished early or some noncritical path becomes the new critical path. In such cases, the money spent early is gone and no benefit comes from early completion by crashing the activity. Conversely, it may be wise to crash an early critical activity when later activities are likely to be delayed and absorb the time gained. Then the manager would still have the option of crashing final activities to get back on schedule.

Finally, the impact crashing would have on the morale and motivation of the project team needs to be assessed. If the least-cost method repeatedly signals a subgroup to accelerate progress, fatigue and resentment may set in. Conversely, if overtime pay is involved, other team members may resent not having access to this benefit. This situation can lead to tension within the entire project team. Good project managers gauge the response that crashing activities will have on the entire project team. See Snapshot from Practice: I’ll Bet You . . . for a novel approach to motivating employees to work faster.
The focus of this chapter has been on how project managers crash activities by typically assigning additional manpower and equipment to cut significant time off of scheduled tasks. Project managers often encounter situations in which they need to motivate individuals to accelerate the completion of a specific, critical task. Imagine the following scenario.

Brue Young just received a priority assignment from corporate headquarters. The preliminary engineering sketches that were due tomorrow need to be e-mailed to the West Coast by 4:00 P.M. today so that the model shop can begin construction of a prototype to present to top management. He approaches Danny Whitten, the draftsman responsible for the task, whose initial response is, “That’s impossible!” While he agrees that it would be very difficult, he does not believe that it is as impossible as Danny suggests or that Danny truly believes that. What should he do?

He tells Danny that he knows this is going to be a rush job, but he is confident that he can do it. When Danny balks, he responds, “I tell you what, I’ll make a bet with you. If you are able to finish the design by 4:00, I’ll make sure you get two of the company’s tickets to tomorrow night’s Celtics-Knicks basketball game.” Danny accepts the challenge, works feverishly to complete the assignment, and is able to take his daughter to her first professional basketball game.

Conversations with project managers reveal that many use bets like this one to motivate extraordinary performance. These bets range from tickets to sporting and entertainment events to gift certificates at high-class restaurants to a well-deserved afternoon off. For bets to work they need to adhere to the principles of expectancy theory of motivation. Boiled down to simple terms, expectancy theory rests on three key questions:

1. Can I do it (Is it possible to meet the challenge)?
2. Will I get it (Can I demonstrate that I met the challenge and can I trust the project manager will deliver his/her end of the bargain)?
3. Is it worth it (Is the payoff of sufficient personal value to warrant the risk and extra effort)?

If in the mind of the participant the answer to any of these three questions is no, then the person is unlikely to accept the challenge. However, when the answers are affirmative, then the individual is likely to accept the bet and be motivated to meet the challenge.

Bets can be effective motivational tools and add an element of excitement and fun to project work. But, the following practical advice should be heeded:

1. The bet has greater significance if it also benefits family members or significant others. Being able to take a son or daughter to a professional basketball game allows that individual to “score points” at home through work. These bets also recognize and reward the support project members receive from their families and reinforces the importance of their work to loved ones.
2. Bets should be used sparingly; otherwise everything can become negotiable. They should be used only under special circumstances that require extraordinary effort.
3. Individual bets should involve clearly recognizable individual effort, otherwise others may become jealous and discord may occur within a group. As long as others see it as requiring truly remarkable, “beyond the call of duty” effort, they will consider it fair and warranted.
Time Reduction Decisions and Sensitivity

Should the project owner or project manager go for the optimum cost-time? The answer is, "It depends." Risk must be considered. Recall from our example that the optimum project time point represented a reduced project cost and was less than the original normal project time (review Figure 9.6). The project direct-cost line near the normal point is usually relatively flat. Because indirect costs for the project are usually greater in the same range, the optimum cost-time point is less than the normal time point. Logic of the cost-time procedure suggests managers should reduce the project duration to the lowest total cost point and duration.

