

CHAPTER 14

Projects, Teamwork, and Ethics

LEARNING OBJECTIVES

When you have completed this chapter you will be able to

- Develop a project problem and mission statement
- Prepare a project plan, including a work scope, schedule and budget
- Prepare a work breakdown structure diagram and responsibilities table
- Complete an earned-value analysis
- Describe and utilize the elements of successful teamwork
- Describe the forming, storming, norming, and performing stages
- Develop and execute an effective meeting
- Explain and apply the fundamental canons of a code of ethics
- Identify and resolve ethical dilemmas

14.1 INTRODUCTION

The design and manufacture of a product is often accomplished as a project performed by a concurrent engineering team. As the group members participate in the development of a project plan, including a problem statement, mission statement, scope of work, schedule, budget, and responsibilities table, they begin to work as a team. Successful projects can often be traced back to effective teamwork. Similarly, effective teamwork can be traced back to thorough project planning.

We can draw an analogy between project planning and a football team during practice sessions, learning new plays on the board during the “chalk-talk,” and then taking the field to drill individual assignments and hone timing. When athletes know what they are supposed to do, and how to do it, they have a good chance at being successful. Similarly, project teams can establish effective teamwork through communication, decision making, collaboration, and self-management.

Finally, we will examine the fundamentals of professional ethics and how they relate to our project work tasks and everyday decision making.

14.2 PROJECTS

A **project** is a unique sequence of work tasks, undertaken once, to achieve a specific set of objectives. Design projects, in particular, focus on achieving a specific design problem. Other projects include construction or software development. We perform work tasks only once in a project. This aspect is distinguished by a project from daily work routines. A design engineer may help on the other hand, performs the same routine by contacting a dozen customer prospects as part of his or her normal daily responsibilities.

The four major elements of a project are the scope of work (i.e., set of work tasks to be performed), the cost for labor, materials, and other resources to accomplish the scope, the time allotted, and the quality of the work performed (Lewis, 2002). The four elements are usually interdependent. We can illustrate the coupling of the four elements as three legs and area of a triangle as shown in Figure 14.1. If, for example, the scope of work is expanded to include more work tasks, the costs, quality, or time allotted will be affected. We can expand the scope without changing the cost or time, quality will be affected. Whenever a change in one of the four elements needs to be made, the project team would be well advised to consider making revisions to the other three elements.

A project has three main phases: planning, executing, and closing. During planning we determine the what, who, how much, and when. We determine what the work tasks are, who the team members are, which tasks they will complete, how much time, money, and other resources are needed, and when the tasks need to be completed. As we execute our work tasks, we also monitor and control our progress to determine if and when any corrective measures need to be taken. During the closing of a project we reflect and document on our successes and failures, such that we and others in the company can benefit.

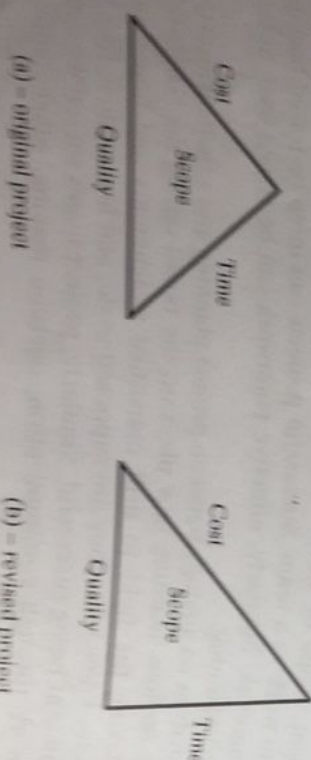


FIGURE 14.1 Scope, cost, time, and quality are interrelated. Change any leg of the triangle or the area of the triangle and the others change also.

14.2.1 Planning a Project

During the project-planning phase, team members prepare a package of items collectively called the **project plan**. The amount of effort that a team spends preparing a project plan usually depends on the extent and type of project. Some design problems require hundreds or thousands of man-hours, weeks, months, or years to solve such as designing a hydroelectric power plant. On the other hand, a simple selection design problem that is expected to take three man-hours would hardly require a project plan.

A fundamental principle of project management is that those who will work on a project should participate in planning it. Those who will do the work usually know best which specific tasks and deliverables need to be completed. They also know how much time and/or other resources may be needed.

A project plan typically includes:

1. Problem statement
2. Project objectives
3. Work breakdown structure
4. Scope of work (work scope)
5. Responsibilities table
6. Organization chart
7. Budget
8. Schedule
9. Risk assessment
10. Risk assessment

1. Problem Statement. A problem statement is a simple sentence or two describing a, what the problem is, b, what the desired end state is, c, what currently prevents it, and d, how we know when we have achieved the desired outcome.

2. Mission Statement. A mission statement is a paragraph of two or three sentences that states what we are going to do, for whom, and how we will go about doing it.

3. Project Objectives. To better understand the amount of work in a project we need to develop **project objectives**, which are specific outcomes that we expect to produce. In a design project, for example, we expect to complete a package of "deliverables," including production drawings, prototype test reports, bills of materials, manufacturing process specifications, and performance simulation reports. Project outcomes should be specific as to quantity and quality. Also, outcomes should be realistic in that they consider available time, personnel, and equipment. An example of some project objectives is shown in Table 14.1. By detailing project objectives, we are determining specific "whats" that will be completed, not the "how." The "how" is determined when the work tasks are detailed, as discussed later.

