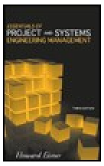

Essentials of Project and Systems Engineering Management, Third Edition

by Howard Eisner

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Chapter 3: The Project Plan

3.1 INTRODUCTION

The project plan (PP) is at the core of the planning function for the project team, and is a blueprint for the work to be performed as well as the proposal to the customer, if such a proposal is indeed required. The project plan has seven essential elements:

1. Needs, goals, objectives, and requirements
2. Task statements, statement of work, and work breakdown structure
3. Technical approach
4. Schedule
5. Organization, staffing, and task responsibility matrix
6. Budget
7. Risk analysis

All project plans should contain these essential elements, although it is recommended that a project plan should be as short and concise as possible. If the customer requires great elaboration of the preceding elements, then a “short form,” or summary of the project plan, should be prepared that will serve the project team on a day-to-day basis. The project plan should be used in at least the following ways:

1. To allow all project team members, including newly assigned personnel, to understand the essentials of the project
2. To provide corporate management, to whom the project reports, with an understanding of the project
3. To convey to the customer the project essentials, as perceived and formulated by the project team
4. To form the basis for a proposal to the customer, where such a proposalis called for

Updates to the formal project plan should be considered on a quarterly basis. Changes to various portions of the plan, such as the schedule, should be carried out when necessary.

In this chapter, use is made of various items in the literature, and in requests for proposal, to show examples of the type of material that has been used on real projects and programs. In addition, an example of a project with eight tasks is postulated so as to convey how the various elements of the project plan are interrelated.

3.2 NEEDS, GOALS, OBJECTIVES, AND REQUIREMENTS

This first part of a project plan can be divided into two parts, the first consisting of needs, goals, and objectives, and the second constituting the requirements. Requirements are of two types, project and system, with the latter being quite voluminous and usually a part of the formal contract between the customer and the system developer. Statements of needs, goals, and objectives can be rather variable.

The statements of needs, goals, objectives, and requirements come from the customer and acquirer of the system to be developed. The outside system developer, therefore, is a recipient (rather than an original source) of these statements. For at least this reason, they are much condensed or simply reiterated or incorporated by reference when a Project Manager deals with them in a project plan.

3.2.1 Needs

The Department of Defense (DoD) acquisition directive [3.1] states that three key aspects of acquisition management are

1. Translating operational needs into stable affordable programs
2. Acquiring quality products
3. Organizing for efficiency and effectiveness

With respect to the first key, the statement is made [3.1] that “prudent management also dictates that new acquisition programs only be initiated after fully examining alternative ways of satisfying identified military needs.” Mission needs are also “identified as a direct result of continuing assessments of current and projected capabilities in the context of changing military threats and national defense policy.” Examples of possible military needs that are identified in the acquisition directive are

1. The need to impede the advance of large armored formations 200 kilometers beyond the front lines, or
2. The need to neutralize advances in submarine quieting made by potential adversaries

Whereas the DoD may have rather formal procedures and processes for identifying and documenting needs, other government agencies and potential commercial clients are likely to be much less structured in their approach to this issue.

The bottom line, with respect to needs, is simply that the system acquirer must make sure that a true need exists for the system in question. If that is not the case, the project may ultimately not be able to be sustained. The reader who wishes to explore this matter in greater depth may obtain the DoD directive cited or examine the commentary of J. Davidson Frame, who spends an entire chapter in his book [3.2] on the matter of “making certain that a project is based on a clear need.”

In terms of the program plan, the statement of need can be abstracted from the needs as represented by the acquisition agent. It can be very short and expressed in only a few lines. This is in distinction to the needs analysis and confirmation carried out by the acquirer of the system. As indicated by the earlier DoD directive, such a needs analysis and assessment can be rather formal and substantial, following the guidelines of the DOD.

3.2.2 Goals and Objectives

Goals and objectives are usually short declarative statements, with goals being rather broad and objectives under each goal being somewhat more specific, although some treat goals and objectives in reverse order. They are often established for programs in distinction to projects. For this reason, they may not be a firm requirement as part of a project plan. An illustrative set of goals and objectives is shown in Table 3.1, in relation to an overall defense science and technology strategy.

Table 3.1: Illustrative Defense Science and Technology Goals and Objectives

Goal A: Deterrence

Objectives

- A.I Deploy weapon systems that can locate, identify, track, and target strategically relocatable targets.
- A.2 Attain worldwide, all-weather force projection capability to conduct limited warfare operations (including special operations forces and low intensity conflict) without the requirement for main operating bases, including a rapid deployment force that is logistically independent for 30 days.
- A.3 Eliminate the threat posed by nuclear ballistic missiles of all ranges, through non-nuclear methods and in compliance with all existing treaties.

Goal B: Superiority

Objectives

- B.1 Attain affordable, on-demand launch and orbit transfer capabilities for space deployed assets with robust, survivable command and control links.
- B.2 Regain the substantial antisubmarine warfare advantages the United States enjoyed until recent years.
- B.3 Achieve worldwide, instantaneous, secure, survivable, and robust command, control, communications, and intelligence (C3I) capabilities within 20 years to include: (a) on-demand surveillance of selected geographical areas; (b) real-time information transfer to command and control authority; and (c) responsive, secure communications from decision makers for operational implementation.
- B.4 Field weapon systems and platforms that deny enemy targeting and allow penetration of enemy defenses by taking full advantage of signature management and electronic warfare.
- B.5 Deploy enhanced, affordable close combat and air defense systems to overmatch threat systems.
- B.6 Field affordable “brilliant weapons” that can autonomously acquire, classify, track, and destroy a broad spectrum of targets (hard fixed, hard mobile, communications nodes, etc.).