How far to reduce the project time from the normal time toward the optimum depends on the sensitivity of the project network. A network is sensitive if it has several critical or near-critical paths. In our example project movement toward the optimum time requires spending money to reduce critical activities, resulting in slack reduction and/or more critical paths and activities. Slack reduction in a project with several near-critical paths increases the risk of being late. The practical outcome can be a higher total project cost if some near-critical activities are delayed and become critical; the money spent reducing activities on the original critical path would be wasted. Sensitive networks require careful analysis. The bottom line is that compression of projects with several near-critical paths reduces scheduling flexibility and increases the risk of delaying the project. The outcome of such analysis will probably suggest only a partial movement from the normal time toward the optimum time.

There is a positive situation where moving toward the optimum time can result in very real, large savings—this occurs when the network is insensitive. A project network is insensitive if it has a dominant critical path, that is, no near-critical paths. In this project circumstance, movement from the normal time point toward the optimum time will not create new or near-critical activities. The bottom line here is that the reduction of the slack of noncritical activities increases the risk of their becoming critical only slightly when compared with the effect in a sensitive network. Insensitive networks hold the greatest potential for real, sometimes large, savings in total project costs with a minimum risk of noncritical activities becoming critical.

Insensitive networks are not a rarity in practice; they occur in perhaps 25 percent of all projects. For example, a light rail project team observed from their network a dominant critical path and relatively high indirect costs. It soon became clear that by spending some dollars on a few critical activities, very large savings of indirect costs could be realized. Savings of several million dollars were spent extending the rail line and adding another station. The logic found in this example is just as applicable to small projects as large ones. Insensitive networks with high indirect costs can produce large savings.

Ultimately, deciding if and which activities to crash is a judgment call requiring careful consideration of the options available, the costs and risks involved, and the importance of meeting a deadline.
puts added pressure on cost containment. In other cases, there are financial incentives tied to cost containment.

Even in situations where cost is transferred to customers there is pressure to reduce cost. Cost overruns make for unhappy customers and can damage future business opportunities. Budgets can be fixed or cut, and when contingency funds are exhausted, then cost overruns have to be made up with remaining activities.

As discussed earlier, shortening project duration may come at the expense of overtime, adding additional personnel, and using more expensive equipment and/or materials. Conversely, sometimes cost savings can be generated by extending the duration of a project. This may allow for a smaller workforce, less-skilled (expensive) labor, and even cheaper equipment and materials to be used. Below are some of the more commonly used options for cutting costs.

**Reduce Project Scope**

Just as scaling back the scope of the project can gain time, delivering less than what was originally planned also produces significant savings. Again, calculating the savings of a reduced project scope begins with the work breakdown structure. However, since time is not the issue, you do not need to focus on critical activities.

**Have Owner Take on More Responsibility**

One way of reducing project costs is identifying tasks that customers can do themselves. Homeowners frequently use this method to reduce costs on home improvement projects. For example, to reduce the cost of a bathroom remodel, a homeowner may agree to paint the room instead of paying the contractor to do it. On IS projects, a customer may agree to take on some of the responsibility for testing equipment or providing in-house training. Naturally, this arrangement is best negotiated before the project begins. Customers are less receptive to this idea if you suddenly spring it on them. An advantage of this method is that, while costs are lowered, the original scope is retained. Clearly this option is limited to areas in which the customer has expertise and the capability to pick up the tasks.

**Outsourcing Project Activities or Even the Entire Project**

When estimates exceed budget, it not only makes sense to re-examine the scope but also search for cheaper ways to complete the project. Perhaps instead of relying on internal resources, it would be more cost effective to outsource segments or even the entire project, opening up work to external price competition. Specialized subcontractors often enjoy unique advantages, such as material discounts for large quantities, as well as equipment that not only gets the work done more quickly but also less expensively. They may have lower overhead and labor costs. For example, to reduce costs of software projects, many American firms outsource work to firms operating in India where the salary of a software engineer is one-third that of an American software engineer. However, outsourcing means you have less control over the project and will need to have clearly definable deliverables.

**Brainstorming Cost Savings Options**

Just as project team members can be a rich source of ideas for accelerating project activities, they can offer tangible ways for reducing project costs. For example, one project manager reported that his team was able to come up with over $75,000 worth of cost saving
suggestions without jeopardizing the scope of the project. Project managers should not underestimate the value of simply asking if there is a cheaper, better way.