Example

Bob Bear, Inc. successfully produces a garden tractor, selling about 50,000 tractors per year. However, the company does not make a snow blower attachment for its garden tractor product. A project is needed to design, prototype, and test a new snow blower attachment that is easy to use, safe, and cost-effective.

Problem Statement

The project team will design, prototype, and test a new snow blower attachment for its existing tractor line. The team will formulate customer and company requirements, develop alternative snow blower concepts, configure snow blower attachments alternatives, establish feasible design variable values, prototype components, and test the final preproduction assembly.

Mission Statement

The project team will design, prototype, and test a new snow blower attachment for its existing tractor line. The team will formulate customer and company requirements, develop alternative snow blower concepts, configure snow blower attachments alternatives, establish feasible design variable values, prototype components, and test the final preproduction assembly.

TABLE 14.1 Partial List of Project Objectives for a Design Project.

1. Obtain detailed understanding of customer and company requirements
 - 1.1 Completed survey of 1,000 customers
 - 1.2 Benchmark study of 5 competitive or substitute products
 - 1.3 House-of-quality diagram
 - 1.4 Engineering design specifications
2. Establish alternative concept designs
 - 2.1 Minimum of five feasible concept designs
 - 2.2 Sketches illustrating physical principles, working geometry, and material
 - 2.3 Completed product function decomposition diagrams
 - 2.4 Completed morphological structure table
 - 2.5 Weighted-rating evaluation table
3. Develop alternative configuration designs
 - 3.1 Three feasible product architecture diagrams
 - 3.2 Special-purpose configuration sketches
 - 3.3 Completed design for assembly checklist
 - 3.4 Completed design for manufacture checklist

A **Work Breakdown Structure**. A work breakdown structure (WBS) is a diagram that illustrates the major work tasks to be completed during a project. It is a graphical "outline" of sorts. The primary work task categories are at the top level, with subordinate tasks underneath each major task. In a glance, the reader gains an overview of the work to be completed. An example is shown in Figure 14.2.

Scope of Work. A scope of work is a written detailed list of tasks to be completed during the project. Each level 1 task is subdivided into level 2 tasks. Level 2 tasks can be expanded into narrative sentences and paragraphs. Alternative items, such as progress reports, test reports, physical prototypes, and deliverables, are also mentioned, in addition to the task description. Project teams use the opportunity to jointly develop the work scope and clarify the project's purpose and objectives before the project begins.

Responsibilities Table. The individuals responsible for each task, as well as others who will be assisting, are listed in a project responsibilities table. Those in charge of a task have "R" next to their work time estimate. The table helps to coordinate key team members and those that assist. An example responsibilities table is given in Table 14.3.

Organization Chart. An organization chart includes the name and function of each team member. The chart helps to facilitate communications and foster accountability. An example chart for a concurrent engineering design team is shown in Figure 14.3.

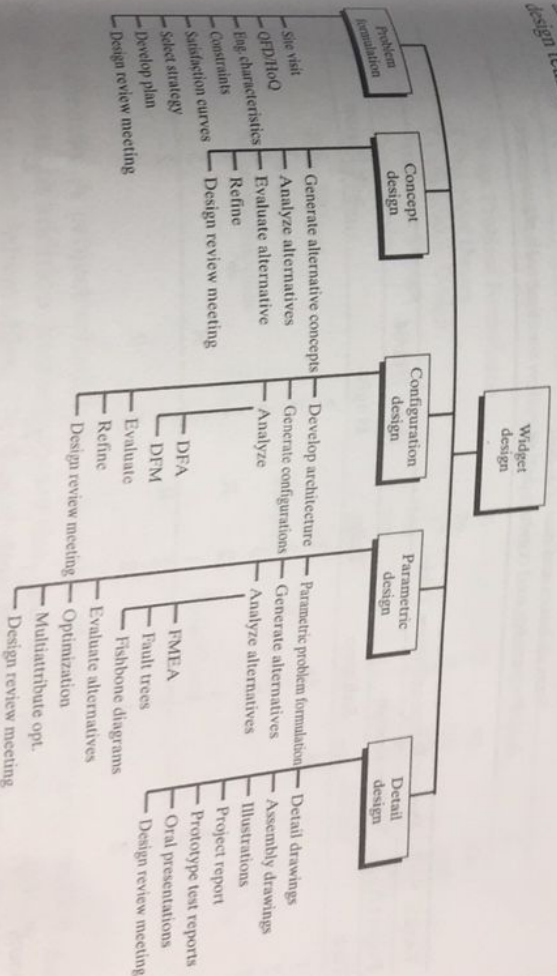


FIGURE 14.2 Work breakdown structure for a typical new product design project.