Goal C: Affordability

Objectives

- C.1 Reduce operations and support resource requirements by 50% without impairing combat capability.

- C.2 Reduce manpower requirements for a given military capability by 10% or more by 2010.
- C.3 Ensure the affordability, producibility, and availability of future weapons systems.

Another example of a stated objective, as articulated by the U.S. Coast Guard (USCG) in a real-world project procurement [3.3], is

1. To support marine safety and law enforcement activities
2. To record activities and resource usage
3. To analyze mission performance
4. To monitor program effectiveness and resource usage
5. To exchange information between USCG offices, other government agencies at the federal and state level, natural resource trustees, and certain private organizations
6. To fulfill specific statutory requirements

We note that these statements of objectives are concise and to the point and refer specifically to the project work that is being procured by the customer, in this case from the Coast Guard.

3.2.3 Requirements

Requirements, as alluded to in earlier chapters, is a dense and important subject. At the outset, we make a distinction between two types:

1. Requirements to be fulfilled by the project (project requirements)
2. Requirements of the “system” that the project addresses (system requirements)

Project requirements refer to all the work to be performed on the project. System requirements are applicable to the “system” that is being addressed by the project. To illustrate the difference, let us assume that the project is to design, but not build, a new “subway” system for a city. That is, the project is limited to design and does not include the construction of any hardware or software for the system. The project requirements, therefore, are limited to all the work to be accomplished as part of the design process only. This may include estimating the cost of the subway system for each year during its entire life cycle. However, the cost of the project itself, limited as it is to the design phase, is clearly a subset of that total cost, and is likely to be only a minor part of the life-cycle cost of the subway system. The system requirements describe, at increasing levels of detail, the full characteristics of the subway system, from initial design to operations and support.

Thus, the Project Manager (PM) must keep in mind this distinction when constructing the project plan. The latter should be focused on the *project* requirements, with the system requirements carried forth, as defined by the customer, in an ancillary document to be used in engineering the system in question. Further discussions of the ways in which the system requirements are to be handled are found in Chapter 8.

Project requirements are often stated by a customer in the main body of a request for proposal in both broad and specific terms, whereas system requirements can be described in several volumes of reports. An example of the former is shown in Exhibit 3.1, drawn from a requirements statement in a U.S. Coast Guard procurement dealing with mission-oriented information systems engineering (MOISE) support.

Exhibit 3.1: U.S. Coast Guard Statement of Requirements [3.3]

The contractor shall furnish the equipment, software, maintenance, services, and support required under the terms and conditions of the contract. The major requirements are

1. Technical, functional, data, programmatic, and strategic integration of information systems
2. System and software development services within the information system (IS) life-cycle phases defined by the U.S. Coast Guard
3. Management, quality assurance, and requirements metrics

4. Cross-cutting requirements that span more than one life-cycle phase
5. Limited quantities of hardware, services, and software to support system development and to transition the systems to an operating and maintenance provider
6. Establishment, staffing, operation, and management of the System Development Center (SDC) to support the development of ISs by a phased approach using task orders
7. Contractor management and personnel requirements, and security procedures

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In a similar vein, the Federal Aviation Administration (FAA), in its procurement of technical assistance contract (TAG) services related to its advanced automation program (AAP) and automation program (ANA), has documented the summary of requirements set forth in Exhibit 3.2.

Exhibit 3.2: FAA Summary of Requirements for TAC Support [3.4]

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a. The contractor shall support FAA's Advanced Automation Program (AAP) and Automation Program (ANA) in an engineering and technical assistance capacity. The contractor's efforts shall complement, support, and extend those of the AAP/ANA engineering staff, which are responsible for the overall technical and contractual direction of the AAP and ANA programs.
b. The contractor shall provide assistance to the FAA in critical technical areas at key periods throughout the contract. A broad range of talents are required to address complex technical problems, for varying periods of time and under stringent response constraints. The contractor's skills must have particular depth, breadth, and quality as follows: [as listed].
c. The contractor's experience and performance must be at a level to provide the highest quality of analytic expertise and, if required, to support the provision of expert testimony.

The two exhibits focus on project requirements. The Project Manager will normally accept these customer statements of requirements for integration into the project plan. Also note that they are relatively brief and differ from system requirements when a large-scale system is being procured. If provided, the system requirements can be cited by reference in the program plan rather than being an integral part of the plan itself.

Other project requirements may also be stated in a procurement that may be regarded as subordinate requirements. These may be described as minimum position qualification requirements, or estimated staffing requirements, or even special contract requirements. For example, Exhibit 3.3 shows the estimated staffing requirements associated with a NASA procurement [3.5].