**Summary**

The need for reducing the project duration occurs for many reasons such as imposed duration dates, time-to-market considerations, incentive contracts, key resource needs, high overhead costs, or simply unforeseen delays. These situations are very common in practice and are known as cost-time trade-off decisions. This chapter presented a logical, formal process for assessing the implications of situations that involve shortening the project duration. Crashing the project duration increases the risk of being late. How far to reduce the project duration from the normal time toward the optimum depends on the sensitivity of the project network. A sensitive network is one that has several critical or near-critical paths. Great care should be taken when shortening sensitive networks to avoid increasing project risks. Conversely, insensitive networks represent opportunities for potentially large project cost savings by eliminating some overhead costs with little downside risk.

Alternative strategies for reducing project time were discussed within the context of whether or not the project is resource limited. Project acceleration typically comes at a cost of either spending money for more resources or compromising the scope of the project. If the latter is the case, then it is essential that all relevant stakeholders be consulted so that everyone accepts the changes that have to be made. One other key point is the difference in implementing time-reducing activities in the midst of project execution versus incorporating them into the project plan. You typically have far fewer options once the project is underway than before it begins. This is especially true if you want to take advantage of the new scheduling methodologies such as fast-tracking and critical-chain. Time spent up front considering alternatives and developing contingency plans will lead to time savings in the end.

<table>
<thead>
<tr>
<th>Key Terms</th>
<th>Crash point</th>
<th>Fast-tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash time</td>
<td>Direct costs</td>
<td>Indirect costs</td>
</tr>
<tr>
<td><em>Outsourcing</em></td>
<td></td>
<td><em>Outsourcing</em></td>
</tr>
</tbody>
</table>

| Project cost-duration graph |

**Review Questions**

1. What are five common reasons for crashing a project?
2. What are the advantages and disadvantages of reducing project scope to accelerate a project? What can be done to reduce the disadvantages?
3. Why is scheduling overtime a popular choice for getting projects back on schedule? Identify four indirect costs you might find on a moderately complex project. Why are these costs classified as indirect?
4. How can a cost-duration graph be used by the project manager? Explain.
5. Reducing the project duration increases the risk of being late. Explain.
6. It is possible to shorten the critical path and save money. Explain how.
1. Draw a project network from the following information.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Predecessor</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>None</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>C</td>
<td>6</td>
</tr>
<tr>
<td>G</td>
<td>C, D</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>E, F</td>
<td>6</td>
</tr>
<tr>
<td>I</td>
<td>G</td>
<td>5</td>
</tr>
<tr>
<td>J</td>
<td>H, I</td>
<td>5</td>
</tr>
</tbody>
</table>

Activities B and H can be shortened to a minimum of 2 weeks. Which activity would you shorten to reduce the project duration by 2 weeks? Why?

2. Assume the network and data that follow. Compute the total direct cost for each project duration. If the indirect costs for each project duration are $400 (19 time units), $350 (18), $300 (17), and $250 (16), compute the total project cost for each duration. Plot the total direct, indirect, and project costs for each of these durations on a cost-time graph. What is the optimum cost-time schedule for the project? What is this cost?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Crash Cost (Slope)</th>
<th>Maximum Crash Time</th>
<th>Normal Time</th>
<th>Normal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>1</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>60</td>
<td>2</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td>1</td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>3</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>100</td>
<td>3</td>
<td>7</td>
<td>90</td>
</tr>
<tr>
<td>G</td>
<td>70</td>
<td>1</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$470</td>
</tr>
</tbody>
</table>

Initial project duration 19

Total direct cost $______
3. Given the data and information that follow, compute the total direct cost for each project duration. If the indirect costs for each project duration are $90 (15 time units), $70 (14), $50 (13), $40 (12), and $30 (11), compute the total project cost for each duration. What is the optimum cost-time schedule for the project? What is this cost?