TABLE 14.2 Example Scope of Work for Section 1

- 1.0 Design problem formulation
 - 1.1 Visit site
 - 1.2 Meet with management/clients to discuss design problem
 - 1.3 Contact consumers
 - 1.4 Make phone calls to determine pros and cons of current unit
 - 1.5 Set an appointment time to witness existing product in operation
 - 1.6 Conduct benchmarking
 - 1.7 Research existing products that are currently available
 - 1.8 Contact manufacturers and request brochures
 - 1.9 Analyze the competition for functionality and performance
- 1.4 Complete QED/HOO
 - 1.5 Determine requirements, engineering characteristics
 - 1.6 Determine parameters
 - 1.7 Define problem definition parameters, design variables
 - 1.8 Define solution evaluation parameters/performance parameters
 - 1.9 Estimate satisfaction levels for performance parameter
 - 1.10 Estimate engineering design specifications
 - 1.11 List in-use purposes for the product
 - 1.12 List customer and company requirements
 - 1.13 Finalize scope of work
 - 1.14 Refine work breakdown structure
 - 1.15 Determine schedule
 - 1.16 Assign a time value to each task
 - 1.17 Prepare Gantt chart
 - 1.18 Prepare budget
 - 1.19 Determine total number of engineering hours
 - 1.20 Determine total number of expert faculty hours
 - 1.21 Sum all hours and material cost
 - 1.22 Prepare for and conduct design review meeting with management

TABLE 14.3 Project Responsibilities Table

Project Name: Widget Design		Date: 7/11/04				
Task	Smith	Johnson	Tully	Hughes	n-th Person	Hours
1.1	6	R	1	2	2	12
1.2	3		3	3	3	14
1.3	1	2	3	6	6	18
1.4	2	1	2	R	4	11
1.5	4	1	1	3	5	14
1.6	3	2	2	R	2	11
1.7	2	1	2	5	3	13
n-th task						
Total hours	21	11	13	23	25	93
R - Responsible engineer in-charge						

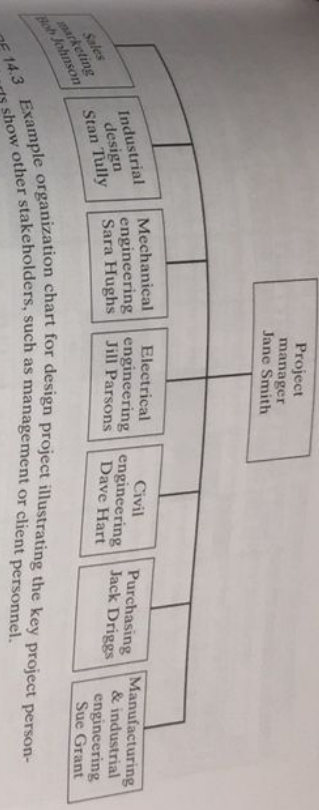


FIGURE 14.3 Example organization chart for design project illustrating the key project personnel. Some charts show other stakeholders, such as management or client personnel.

8. Budget. The planning for each work task is assigned to one or more individuals. They, in turn, estimate the man-hours, and other resources, necessary to complete the assigned task and are summarized in the project budget. An example budget is shown in Table 14.4.

TABLE 14.4 Example Project Budget Listing Major Work Tasks, Time, and Expenses Required to Complete the Project Tasks

Project Name: Snow Blower Attachment Design		Date: 2/7/04			
Task	Description	Sr. Engineers	Admin.	Hours	\$
1.0	Design Problem Formulation	91	2	93	1900
1.1	Conceptual Design	96	6	102	2160
1.2	Configuration Design	97	8	105	2260
1.3	Parametric Design	160	9	169	3560
1.4	Detail Design	202	10	212	4440
1.5	Total Hours	646	35	681	
1.6	Rate: \$/Hour	20	40		
1.7	Total Labor Cost	\$ 12,920	\$ 1,400		\$ 14,320
1.8	Materials/Supplies				\$200
1.9	Total Costs:				\$ 14,520.00

9. Schedule. A project schedule is a chart that illustrates when each task begins and ends. In addition, key events are denoted, including interim review meetings and report deliverables. The **Gantt chart** format shows work tasks as horizontal bars as shown in Figure 14.4. Special events, called **milestones** and deliverables are often shown as small diamonds, triangles, or circles.

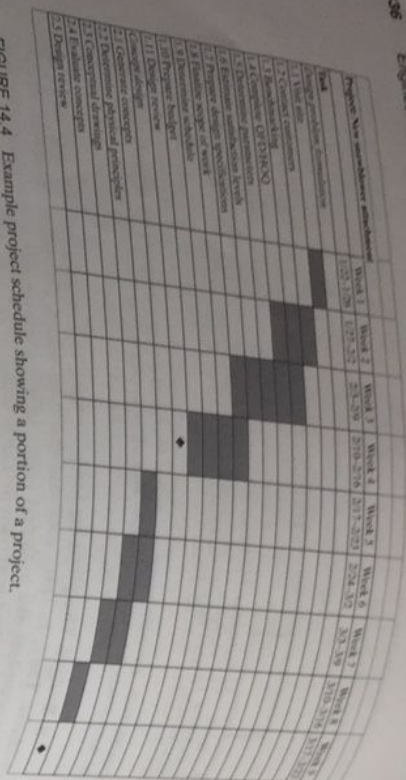


FIGURE 14.4 Example project schedule showing a portion of a project.

The major drawback of the Gantt chart is that succeeding tasks are not "connected" to preceding tasks. It is difficult to determine what effect a delay in a preceding task will have on succeeding tasks and the overall project completion date.

An advanced method, called activity network diagramming, overcomes Gantt chart drawbacks. Project activities are connected by arrows illustrating the network of dependencies. Combinations of parallel and sequential activities are thereby effectively managed. A critical path through the network can be also identified using some simple rules and basic arithmetic. The critical path determines the shortest time to complete the whole network of activities. The program evaluation and review technique (PERT) is an extension of the critical path method and uses quantitative measures to enhance project scheduling. Activity network diagramming is beyond the scope of this book. More information on this method and other aspects of project management can be found in Badiru and Pulat (1995) and Stubb et al. (1994).