Exhibit 3.3: Illustrative Estimated Staffing Requirements

Labor Category	Estimated Hours Required
1. Program Manager	100
2. Senior Instructor	300
3. Instructor	120
4. Senior Facilitator	100
5. Facilitator	80
6. Course Development Specialist	240
7. Administrative/Clerical	120
Total	1060

These subordinate requirements impact the staffing of the project and, of course, the estimated cost of the project, as described in later parts of the project plan. A list of other special contract requirements from this same NASA procurement follows:

1. Printing and duplicating
2. Task ordering procedure
3. Key personnel and facilities

4. Observance of legal holidays
5. Protection of information
6. Level of effort (cost)
7. Property administration
8. Contractor's program manager
9. Special provisions regarding travel costs
10. Minimum position qualifications
11. Identification of contractor employees
12. Advance understanding: nonfee-bearing costs
13. General-purpose equipment
14. Contractor-acquired property: submission of vouchers

These subordinate requirements should only be cited by reference and not be included in detail in the requirements portion of the project plan. An alternative is to list them as an appendix to the plan.

3.3 TASK STATEMENTS, STATEMENT OF WORK (SOW), AND WORK BREAKDOWN STRUCTURE (WBS)

Task statements are usually part of the statement of work (SOW) provided by the customer. Thus, these are used interchangeably in this text. These statements are normally accepted and reiterated by the system developer in the program plan. Changing the customer's SOW is not a recommended action because it may turn into a point of contention later in the process. Work breakdown structures (WBSs) may or may not be part of the customer's definition of the work to be performed. When it is provided by the customer, it almost always should be accepted and used by the system developer.

An example of task statements (sometimes also called task areas) is shown in Exhibit 3.4, drawn from a real-world request for proposal from the FAA to industry. Under each of the task areas listed in the Exhibit, there is a short description of the tasks to be performed. Thus, task statements are embedded in the defined task areas.

Exhibit 3.4: Example of Task Statements and Task Areas from the FAA [3.4]

- Task Area 1
  - Requirements Analysis and Documentation
  - Computer-Human Interface (CHI)
  - Specification Development
  - Reliability, Maintainability, and Availability (RMA) and Fault Tolerance (FT)
  - System Modeling and Performance Analysis
  - Local Communication Network (LCN)
  - Algorithm Evaluation
  - Interfaces
  - Standards
  - Technical Planning and Risk Analysis
  - Software Engineering

- Task Area 2
    - Advanced Automation System (AAS) Contractor Requirements Trace-ability and Compliance Tracking
    - Technical Support
    - Engineering Change Proposals (ECPs)
    - Testing and Evaluation
    - Implementation
    - Division/Branch Segment
    - Integrated Logistics Management
- Task Area 3
    - Terminal Automation Program Management
    - En Route/Traffic Management Systems Automation Program Management
    - Maintenance Automation Program Management
- Task Area 4
    - Planned Product Improvement Design Evaluation
    - Planned Product Improvement Operational Test and Evaluation (OT&E)
    - Operational Test and Evaluation
    - Site Implementation
    - Manufacturing and Production
    - Factory Testing
- Task Area 5
    - Configuration Management
    - Financial Management
    - Data Management
    - Office Automation
    - Program Control

A similar example for work to be performed under a solicitation from the Defense Systems Management College (DSMC) is provided in Exhibit 3.5. Here, again, task areas are defined and elaborated to constitute task statements.

Exhibit 3.5: Example of Task Areas from the Defense Systems Management College [3.6]

- Task Area 1: Curriculum Design and Development
- Task Area 2: Program Management Course Curriculum Material Update
- Task Area 3: Development of Automated DSMC Management and Teaching Tools
- Task Area 4: Statistical Analysis Support
- Task Area 5: Executive Education Curriculum Development

- Task Area 6: Quality of Instruction
- Task Area 7: Define Teaching Quality
- Task Area 8: Establishment of Baselines
- Task Area 9: Reports

A third illustration of how a statement of work may be formulated is found in Exhibit 3.6. This exhibit lists seven “detailed items of work” with a breakdown of more specific work under the first item.

Exhibit 3.6: Example of Items of Work from the Department of Transportation’s Volpe Center [3.7]

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1. Project Planning and Scheduling Support
    1. User and System Requirements Analysis
    2. Technical Meeting Support
    3. Technology Assessment
    4. Project Management Support
    5. Transition Planning
    6. Environmental Impact Assessments
    7. Cost Benefit Analyses
2. System Design and Development Support
3. Software Development Support
4. Systems Integration Support
5. Testing and Evaluation Support
6. Training Support
7. Documentation and Configuration Management Support

The work breakdown structure (WBS) is also a formal exposition of work to be performed and is illustrated in Figure 3.1 for a NASA program known as Earth Observing System Data and Information System (EOSDIS) Phase B [3.8]. The most convenient form of a WBS is one in which there is a one-to-one correspondence between the tasks and the WBS. In such a case, the WBS elements can be considered a further breakdown of the major tasks into subtasks and each WBS element is identical to a subtask. If a WBS has not been defined by the customer, it is a recommended procedure to have the WBS correspond directly to the tasks and subtasks. However, if the customer provides a WBS, it may be necessary to develop a “cross-walk” between the task statements and the WBS. Such a cross-walk is shown symbolically in Table 3.2. This usually creates a layer of complexity that is not really desirable but may be necessary in order to satisfy the instructions of the customer.