<table>
<thead>
<tr>
<th>Act.</th>
<th>Crash Cost (Slope)</th>
<th>Maximum Crash Time</th>
<th>Normal Time</th>
<th>Normal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>1</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>60</td>
<td>2</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>1</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>E</td>
<td>60</td>
<td>3</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>100</td>
<td>1</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>G</td>
<td>30</td>
<td>1</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>H</td>
<td>40</td>
<td>0</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>I</td>
<td>200</td>
<td>1</td>
<td>3</td>
<td>200</td>
</tr>
</tbody>
</table>

Total $730

![Network Diagram]

Initial project duration 15
Total direct cost $
4. If the indirect costs for each duration are $1,200 for 16 weeks, $1,130 for 15 weeks, $1,000 for 14 weeks, $900 for 13 weeks, $860 for 12 weeks, $820 for 11 weeks and $790 for 10 weeks, compute the total costs for each duration. Plot these costs on a graph. What is the optimum cost-time schedule?

<table>
<thead>
<tr>
<th>Act.</th>
<th>Crash Cost (Slope)</th>
<th>Maximum Crash Time</th>
<th>Normal Time</th>
<th>Normal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>70</td>
<td>2</td>
<td>7</td>
<td>60</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>2</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>3</td>
<td>5</td>
<td>110</td>
</tr>
<tr>
<td>F</td>
<td>200</td>
<td>3</td>
<td>5</td>
<td>90</td>
</tr>
<tr>
<td>G</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>H</td>
<td>40</td>
<td>1</td>
<td>2</td>
<td>70</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>140</td>
</tr>
</tbody>
</table>

$\text{Total Cost} = 680$

Time unit = 1 week
5. If the indirect costs for each duration are $300 for 27 weeks, $240 for 26 weeks, $180 for 25 weeks, $120 for 24 weeks, $60 for 23 weeks, and $50 for 22 weeks, compute the direct, indirect and total costs for each duration. What is the optimum cost-time schedule? The customer offers you $10 dollars for every week you shorten the project from your original network. Would you take it? If so for how many weeks?

<table>
<thead>
<tr>
<th>Act.</th>
<th>Crash Cost (Slope)</th>
<th>Maximum Crash Time</th>
<th>Normal Time</th>
<th>Normal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>80</td>
<td>2</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>30</td>
<td>3</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td>1</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>D</td>
<td>50</td>
<td>2</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>E</td>
<td>100</td>
<td>4</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>30</td>
<td>1</td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>

Total direct cost $300

Time unit = 1 week
6. Use the information contained below to compress one time unit per move using the least cost method. Reduce the schedule until you reach the crash point of the network. For each move identify what activity(s) was crashed, the adjusted total cost, and explain your choice if you have to choose between activities that cost the same.

Note: Crash point of the network is the point in which the duration cannot be reduced any further.

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Slope</th>
<th>Maximum Crash Time</th>
<th>Time</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>—</td>
<td>0</td>
<td>4</td>
<td>$50</td>
</tr>
<tr>
<td>B'</td>
<td>$40</td>
<td>3</td>
<td>5</td>
<td>70</td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td>1</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>D</td>
<td>40</td>
<td>2</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>E</td>
<td>40</td>
<td>2</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>F</td>
<td>40</td>
<td>1</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>G</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>H</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>I</td>
<td>—</td>
<td>0</td>
<td>3</td>
<td>50</td>
</tr>
</tbody>
</table>

Total direct normal costs—$550

References


**Case**

**International Capital, Inc.—Part B**

Given the project network derived in Part A of the case from Chapter 7, Brown also wants to be prepared to answer any questions concerning compressing the project duration. This question will almost always be entertained by the accounting department, review committee, and the client. To be ready for the compression question, Brown has prepared the following data in case it is necessary to crash the project. (Use your weighted average times \( t_e \) computed in Part A of the International Capital case found in Chapter 7.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Normal Cost</th>
<th>Maximum Crash Time</th>
<th>Crash Cost/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$3,000</td>
<td>3</td>
<td>$500</td>
</tr>
<tr>
<td>B</td>
<td>5,000</td>
<td>2</td>
<td>1,000</td>
</tr>
<tr>
<td>C</td>
<td>6,000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>20,000</td>
<td>3</td>
<td>3,000</td>
</tr>
<tr>
<td>E</td>
<td>10,000</td>
<td>2</td>
<td>1,000</td>
</tr>
<tr>
<td>F</td>
<td>7,000</td>
<td>1</td>
<td>1,000</td>
</tr>
<tr>
<td>G</td>
<td>20,000</td>
<td>2</td>
<td>3,000</td>
</tr>
<tr>
<td>H</td>
<td>8,000</td>
<td>1</td>
<td>2,000</td>
</tr>
<tr>
<td>I</td>
<td>5,000</td>
<td>1</td>
<td>2,000</td>
</tr>
<tr>
<td>J</td>
<td>7,000</td>
<td>1</td>
<td>1,000</td>
</tr>
<tr>
<td>K</td>
<td>12,000</td>
<td>6</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Total normal costs = $103,000