10. Risk Assessment. The last section of a project plan involves an assessment of the likely risks that face the project and possible contingency plans to overcome such situations. We call this activity risk assessment. First, we determine what risks might exist. Two questions that we might ask are "What is likely to go wrong with the project?" and "What could prevent us from achieving our objectives?" Construction projects, for example face considerable risks, such as building-permit-approval delays, inclement weather, construction-material-delivery delays, and worker strikes. Design projects face risks such as the accidental death or sickness of key personnel, glitches with computer software, delays with fabricating prototypes, testing accidents, and

delays. The second aspect of the risk assessment is to consider a variety of contingency plans. Recognizing key risks in a project and having a couple of ready fallback plans is just smart business. The project plan is a road map of what the team should be working on, and how much time and resources to devote to each task. Even though the plan is based on estimates that may be under or over, or ahead or behind schedule, the plan helps the team to keep the project on track. Without a plan the team has no idea if it is "on-track" or not. A road map the team may not know where it is going, or worse yet, it may reach its destination. Project planning phase a significant amount of information is gathered and collected. Project notebooks can organize and protect data, and observations. In addition, a team notebook or file cabinet is used to store originals of key documents. Notebooks and file cabinets should be organized into convenient sections as suggested in Table 14.5.

TABLE 14.5 Example Project Notebook/File Cabinet Sections

Identification sheet	
Project name	Team member name
Telephone/e-mail addresses	
Design problem formulation	
Engineering design specifications	
Customer notes	
House of quality	
Prior art (library research, Web)/benchmarks	
Alternative generation, analyses, and evaluation	
Analysis plan	
Computations, experiments	
Citations for equations, data	Spreadsheets
Sketches, figures, schematics, drawings	
Evaluation plan	
Evaluations/computations	
References/bibliography	
Project engineering	
Project meeting notes	
Work breakdown structure	
Scope of work	
Project schedule and updates	
Budget, earned-value analyses	
Risk assessments	
Time sheet—log of work/team meeting hours	
Punch lists of things to be done	
Vendor information	
Telephone numbers, addresses	
Phone conversations notes	
Web site printouts	
Product/vendor literature	

As part of the planning phase, a project team may prepare a project proposal for review and approval by upper-level management. A project proposal is a written document that describes the problem, mission, objectives, scope of work, budget, schedule, and risks. A project proposal template is shown in Table 14.6.

TABLE 14.6 Example Template for a Design Project Proposal

Design Project Proposal
Cover letter
Title page
Table of contents
Introduction
Problem statement
Mission statement
Engineering design specifications (QFD)
Project objectives
Scope of work
Work breakdown structure (WBS), 2-level diagram
Work scope describing work tasks
Project deliverables associated with tasks
Schedule
Gantt chart
Critical path network diagram
Milestones
Budget
Responsibilities table
Budget
Other resource requirements
Project management
Organization chart of project stakeholders
Project budget and schedule control system
Risk assessment
Design change notice (DCN's) procedure
Appendix
Site visit data

Successful project teams develop comprehensive project plans.

14.2.2 Executing a Project

As we execute a project we work together in groups, meeting with our teammates to discuss important developments, coordinate work efforts, and make team decisions when required. We also work on individual assignments by

themselves. We need a way to control the project to make sure our efforts are coordinated and appropriate. Then, we can take corrective measures as needed.

Budget-value analysis is a widely used project control method that compares actual versus budgeted expenses on a period-by-period basis. The first step in preparing an earned-value analysis is to calculate the **budgeted cost of work scheduled (BCWS)** for each time period. If, for example, we choose to schedule the project in three periods, we would take the total amount budgeted for the work and allocate it over the weeks that we are scheduled. For example, Table 14.7 shows a project that has three tasks, A, B, and C. Task A is budgeted for \$1,000 and a project that the project team members will work evenly over the three weeks during which it is scheduled. We therefore enter \$1,000 per week for task A. Let's assume that our work efforts are evenly divided among the three weeks. Again, we therefore distribute the \$10,500 in \$3,500 increments over the three weeks. We similarly distribute for work task C, which is scheduled over weeks 2, 3, and 4. We similarly distribute for work task B, which is scheduled over weeks 1, 2, and 3.

We determine the weekly budget by adding across the columns, arriving at a total budget of \$1,000 for the first week, \$4,500 for the second week, and so on. The BCWS is shown in Table 14.7 and is an accumulation of the weekly amounts. In any week, we can look at the BCWS column to know what we should have spent in total. The BCWS is a measure of the **actual cost of work performed (ACWP)**. Fortunately, the accounting department prepares these amounts as weekly expenses. The accounting department tallies payroll, material, and other costs that are actually expended each week as the project continues.