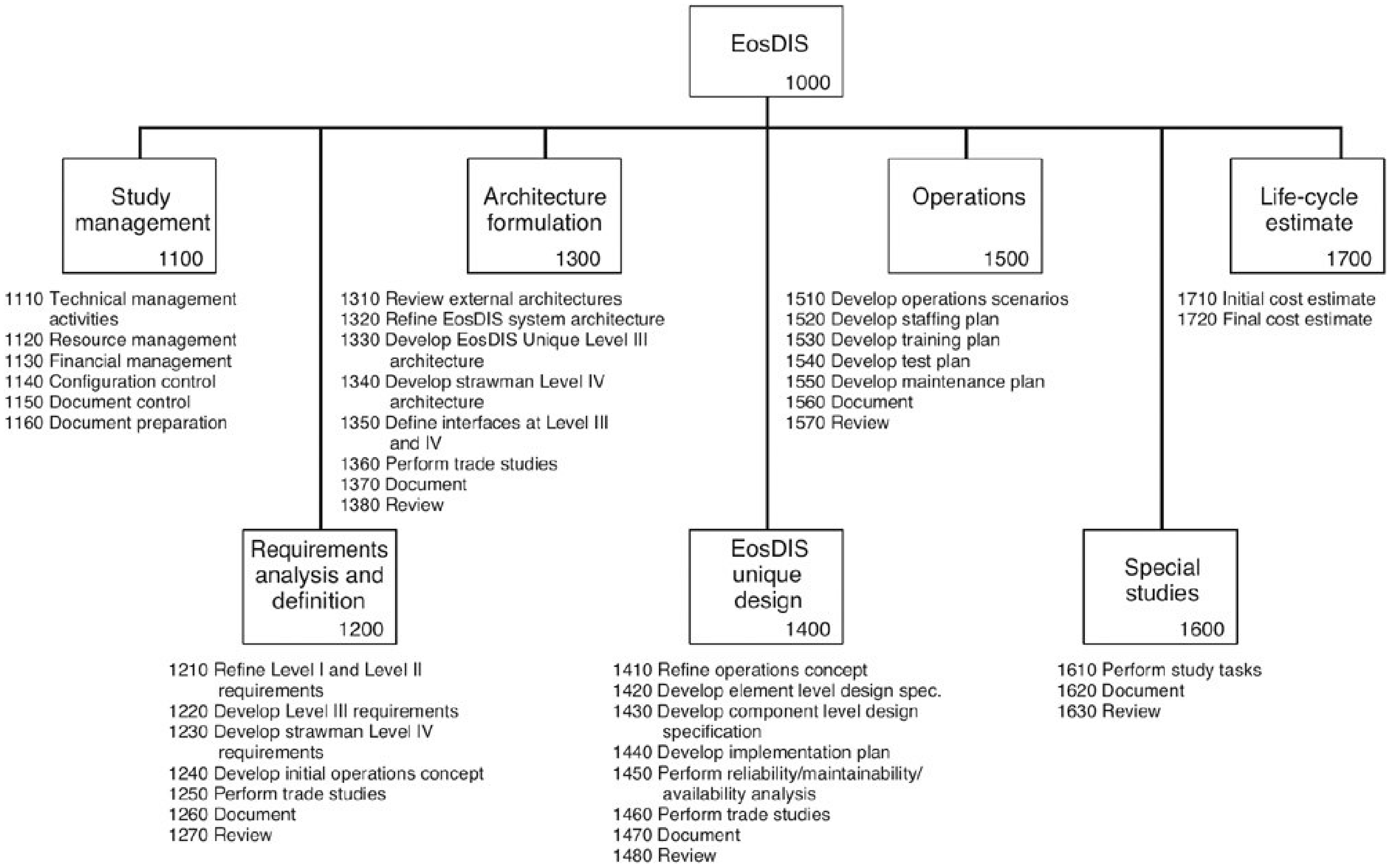

Figure 3.1: EOSDIS Phase B work breakdown structure.

Table 3.2: Cross-Walk Between SOW and WBS

		Work Breakdown Structure				
		WBS 1.0	**WBS 2.0**	**WBS 3.0**	**WBS 4.0**	**WBS 5.0**
Statement of Work (SOW)	Task 1	X	X		X	
	Task 2		X	X		X
	Task 3		X		X	
	Task 4	X		X	X	
	Task 5	X	X			X
	Task 6			X		X

3.4 TECHNICAL APPROACH

The technical approach is a task-by-task description of how the project team intends to execute the tasks and subtasks in the SOW, from a technical perspective. The technical approach is usually formulated, in detail, in response to a request for proposal (REP) if such an REP is a precursor to the project. In such a situation, this technical approach can be abstracted and used in this section of the project plan.

The technical approach changes, of course, for each project and the domain of the project. The approach to building a management information system (MIS) is different from the approach to constructing a subway or transit system. However, some questions that might be common to all projects, with respect to the technical approach, are cited in Exhibit 3.7. These questions assist the project team in addressing a wide variety of technical issues.

Exhibit 3.7: Two Dozen Selected Questions for Technical Approach

1. How do we plan to execute this task/subtask?
2. How will we employ a systems approach and systems engineering process?
3. What is special or unique about our approach?

4. What technology do we plan to utilize or transition?
5. Is this technology at or pushing the state of the art?
6. How can we be most productive and efficient?
7. What computer tools will we be using?
8. How can we demonstrate that we will, as a minimum, satisfy all customer requirements?
9. Do we plan to exceed requirements in certain areas?
10. Are certain requirements vague, incorrect, or inconsistent?
11. What special facilities will we need?
12. What aspects of our previous work can be brought to bear?
13. Do we plan to use any special models or simulations in order to assess system performance?
14. How will we execute a coherent technical performance measurement program?
15. What is our approach to system and subsystem testing?
16. Do we have a unique knowledge base to support our approach?
17. Can our independent research and development (IR&D) program results be utilized for this project?
18. What specialty engineering capabilities will we be using?
19. How does our technical approach correlate with our Systems Engineering Management Plan (SEMP)?
20. Do we plan to use special processes such as concurrent engineering, business process reengineering, or Total Quality Management (TQM)?
21. How can we approach software development with the most up-to-date methods?
22. What types of technical support will be needed from the rest of the company?
23. How will we find the most cost-effective solution?
24. How will we prove that we have the most cost-effective solution?