Using the data provided, determine the activity crashing decisions and best-time cost project duration. Given the information you have developed, what suggestions would you give Brown to ensure she is well prepared for the project review committee? Assume the overhead costs for this project are $700 per workday. Will this alter your suggestions?

**Case**

**Whitbread World Sailboat Race**

Each year countries enter their sailing vessels in the nine-month Round the World Whitbread Sailboat Race. In recent years, about 14 countries entered sailboats in the race. Each year's sailboat entries represent the latest technologies and human skills each country can muster.
Bjorn Ericksen has been selected as a project manager because of his past experience as a master helmsman and because of his recent fame as the “best designer of racing sailboats in the world.” Bjorn is pleased and proud to have the opportunity to design, build, test, and train the crew for next year’s Whitbread entry for his country. Bjorn has picked Karin Knutsen (as chief design engineer) and Trygve Wallvik (as master helmsman) to be team leaders responsible for getting next year’s entry ready for the traditional parade of all entries on the Thames River in the United Kingdom, which signals the start of the race.

As Bjorn begins to think of a project plan, he sees two parallel paths running through the project—design and construction and crew training. Last year’s boat will be used for training until the new entry can have the crew on board to learn maintenance tasks. Bjorn calls Karin and Trygve together to develop a project plan. All three agree the major goal is to have a winning boat and crew ready to compete in next year’s competition at a cost of $3.2 million. A check of Bjorn’s calendar indicates he has 45 weeks before next year’s vessel must leave port for the United Kingdom to start the race.

**THE KICKOFF MEETING**

Bjorn asks Karin to begin by describing the major activities and the sequence required to design, construct, and test the boat. Karin starts by noting that design of the hull, deck, mast, and accessories should only take six weeks—given the design prints from past race entries and a few prints from other countries’ entries. After the design is complete, the hull can be constructed, the mast ordered, sails ordered, and accessories ordered. The hull will require 12 weeks to complete. The mast can be ordered and will require a lead time of eight weeks; the seven sails can be ordered and will take six weeks to get; accessories can be ordered and will take 15 weeks to receive. As soon as the hull is finished, the ballast tanks can be installed, requiring two weeks. Then the deck can be built, which will require five weeks. Concurrently, the hull can be treated with special sealant and friction-resistance coating, taking three weeks. When the deck is completed and mast and accessories received, the mast and sails can be installed, requiring two weeks; the accessories can be installed, which will take six weeks. When all of these activities have been completed, the ship can be sea-tested, which should take five weeks. Karin believes she can have firm cost estimates for the boat in about two weeks.

Trygve believes he can start selecting the 12-man or woman crew and securing their housing immediately. He believes it will take six weeks to get a committed crew on-site and three weeks to secure housing for the crew members. Trygve reminds Bjorn that last year’s vessel must be ready to use for training the moment the crew is on-site until the new vessel is ready for testing. Keeping the old vessel operating will cost $4,000 per week as long as it is used. Once the crew is on-site and housed, they can develop and implement a routine sailing and maintenance training program, which will take 15 weeks (using the old vessel). Also, once the crew is selected and on-site, crew equipment can be selected, taking only two weeks. Then crew equipment can be ordered; it will take five weeks to arrive. When the crew equipment and maintenance training program are complete, crew maintenance on the new vessel can begin; this should take 10 weeks. But crew maintenance on the new vessel cannot begin until the deck is complete and the mast, sails, and accessories have arrived. Once crew maintenance on the new vessel begins, the new vessel will cost $6,000 per week until sea training is complete. After the new ship maintenance is complete and while the boat is being tested, initial sailing training can be implemented; training should take seven weeks. Finally, after the boat is tested and initial training is complete, regular sea training can be implemented—weather permitting; regular sea training requires eight weeks. Trygve believes he can put the cost estimates together in a week, given last year’s expenses.
Bjorn is pleased with the expertise displayed by his team leaders. But he believes they need to have someone develop one of those critical path networks to see if they can safely meet the start deadline for the race. Karin and Trygve agree. Karin suggests the cost estimates should also include crash costs for any activities that can be compressed and the resultant costs for crashing. Karin also suggests the team complete the following priority matrix for project decision making:

Bjorn reviews the materials and wonders if the project will come in within the budget of $3.2 million and in 45 weeks. Advise the Whitbread team of their situation.
Case

Nightingale Project—A

You are the assistant project manager to Rassy Brown, who is in charge of the Nightingale project. Nightingale was the code name given to the development of a handheld electronic medical reference guide. Nightingale would be designed for emergency medical technicians and paramedics who need a quick reference guide to use in emergency situations.

Rassy and her project team were developing a project plan aimed at producing 30 working models in time for MedCON, the biggest medical equipment trade show each year. Meeting the MedCON October 25 deadline was critical to success. All the major medical equipment manufacturers demonstrated and took orders for new products at MedCON. Rassy had also heard rumors that competitors were considering developing a similar product, and she knew that being first to market would have a significant sales advantage. Besides, top management made funding contingent upon developing a workable plan for meeting the MedCON deadline.

The project team spent the morning working on the schedule for Nightingale. They started with the WBS and developed the information for a network, adding activities when needed. Following is the preliminary information for activities with duration time and predecessors:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Duration</th>
<th>Predecessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Architectural decisions</td>
<td>10</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Internal specifications</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>External specifications</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Feature specifications</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Voice recognition</td>
<td>15</td>
<td>2,3</td>
</tr>
<tr>
<td>6</td>
<td>Case</td>
<td>4</td>
<td>2,3</td>
</tr>
<tr>
<td>7</td>
<td>Screen</td>
<td>2</td>
<td>2,3</td>
</tr>
<tr>
<td>8</td>
<td>Speaker output jacks</td>
<td>2</td>
<td>2,3</td>
</tr>
<tr>
<td>9</td>
<td>Tape mechanism</td>
<td>2</td>
<td>2,3</td>
</tr>
<tr>
<td>10</td>
<td>Database</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Microphone/soundcard</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>Pager</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Barcode reader</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>Alarm clock</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>Computer /O</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>Review design</td>
<td>10</td>
<td>5,6,7,8,9,10,11,12,13,14,15</td>
</tr>
<tr>
<td>17</td>
<td>Price components</td>
<td>5</td>
<td>5,6,7,8,9,10,11,12,13,14,15</td>
</tr>
<tr>
<td>18</td>
<td>Integration</td>
<td>15</td>
<td>16,17</td>
</tr>
<tr>
<td>19</td>
<td>Document design</td>
<td>35</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>Procure prototype components</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>21</td>
<td>Assemble prototypes</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>22</td>
<td>Lab test prototypes</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>23</td>
<td>Field test prototypes</td>
<td>20</td>
<td>19,22</td>
</tr>
<tr>
<td>24</td>
<td>Adjust design</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>25</td>
<td>Order stock parts</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>26</td>
<td>Order custom parts</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>27</td>
<td>Assemble first production unit</td>
<td>10</td>
<td>25, FS—8 time units</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26, FS—13 time units</td>
</tr>
<tr>
<td>29</td>
<td>Test unit</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>29</td>
<td>Produce 30 units</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>30</td>
<td>Train sales representatives</td>
<td>10</td>
<td>29</td>
</tr>
</tbody>
</table>
Use any project network computer program available to you to develop the schedule for activities (see Case Appendix for further instructions)—noting late and early times, the critical path, and estimated completion for the project. Prepare a short memo that addresses the following questions:

1. Will the project as planned meet the October 25th deadline?
2. What activities lie on the critical path?
3. How sensitive is this network?