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TABLE 14.7 Earned-Value Analysis Table before the Project Starts (Week #0)

Week	Work Task			End of Week:		
	A	B	C	Weekly	BCWS	BCWP
1	1000	3500	2800	1000	1000	
2	1000	3500	2800	4500	5500	
3		3500	2800	7300	12800	
4			2800	6300	19100	
5			2800	2800	21900	
6			2800	2800	24700	
7			2800	2800	27500	
8			2800	2800	30300	
Total	3000	10500	16800	30300		
% Complete	0	0	0	0		
BCWP	0	0	0	0		

340 Engineering Design

TABLE 14.8 Earned-Value Analysis Table as of the End of Week #1

Week	Earned-Value Analysis			End of Week		
	Work Task	Weekly	BCWS	BCWP	Schedule Variance	ACWP
1	A	1000	1000	750	-250	600
2	B	1000	1000	750	-250	600
3	C	1000	1000	750	-250	600
4	D	1000	1000	750	-250	600
5	E	1000	1000	750	-250	600
6	F	1000	1000	750	-250	600
7	G	1000	1000	750	-250	600
8	H	1000	1000	750	-250	600
Total		8000	10800	16800	30300	150
% Complete		25	0	0	750	
BCWP		750	0	0	750	

These amounts are entered weekly into the weekly column labeled ACWP. Let's assume that the total expenses for the project are \$600. This amount is shown in Table 14.8.

The next step is to calculate the **budgeted cost of work performed (BCWP)** by estimating the **percent complete** for each task and multiplying it by the total task budget amount. The result is a measure of the amount of the budget that was planned for the work actually completed. Assume that at the end of week 1, we have completed about 25 percent of task A; 25 percent of \$3,000 is \$750. We enter this value in the first row of the BCWP column.

Next we compute the schedule variance and the cost variance, for week 1, according to the following formulas:

$$\text{Schedule Variance} = \text{BCWP} - \text{BCWS}$$

$$\text{Cost variance} = \text{BCWP} - \text{ACWP}$$

$$\text{Schedule variance} = \$750 - \$1,000 = \$ -250$$

$$\text{Cost variance} = \$750 - \$600 = \$150$$

The **schedule variance** is a measure of how much work we accomplished in relation to the amount that was planned. Since we had planned \$1,000 of work, but accomplished only \$750, a negative schedule variance means that we are behind and that we need to make more progress in the coming weeks.

The **cost variance** is a measure of how much we spent in relation to how much we should have spent for the work accomplished. Since we should have spent \$750 to accomplish the amount of work we paid \$600 for, we are under budget by \$150. Since we saved \$150, we might spend some of it on extra help to get caught up to our schedule. A negative cost variance would mean that we overspent for the work performed.

Negative values indicate poor performance, such as behind schedule or over budget, and positive values indicate good performance, such as ahead of schedule or under budget.

Let's assume that we have been working on the project for seven weeks, and we are finishing the earned-value analysis at the end of week 7, as shown in Table 14.9.

Let's examine the project started. Then around week 7 the team began to slip, since by examining the cost variance, we see that the team began to slip around week 4 and especially week 5.

Similarly, the project manager uses the weekly earned-value analysis results to correct budget actions, such as assigning more or less personnel to the project, or reallocating budget funds among team members or tasks. The schedule variance in week 7 appears to show that the team is getting back on track with the project, and may finish the project almost on time, but the cost variance indicates they might finish over budget.

A graphical chart of the BCWS, BCWP, and ACWP is shown in Figure 14.5, which means that the team was behind schedule. We see that this gap is narrowing; therefore, they are catching up.

We also see that the ACWP curve is close to the BCWP for the early weeks, meaning that the team was spending their budget in proportion to the work they actually performed. The situation worsened in weeks 4–6 but improved after that.

TABLE 14.9 Earned-Value Analysis for End of Week #7

Week	Earned-Value Analysis			End of Week:		
	Work Task	Weekly	BCWS	BCWP	Schedule Variance	ACWP
1	A	1000	1000	750	-250	600
2	B	1000	1000	750	-250	600
3	C	1000	1000	750	-250	600
4	D	1000	1000	750	-250	600
5	E	1000	1000	750	-250	600
6	F	1000	1000	750	-250	600
7	G	1000	1000	750	-250	600
Total		8000	10800	16800	30300	150
% Complete		97	93	85		
BCWP		2910	9765	14280	26955	

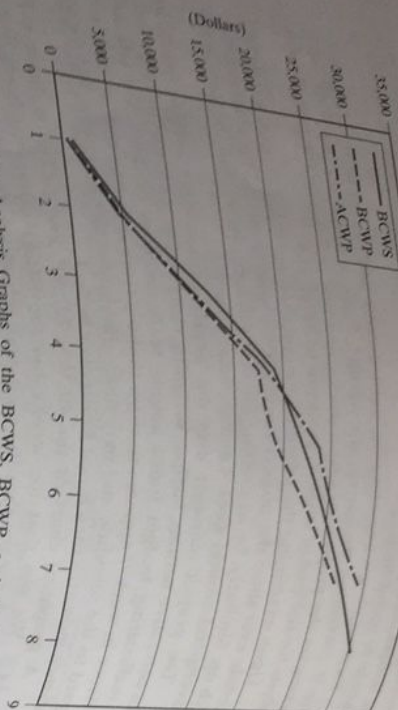


FIGURE 14.5 Earned-value Analysis Graphs of the BCWS, BCWP, and ACWP. The gap between the BCWP and BCWS lines is the schedule variance. The gap between the BCWP and ACWP is the cost variance.

14.2.3 Closing a Project

At the conclusion of a project we perform a project review. We reflect back what we learned, what we did well, and what we could have done better. We record and archive these findings for future use. Archival information can give future project teams a head start and hopefully prevent them from making similar mistakes. An official closing of the project signifies that our project team is no longer working or spending resources on it and is available for reassignment.