Question 19 of Exhibit 3.7 raises the issue of the relationship between the Systems Engineering Management Plan and the technical approach. These two documents are not the same, but certain elements of the SEMP, as a minimum, should be addressed in the technical approach. These include the systems engineering process, technical performance measurement, methods of systems analysis, technology transitioning, and technical integration.

3.5 SCHEDULE

A schedule is an expression of the tasks and activities to be performed along a time line. Two main methods of describing a schedule are in use today, namely, (1) a Gantt Chart and (2) a program evaluation and review technique (PERT) Chart. Figures 3.2 and 3.3 show examples of these types of schedules. Both figures are constructed for a hypothetical project of eight principal tasks that involve selecting commercial-off-the-shelf (COTS) software for use by a project team. Such software might be, for example, a project management package or some other package (e.g., geographic information system, executive information system) that would be needed by a project team.

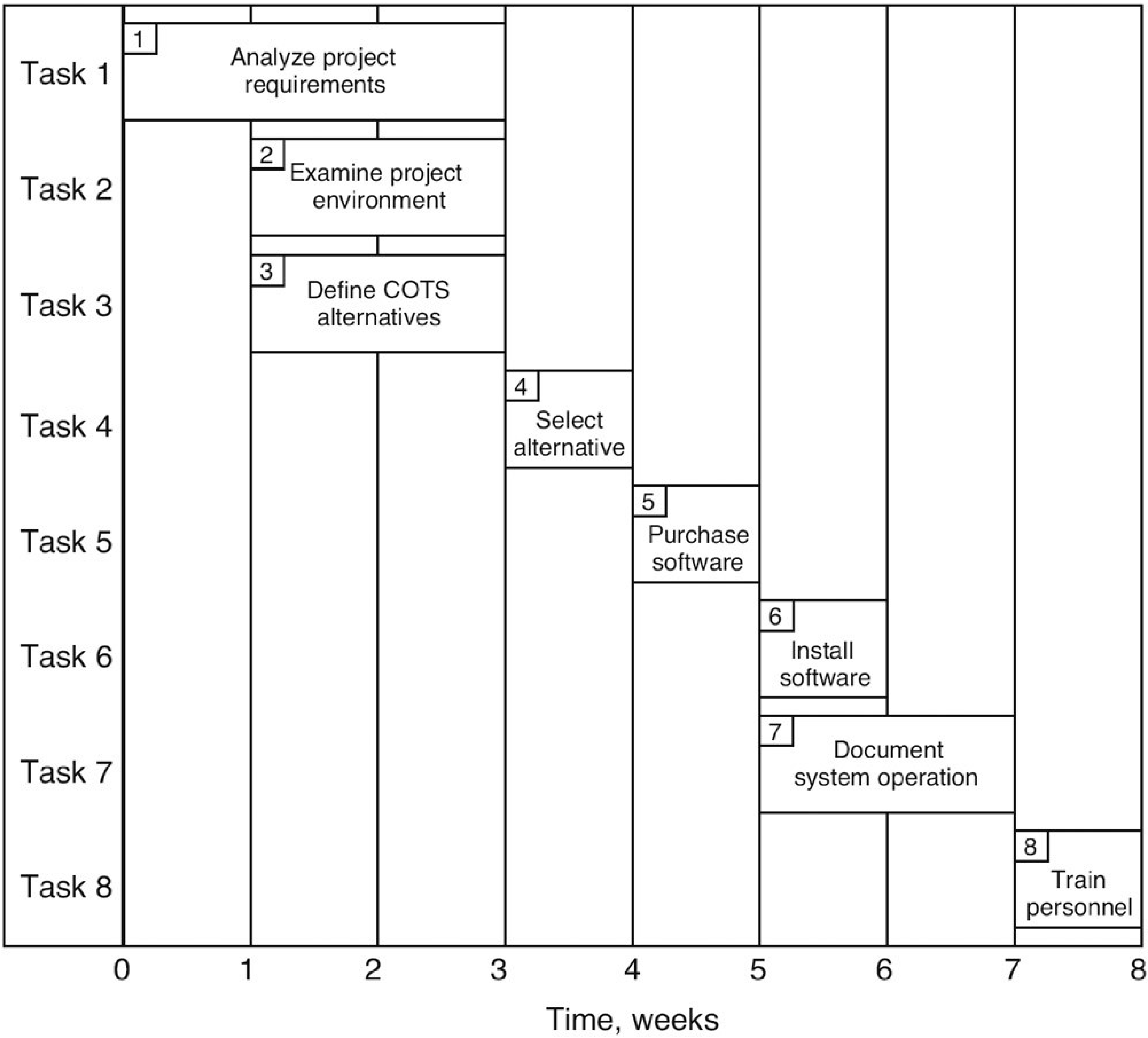

Figure 3.2: Example of project schedule.