Case

Nightingale Project—B

Rassy and the team were concerned with the results of your analysis. They spent the afternoon brainstorming alternative ways for shortening the project duration. They rejected outsourcing activities because most of the work was developmental in nature and could only be done in-house. They considered altering the scope of the project by eliminating some of the proposed product features. After much debate, they felt they could not compromise any of the core features and be successful in the marketplace. They then turned their attention to accelerating the completion of activities through overtime and adding additional technical manpower. Rassy had built into her proposal a discretionary fund of $200,000. She was willing to invest up to half of this fund to accelerate the project, but wanted to hold onto at least $100,000 to deal with unexpected problems. After a lengthy discussion, her team concluded that the following activities could be reduced at the specified cost:

- Development of voice recognition system could be reduced from 15 days to 10 days at a cost of $15,000.
- Creation of database could be reduced from 40 days to 35 days at a cost of $35,000.
- Document design could be reduced from 35 days to 30 days at a cost of $25,000.
- External specifications could be reduced from 18 days to 12 days at a cost of $20,000.
- Procure prototype components could be reduced from 20 days to 15 days at a cost of $30,000.
- Order stock parts could be reduced from 15 days to 10 days at a cost of $20,000.

Ken Clark, a development engineer, pointed out that the network contained only finish-to-start relationships and that it might be possible to reduce project duration by creating start-to-start lags. For example, he said that his people would not have to wait for all of the field tests to be completed to begin making final adjustments in the design. They could start making adjustments after the first 15 days of testing. The project team spent the remainder of the day analyzing how they could introduce lags into the network to hopefully shorten the project. They concluded that the following finish-to-start relationships could be converted into lags:

- Document design could begin 5 days after the start of the review design.
- Adjust design could begin 15 days after the start of field test prototypes.
- Order stock parts could begin 5 days after the start of adjust design.
- Order custom parts could begin 5 days after the start of adjust design.
- Training sales representatives could begin 5 days after the start of test unit and completed 5 days after the production of 30 units.
As the meeting adjourns, Rassy turns to you and tells you to assess the options presented and try to develop a schedule that will meet the October 25th deadline. You are to prepare a report to be presented to the project team that answers the following questions:

1. Is it possible to meet the deadline?
2. If so, how would you recommend changing the original schedule (Part A) and why?
   Assess the relative impact of crashing activities versus introducing lags to shorten project duration.
3. What would the new schedule look like?
4. What other factors should be considered before finalizing the schedule?

CASE APPENDIX: TECHNICAL DETAILS

Create your project schedule and assess your options based on the following information:

1. The project will begin the first working day in January.
2. The following holidays are observed: January 1, Memorial Day (last Monday in May), July 4, Labor Day (first Monday in September), Thanksgiving Day (fourth Thursday in November), December 25 and 26.
3. If a holiday falls on a Saturday, then Friday will be given as an extra day off; if it falls on a Sunday, then Monday will be given as a day off.
4. The project team works Monday through Friday.
5. If you choose to reduce the duration of any one of the activities mentioned, then it must be for the specified time and cost (i.e., you cannot choose to reduce database to 37 days at a reduced cost; you can only reduce it to 35 days at a cost of $35,000).
6. You can only spend up to $100,000 to reduce project activities; lags do not contain any additional costs.

Case

The “Now” Wedding—Part A

On December 31 of last year, Lauren burst into the family living room and announced that she and Connor (her college boyfriend) were going to be married. After recovering from the shock, her mother hugged her and asked, “When?” The following conversation resulted:

Lauren: January 21.
Mom: What?
Dad: The Now Wedding will be the social hit of the year. Wait a minute. Why so soon?
Lauren: Because on January 30 Connor, who is in the National Guard, will be shipping out overseas. We want a week for a honeymoon.
Mom: But Honey, we can’t possibly finish all the things that need to be done by then. Remember all the details that were involved in your sister’s wedding? Even if we start tomorrow, it takes a day to reserve the church and reception hall, and they need at least 14 days’ notice. That has to be done before we can start decorating, which takes 3 days. An extra $200 on Sunday would probably cut that 14 day notice to 7 days, though.
Dad: Oh, boy!
Lauren: I want Jane Summers to be my maid of honor.
Dad: But she’s in the Peace Corps in Guatemala, isn’t she? It would take her 10 days to get ready and drive up here.
Lauren: But we could fly her up in 2 days and it would only cost $1,000.
Dad: Oh, boy!
Mom: And catering! It takes 2 days to choose the cake and decorations, and Jack’s Catering wants at least 5 days’ notice. Besides, we’d have to have those things before we could start decorating.
Lauren: Can I wear your wedding dress, Mom?
Mother: Well, we’d have to replace some lace, but you could wear it, yes. We could order the lace from New York when we order the material for the bridesmaids’ dresses. It takes 8 days to order and receive the material. The pattern needs to be chosen first, and that would take 3 days.
Dad: We could get the material here in 5 days if we paid an extra $20 to airfreight it. Oh, boy!
Lauren: I want Mrs. Jacks to work on the dresses.
Mom: If we did all the sewing we could finish the dresses in 11 days. If Mrs. Jacks helped we could cut that down to 6 days at a cost of $48 for each day less than 11 days. She is very good too.
Lauren: I don’t want anyone but her.
Mom: It would take another 2 days to do the final fitting and 2 more days to clean and press the dresses. They would have to be ready by rehearsal night. We must have rehearsal the night before the wedding.
Dad: Everything should be ready rehearsal night.
Mom: We’ve forgotten something. The invitations!
Dad: We should order the invitations from Bob’s Printing shop, and that usually takes 7 days. I’ll bet he would do it in 6 days if we slipped him an extra $20!
Mom: It would take us 2 days to choose the invitation style before we could order them and we want the envelopes printed with our return address.
Lauren: Oh! That will be elegant.
Mom: The invitations should go out at least 10 days before the wedding. If we let them go any later, some of the relatives would get theirs too late to come and that would make them mad. I’ll bet that if we didn’t get them out until 8 days before the wedding, Aunt Ethel couldn’t make it and she would reduce her wedding gift by $200.
Dad: Oh, boy!!
Mom: We’ll have to take them to the Post Office to mail them and that takes a day. Addressing would take 3 days unless we hired some part-time girls and we can’t start until the printer is finished. If we hired the girls we could probably save 2 days by spending $40 for each day saved.
Lauren: We need to get gifts for the bridesmaids. I could spend a day and do that.
Mom: Before we can even start to write out those invitations we need a guest list. Heavens, that will take 4 days to get in order and only I can understand our address file.
Lauren: Oh, Mom, I’m so excited. We can start each of the relatives on a different job.

* This case was adapted from a case originally written by Professor D. Clay Whybark, University of North Carolina, Chapel Hill, N.C.
Mom: Honey, I don’t see how we can do it. Why, I’ve got to choose the invitations and patterns and reserve the church and . . .

Dad: Why don’t you just take $3,000 and elope. Your sister’s wedding cost me $2,400 and she didn’t have to fly people up from Guatemala, hire extra girls and Mrs. Jacks, use airfreight, or anything like that.

1. Using a yellow sticky approach (see p. 153), develop a project network for the “Now” Wedding.

2. Create a schedule for the wedding using MS Project. Can you reach the deadline of January 21 for the Now Wedding? If you cannot, what would it cost to make the January 21 deadline and which activities would you change?

Case

The “Now” Wedding—Part B

Several complications arose during the course of trying to meet the deadline of January 20 for the Now Wedding rehearsal. Since Lauren was adamant on having the wedding on January 21 (as was Connor for obvious reasons), the implications of each of these complications had to be assessed.

1. On January 1 the chairman of the Vestry Committee of the church was left unimpressed by the added donation and said he wouldn’t reduce the notice period from 14 to 7 days.

2. Mother comes down with the three-day flu as she starts work on the guest list January 2.

3. Bob’s Printing Service’s press was down for one day on January 5th in order to replace faulty brushes in the electric motor.

4. The lace and dress material are lost in transit. Notice of the loss is received on January 10.