14.3 TEAMWORK

A **team** is a group of people who have complementary skills and knowledge, work together toward common goals, and hold each other mutually accountable. A product development team, for example, will have members with special skills and knowledge in areas such as sales, marketing, engineering design, purchasing, manufacturing engineering, production, and distribution. They share the goal of developing a successful product. They also are mutually accountable for the performance of the fellow team members.

Not all teams have **teamwork**, however. In team sports, for example, we routinely witness examples where teamwork breaks down, with personality issues, poor timing, or not paying attention to the game. Engineering design and manufacturing teams are quite similar.

Elements of Teamwork

Let's examine a well-executed offensive play in football to identify some of the ingredients for teamwork. The quarterback receives the recommendation from the head coach. During the huddle, the quarterback executes a defensive lineup, spots an opportunity to run a different play, and calls for a play in a coordinated fashion. Individual team members perform the new roles, but with a common purpose of scoring. Blockers protect the quarterback as he drops back into the pocket for a pass. A halfback separates to a fake a running play. As one receiver sprints from the quarterback line he sees an opening and adapts his running pattern. The quarterback follows the football in his direction. The receiver successfully catches the ball and runs toward the goal line with his teammates blocking a path in front of him. Using his well-conditioned running skills he dodges the last tackler and scores a touchdown. Now that was teamwork!

Successful project teams and sports teams exhibit a number of common traits which can be classified into four major categories (McGourty and Redmond, 2001): communication, decision making, collaboration, and self-management.

Communication Communication is the means by which we exchange information between team members. The quarterback communicated his observation to the offensive line, thereby taking advantage of an opportunity. He also effectively communicated the timing of the hike, preventing an offside penalty. Team members were watching and listening and came to the aid of one another.

Decision making. An effective communicator will spend time in preparing better oral presentation. Written documents such as e-mails, memoranda, and reports. And an effective communicator will take specific actions to make himself or herself understood.

Listening. Skills are an important aspect of good communication. The listening teammates had their "heads up," watching and listening to the play as it unfolded. Without their "listening" the play might have ended differently. Whether in professional football or business, we can find people who "miss the call" because they are not listening carefully or paying attention.

Listening is an individual skill, something that we have control over, and something that we can improve. Listening guidelines include:

- Stop talking.* Hear "the play?" Engage in only one discussion at a time.
- Show respect.* Empathize with the speaker. Show interest in what is being said, respond with appropriate body language, and refrain from interrupting.
- Concentrate on what is being said.* Do we understand the message completely? Is there something missing?

Stay calm. Keep control of our emotions. React to the ideas or facts not to the speaker presenting them. Try not to jump to any conclusions.

Empowering Groups

Ask questions. Take responsibility for some of the communication. Paraphrase the speaker's main points until we understand them. We should try to understand the speaker before trying to have our views understood.

Decision Making Effective decision making begins with having a clear understanding of the problem. It also involves activities for generating, analyzing, evaluating, and refining alternatives, and then implementing the best one in a timely fashion.

Team decision making takes effort. For example, when we make "high school" decisions we don't necessarily need to communicate with, or understand, others. We can use our own criteria and selection process to decide the best alternative. Team decision making, on the other hand, requires subordinating our own individual desires for the good of the team.

Assuming that the team has gathered the pertinent data and established evaluation criteria and importance weights, they can prepare a weighted rating evaluation to prioritize the alternatives. The final decision, however, comes down to the team making its final selection. Various approaches include a handoff to management, voting, and consensus.

The handoff to management is an abdication of the team's responsibility to find the best solution for the company. Non-effective teams will pass decisions up the chain of command, especially if the team is concerned about personal retribution. Effective teams will be decisive and recommend action plans for management review and approval.

Voting is a seemingly democratic process, which can lead to some less-than-desirable consequences. If the team decides to use a "unanimous vote required" criterion one team member has the power to veto all choices, such that everyone loses. If the team uses a "majority vote wins" criterion then as the majority wins, the minority loses. Ignoring the minority's issues may put the company at risk.

A **consensus decision** occurs when the team thoughtfully examines all of the issues and agrees upon a course of action that does not compromise any strong convictions of a team member. The approach gives everyone an opportunity to present his case, while recognizing that in some circumstances a "command decision" has to be made. While a team member may not get the choice he favors, at least he knows why, and moreover, agrees that the decision has to be made.

Collaboration Teams that exhibit effective collaboration have members that are committed to the goals of the team, work cooperatively and constructively, actively participate in team activities, and support fellow team members. In our example, the blockers protected the quarterback. And the receiver got blocking help from his teammates when they realized the opportunity for a team score. Collaboration requires subordination of individual desires so that the team can benefit.

Teamwork Effective teams have members that manage themselves, monitor their own progress to meet established goals, stay focused on team tasks, use meeting time effectively, solicit constructive feedback on team tasks, involve others in all the decision making, and put top priority on team results.

Improving our collaboration, communication, decision making, and teaming skills we can become better team members. Fifteen teaming skills are presented in Table 14.10. Informally, we can regularly evaluate our teaming skills. We could also ask our fellow team members, we could ask our manager, computer, or internet-based, to survey team members on teaming skills (Egger, 2008; Longmy et al., 2007; McCourty and Longmy, 2007). The forms are distributed to team members for completion, collected and forwarded to an independent person, thereby protecting the team. A summary report is then prepared and returned to each team member. Frequent feedback and self-reflection are potent tools that help to improve teaming skills.