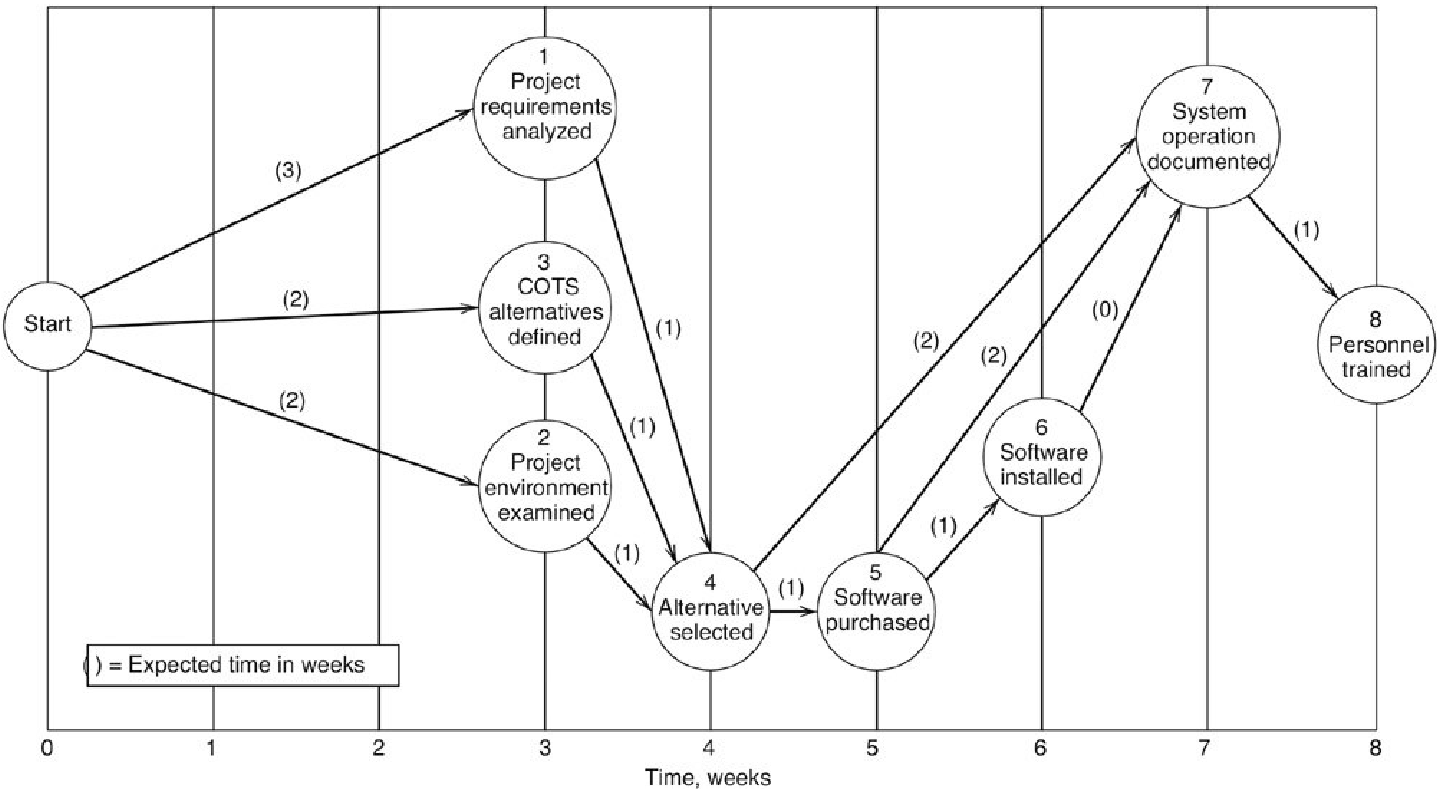

Figure 3.3: Example of a project PERT chart.

Both figures map the tasks against a time line for the eight weeks of the total project. The Gantt chart is quite straightforward and easy to read. Each bar represents a single task. The PERT chart is somewhat more complex but is also simple to grasp. Each circle represents an event—a specific point in time at which a measurable activity is either started or completed. The lines between the events are activities during which resources are expended to achieve the designated end event. Further details regarding how a PERT chart is developed are provided in Chapter 4. However, one major point is that the PERT chart places in evidence the longest path through the network, which is known as the *critical path.* By definition, all other paths are at most as long as the critical path. Those parallel paths that are shorter have "slack" in them. Slack represents an opportunity for moving some tasks or subtasks forward or backward to utilize resources in more efficient ways.

The schedule for a complex project can literally take up the space of an entire wall. The schedule in the program plan should be an overview schedule, emphasizing major tasks and milestones. Too much detail is not warranted in an overview project plan. A full computer-generated schedule might be included only as an appendix to the plan.

The schedule must be ultimately consistent with the customer's delivery requirements. This applies to interim dates as well as the final project completion date. To the extent that the schedule drawn up by the project team does not do this, it has to be continually reworked until all customer requirements with respect to the schedule are met. If this is not possible, then the plan is not viable and there is an impasse that must be negotiated and resolved before work can begin.

3.6 ORGANIZATION, STAFFING, AND TASK RESPONSIBILITY MATRIX (TRM)

The project organization can be simply the organization chart (see Figure 1.2 in Chapter 1), supplemented by a short description of key roles and responsibilities. Staffing refers to the next step of actually assigning categories of personnel to the various project tasks. This results in a *task responsibility matrix* (TRM), as illustrated in Table 3.3, based on the schedule in Figure 3.2. We note that person-week totals by task and by category of personnel are easily derived from the assignment of personnel types to the tasks. As indicated previously, if a WBS is part of the project, and the relationship between the tasks and the WBS has been developed, then it is possible to also develop a profile of which personnel are expected to execute the elements of the WBS.