TABLE 14.10 Teamwork skills

Collaboration	1.	Understands and commits to team goals
	2.	Participates actively in team activities
	3.	Respects individual viewpoints/differences
	4.	Accepts criticism
	5.	Assists other teammates
Communication	6.	Listens attentively to others on team
	7.	Provides constructive feedback
	8.	Communicates clearly and concisely
	9.	Makes decisions based on facts
Decision Making	10.	Anticipates problems
	11.	Contributes to meetings
	12.	Monitors self-progress
Self-Management	13.	Completes individual tasks thoroughly
	14.	Completes individual tasks on time
	15.	Asks for help when needed

14.3.2 Stages of Team Development

Teamwork develops over time. We don't expect a group of football players to exhibit teamwork the first day of practice. Neither can we expect a business team to do the same. A professional team will practice their skills until they are ready for the game. Unfortunately, few business teams have the same opportunity. Business team members usually develop their skills of communication, decision making, collaboration, and self-management on-the-job.

One tongue-in-cheek model of team development includes the following sequence of stages:

1. project initiation,
2. wild enthusiasm,
3. disillusionment,
4. chaos,
5. search for the guilty,
6. punishment of the innocent,
7. promotion of the nonparticipants,
8. and finally, definition of the project requirements (Lewis, 2002).

On a more serious note, however, we do find that teams actually experience different stages. Tuckman presented a model describing four stages: forming, storming, norming, and performing (1965).

Forming. At the beginning of a project, participants transition from being individuals to being team members. Somewhat anxiously, members positively interact to learn about the nature of the tasks to be performed, the goals of the project, and the personalities and work styles of fellow members.

Storming. During this stage, members begin to realize the enormity of the project. They recognize differences in individual abilities, personalities, and work styles. Disagreement and conflict may lead some members to retreat from the group to try and "do it alone." Tension, conflict, and scapegoating often occur.

Norming. During this stage members begin to cooperate with each other. They begin to understand and respect individual strengths and weaknesses. They begin to focus on common goals and communicate more openly. They evolve acceptable standards of behavior, or norms, for performing their roles and resolving conflict. And slowly a team spirit begins to emerge.

Performing. During this stage the team is productive and satisfaction is high. Team members share accountability for their actions and are strongly united. Project activities are conducted in an atmosphere of trust and mutual support. Conflicts are resolved openly and effectively as members are comfortable with their roles.

The most important aspect of Tuckman's model is that most groups evolve through these same four stages. They are destined to form, storm, norm, and perform. Therefore, we should recognize that our team interactions will be dynamic and they will evolve. And more importantly, we need to work through the difficult times.

Effective Team Meetings

Effective team meetings need to be well planned and efficiently executed. Team members should concentrate on the agenda. Just like a scope of work, an agenda should be a combination with a schedule. When possible, it should be sent to team members in advance for review and comment. If an agenda is not prepared, we need to use the first five minutes or so of a meeting to prepare one.

An agenda should list the topics to be discussed along with an estimated time required and the initials of the person coordinating that item of discussion. Topics should be ordered logically. The topics should be designated in order of importance. A facilitator keeps the meeting focused and moving. He or she intervenes when discussions take tangents and prevents anyone from sidetracking or from being overlooked. The last item of the agenda should be a summary or from being overlooked. The last item of the agenda should be a summary or from being overlooked. The last item of the agenda should be a summary or from being overlooked. The last item of the agenda should be a summary or from being overlooked.

Effective Execution Having an agenda will enhance any meeting. By executing the agenda, the team will accomplish what it expects to accomplish, in the time it expects to take. The following guidelines, however, are recommended to facilitate its execution.

- **Start on time.** Coming late to a meeting wastes the other participants' time and is disrespectful.
- **Practice effective listening skills.** Understand first, before trying to be understood.
- **Facilitate the facilitator.** Help keep the meeting on time and on topic.
- **Come prepared.** We should never "wing it." If we are presenting an agenda topic, we should be ready for our listeners. It may be the only chance to get our points across.
- **Discuss fact not fiction.** If facts are not available, try to reschedule the topic, such that an informed and factual decision can be made.
- **Take action.** Encourage a consensus decision and move on.
- **Take minutes.** Record key topics, decisions made, and actions to be taken.
- **Draft next agenda.** Before participants leave discuss tentative topics, times, and presenters.
- **Turn off cell phones.** The other meeting participants are honoring us by attending. We should not let any personal calls interrupt the meeting, thereby wasting their time.

14.3.4

to and signifying the goals of team

- Commit to the goals of the team
- Perform assigned tasks completely, accurately and on time
- Respect the contributions of others
- Assist other team members when needed
- Ask for help before we get into trouble
- Follow guidelines for effective meetings
- Actively participate in team deliberations
- Focus on problems not people or personalities
- Constructively resolve conflicts or differences of opinion
- Comment clearly and constructively

14.4

As engineering professionals, we make decisions that affect our fellow employees, customers, the public, and the profession. As we make product decisions, for example, we strive to design and manufacture each product so that they are both safe and financially successful for our employer. In some cases, however, a safer product may mean less profits for our company. Should we approve engineering changes that endanger customers, even if it means we are appointing our managers? Will our management appreciate and respect the long-term benefits of ethical decision making? Who should we be loyal to? Our employer or the public? Are we obligated to follow a course of action to? Do we have a professional responsibility to "do the right thing"?

14.4.1

Professional ethics are standards of conduct to be followed by every member of that profession, Engineering societies such as the American Society of Mechanical Engineers (ASME) and the American Society of Civil Engineers, as well as many other societies, embody these ethical standards of conduct in their *code of ethics*.

A code of ethics is important because: (1) a code of ethical standards provides a systematic collection of rules to guide all members of the profession, (2) a code encourages value-laden decisions for the public good, (3) code provides employees a working environment to resist the pressures of unethical business practices, (4) a code protects members in that profession from being

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and (3) a code helps to sustain the

With the principles of the ASME code emphasize that if we want to maintain the integrity, honor, and dignity of the profession we must first and foremost advance the enhancement of human welfare. The knowledge and skill for the enhancement of human welfare can be accomplished by being honest, impartial, and fair. That this can be accomplished by being honest, impartial, and fair is the responsibility of the engineer. We must use our knowledge and skill to advance the welfare of our employers, clients, and the public, and by striving to improve the welfare of our society. We must also maintain the integrity, honor, and dignity of our profession. Note how the ASME code emphasizes the importance of the engineer's ethical values that we can use to guide our decision making.

exercising good judgment in the practice of our profession

loyal to our employer, clients, public and the profession.

being reliable, dependable, accountable, and trustworthy

fundamental canons are a set of standards or rules that members

The law should follow the science. We should follow the science.

Engineers are not only responsible for the performance of their professional duties. There is nothing more

important than the safety, health, and welfare of the public. We are responsible for conducting safety reviews, and for providing users with information for their operation. We should not approve designs that could endanger others. If our judgment is overruled we are obligated to inform our clients, suppliers, or other authorities of the possible consequences. We are also required to report other individuals or firms that are in violation.

2. Engineers shall perform services only in areas of their competence. We are obligated to perform engineering work in fields where we are not qualified by education and experience. We have a responsibility to refuse such work.

Engineers shall continue their professional development throughout their

3. Engineers shall provide opportunities for the professional development of officers under their supervision. We are responsible for keeping up with those engineers under our supervision. We are responsible for keeping up with technology, to know what the current standards of engineering practice are, and we should encourage those under our supervision to do so.

Engineers shall act in professional matters for each employer or client as

4. Litig-
agents or trustees, and shall avoid conflicts of interest. We have a re-

to inform our clients or employers of known conflicts of interest.

...should not accept remuneration or other valuable consideration for specifying

We must treat all information received from our clients and em-

We should not accept outside employment without notification.

employer.

5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others. We should not misrepresent our professional qualifications. We should not embellish or plagiarize technical

reports. We should not injure the professional reputation of other engineers. We should not propose or accept any contracts on a contingency basis such that our judgment might be compromised.

6. *Engineers shall associate only with reputable persons or organizations. We should not associate with a dishonest or fraudulent party, nor use that party to engage in unethical practices.*

7. *Engineers shall issue public statements only in an objective and truthful manner. We should never embellish or misrepresent the facts. We should be objective and present both sides of an argument. We have a responsibility to extend public knowledge and to prevent misunderstandings.*

8. *Engineers shall consider environmental impact and sustainable development in the performance of their professional duties. We must consider the impact of our plans or designs on the environment and provide for the development, health, and welfare of the public.*

9. *Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct. We should not make unwarranted claims against another engineer.*

10. *Engineers who are members of the Society shall endeavor to abide by the Constitution, By-Laws and Policies of the Society, and they shall disclose the knowledge of any matter involving another member's alleged violation of the Code of Ethics or the Society's Conflicts of Interest Policy in a prompt, complete and truthful manner to the chair of the Committee on Ethical Standards and Review. If we want to be a member of the profession, we have to abide by the rules of the profession.*

14.4.2 Resolving Ethical Dilemmas

Most employees and employers conduct themselves in an ethical manner. However, there may come a time when we are faced with an unethical situation. How should we go about resolving it? Hopefully we can work it out inside the company. If not, we may need to "blow the whistle" on our employers and go public with our concerns. The following steps are recommended:

1. Obtain the facts of the situation.
2. List the stakeholders who have a vested interest in the outcome.
3. Consider the motivations of the stakeholders.
4. Formulate alternative solutions using codes of ethics, or ethical values.
5. Evaluate the alternatives and reject unethical solutions.
6. Seek assistance from co-workers, supervisors, and ombudsmen.
7. Select the alternative that satisfies the highest ethical values.
8. Implement the selected solution through the chain of command.

9. Monitor the outcome.

10. If unsatisfactory, contact legal counsel, professional society, or the media.

SUMMARY

- 14.5 The interdependent elements of a project are the work scope, time, budget, and quality of the work performed.
- 7 A work breakdown structure is an illustration of the basic work tasks.
- 7 Those who will be working on the project should plan it.
- 7 A project schedule indicates the beginning and ending of work tasks.
- 7 A project-value analysis is a method used to determine whether a project is ahead or behind schedule and under or over budget.
- 7 Teamwork involves communication, decision making, collaboration, and self-management.
- 7 Effective listening skills facilitate being a good communicator.
- 7 Consensus decision making is preferable to voting.
- 7 Teamwork develops through forming, storming, norming, and performing.
- 7 Having a complete agenda is the first step to an effective meeting.
- 7 Professional ethics are standards of conduct based on ethical values.
- 7 A code of ethics provides guidelines of conduct that members must follow.

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