Table 3.3: Task Responsibility Matrix (TRM)

	Personnel (Staff) Categories								
	A Senior Software Engineer		**B Software Engineer**		**C Documentation Specialist**		**D Training Specialist**		
	Number of People	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Total Person-Weeks**

Table 3.3: Task Responsibility Matrix (TRM)

	Personnel (Staff) Categories								
	A Senior Software Engineer		**B Software Engineer**		**C Documentation Specialist**		**D Training Specialist**		
	Number of People	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Number of People**	**Person-Weeks**	**Total Person-Weeks**
Task 1	1	3							3
Task 2			1	2					2
Task 3	1	2	1	2					4
Task 4	1	1	1	1					2
Task 5			1	1					1
Task 6	1	1	1	1					2
Task 7	1	2	1	2	1	3	1	1	8
Task 8	1	1	1	1			1	1	3
Totals:		10		10		3		2	25

It is considered optional for the project plan to contain the specific names of the people that represent the various personnel categories. Clearly, this step must ultimately be taken, but it does not necessarily have to be part of the program plan document. In many ways, it is preferable to treat the assignments by category rather than by the names of specific individuals.

3.7 BUDGET

From the previously developed information, and some additional cost data, it is then possible to formulate a budget for the project. Such a project budget is illustrated in Table 3.4, utilizing the same data from the task responsibility matrix in Table 3.3. Cost items may also be broken down by week, as illustrated in Table 3.5. This facilitates cost tracking, as discussed in the next chapter.

Table 3.4: Project Budget

Direct Labor	**Rate/Week**	**Person-Weeks**	**Cost**
Senior software engineer	$1,000	10	$10,000
Software engineer	700	10	7,000
Documentation specialist	500	3	1,500
Training specialist	600	2	1,200
Fringe benefits @ 30%		25	$19,700
			$ 5,910
Overhead @ 70%		Subtotal 1	$25,610
			$17,927
Other direct costs		Subtotal 2	$43,537
1. Software			
2. Training materials			$8,000
			1,000
General & administrative @ 15%		Subtotal 3	$52,537
			7,881
		Total cost	$60,418
		Fee (profit) @ 10%	6,042
		Cost and fee (Price)	$66,460

Table 3.5: Cost Budget by Week

	Week 1		**Week 2**		**Week 3**		**Week 4**		**Week 5**		**Week 6**		**Week 7**		**Week 8**	
Labor Category	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**

Table 3.5: Cost Budget by Week

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
Labor Category	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**	**P-wk**	**Cost**
Senior software eng'r	1	1,000	2	2,000	2	2,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000
Software eng'r	—	—	2	1,400	2	1,400	1	700	2	1,400	1	700	1	700	1	700
Document specialist	—	—	—	—	—	—	—	—	1	500			1	500	—	—
Training specialist	—	—	—	—	—	—	—	—	—	—	—	—	1	600	1	600
	1	1,000	4	3,400	4	3,400	2	1,700	4	2,900	3	2,200	4	2,800	3	2,300
Fringe @ 30%		300		1,020		1,020		510		870		660		840		690
Subtotal 1		1,300		4,420		4,420		2,210		3,770		2,860		3,640		2,990
Overhead @ 70%		910		3,094		3,094		1,547		2,639		2,002		2,548		2,093
Subtotal 2		2,210		7,514		7,514		3,757		6,409		4,862		6,188		5,083
ODCs: Software		—	—	—	—	—	—	—	—	8,000	—	—	—	—	—	—
train, mat'ls		—	—	—	—	—	—	—	—	1,000	—	—	—	—	—	—
Subtotal 3		2,210		7,514		7,514		3,757		15,409		4,862		6,188		5,083
G&A @ 15%		331		1,127		1,127		564		2,311		730		928		763
Total cost		2,541		8,641		8,641		4,321		17,720		5,592		7,116		5,846
		Total cost $ 60,418														
Cumulative cost		2,541		11,182		19,823		24,144		41,864		47,456		54,572		60,418

From Table 3.4, a project budget is prepared by first examining the direct labor costs. These costs are incurred as a result of project personnel working on the various tasks of the project. As shown in the figure, and using the person-week data provided in Table 3.3, we list the four categories of personnel together with their labor rates per week and the person-weeks that each has been assigned. This yields the direct labor cost by category. The summation of these costs ($19,700) is the total direct labor cost for this project. This is augmented by adding the fringe benefits, in this case 30% of the direct labor costs. The resultant sum, shown as subtotal 1, is $25,610. The next item of cost to consider is the overhead cost. This example shows the overhead rate to be 70%, or a total of $17,927. Some companies embed fringe benefits into the overhead percentage and therefore there is no reason to consider fringe and overhead separately. In this model, they are constructed as separate rates.

Subtotal 2 shows the direct costs with fringe and overhead costs added, yielding an amount of $43,537. At this point in the process, other direct costs (ODCs) are considered. These may be a variety of cost items, such as materials, consultants, subcontractors, and services provided from outside the company. In Table 3.4, two such costs are listed: the cost of purchasing software, estimated at $8,000, and the cost of training materials, shown as $1,000. Adding these costs to subtotal 2 leads to subtotal 3, which is $52,537.

Next, general and administrative (G&A) costs are added. These are represented as a percentage, in this case 15%, or a total of $7,881. Summing this cost with subtotal 3 yields the total estimated project cost of $60,418. This, of course, is a critical number. If all went according to plan, the overall project, for this example, would cost $60,418. Finally, a fee is added, in this case 10%. This is the profit that the company wishes to make by engaging in this effort. Adding the fee to the cost results in the overall estimated price of $66,460.

In order to calculate the bottom-line cost without ODCs, and do it quickly, we introduce the notion of a “cost factor.” This cost factor (CF) is a multiplier on the direct labor costs that results in the total project cost, without any ODCs. The cost factor is

$$CF = (1 + FR)(1 + OH)(1 + GA)$$

where

- FR = fringe rate (expressed as a decimal)
- OH = overhead rate
- GA = general and administrative rate

Thus, in the example shown in Table 3.4, the cost factor is

$$CF = (1 + 0.3)(1 + 0.7)(1 + 0.15) = (1.3)(1.7)(1.15) = 2.54$$

This means that every dollar of cost at the direct labor line translates into $2.54 in bottom-line cost, exclusive of ODCs.

In a similar vein, the “price factor” (PF) translates direct costs into bottom-line prices and is

$$PF = (CF)(1 + PR)$$

where PR is the profit (fee), expressed as a decimal. By using numbers from Table 3.4, the price factor is

$$PF = (2.54)(1 + 0.1) = (2.54)(1.1) = 2.79$$

Again, both the cost and price factor are rapid ways to estimate bottom-line costs and profits, but without other direct costs.

We note that some elements of cost are estimated by the Project Manager (more likely in concert with the Project Controller and the Chief Systems Engineer). These include the original person-week estimates, and the software and training materials costs (ODCs). All other costs are derivable from the fringe, overhead, and G&A costs. These three costs are characteristic of the corporate structure and generally are not under the control of the Project Manager. In a similar vein, company management will likely select the fee (profit) that is to be bid, obtaining an input from the Project Manager.

The PM must control the project to the overall cost number and not the total bid price. The fee is not to be spent by the PM unless some agreement has been reached within the company’s decision-making apparatus to do so for this project. There are even times when the PM is not aware of the fee (profit) that has been proposed.

The customer may also wish to see the estimated project costs broken down by time period (as in Table 3.5) or by project task. The task breakdown of cost would be derived from using the task person-week data shown in Table 3.3.

An inviolate notion in project as well as corporate management is that cost and price are not the same. If it turns out that the project is successful, then the enterprise would receive the bid price from the customer, which then would be booked as company sales or revenues. The difference between project revenue and project cost is, of course, the profit that is made by the project. If that number is positive and equal to or greater than the bid profit, then all is well. If it is negative, then the PM may be in some difficulty, with a lot of explaining to do.

3.8 RISK ANALYSIS

In order to avoid future difficulty, the project triumvirate, as a minimum, should carry out a risk analysis, the results of which become part of the project plan. This analysis attempts to focus on trouble spots before the fact, developing risk-mitigation strategies prior to actual work on project tasks.

In general, it can be said that there are four kinds of risk that the Project Manager would be concerned with. These are

1. Technical performance risk
2. Schedule risk
3. Cost risk
4. Administrative risk

Technical performance risk (TPR) flows from items of design, development, and construction of the system that result in not meeting the technical requirements set forth by the customer. These might include situations where one is pushing the state of the art, not meeting system response times, experiencing harsh environments that degrade system performance and numerous others. TPR is by far the most complex area and must be examined by domain-knowledge personnel to identify what tasks appear to be most difficult from the perspective of system performance. Background information regarding the details of how to carry out a technical performance risk analysis can be found in the literature [3.9, 3.10, 3.11, 3.12]. It is also considered again in Chapter 8. Technical performance risk is also a primary factor in creating schedule and cost risks.

Schedule risk, of course, involves not meeting project milestones. If internal milestones are not met, then the PM may be able to get back on schedule by the deployment of additional resources and other means. Customer delivery and review dates are viewed as much more serious, especially the delivery of parts of the system and special reports to the customer. If penalty clauses for late delivery are operative, schedule risks in this regard are considered critical. Analysis of the project PERT chart is usually a good place to start in assessing schedule risk. Activities and events on the critical path should be examined in considerable detail because this path is the controlling factor in the overall project schedule. Long lead-time items that come from other vendors should be subject to scrutiny and it may be necessary to have backup plans for such items. Cases in which the customer has to provide an input or pieces of hardware and software should also be examined in detail, the question being:

What happens if the customer fails to provide these inputs when required? Schedule risks, although numerous, are subject to analysis and can, in a great many cases, be accurately predicted.

Cost risk is often experienced when not enough effort has gone into the early cost-estimation processes. “Guesses” are accepted as hard data and not discovered as incorrect until the situation is investigated. For example, in the sample costing shown in Table 3.4, software costs are estimated to be $8,000, representing about 13% of the total project cost. If these costs turn out to be $12,000 instead of the original $8,000 estimate, an increase in cost of $4,600 would be experienced (the $4,000 increase plus the G&A of $600). There is very little room in this illustrative project to make up a cost increase of this amount.

Risk to the project may be present when the overhead and G&A rates in the enterprise are not stable. If these rates increase in the middle of the project, they will impact total cost even though the PM may be doing everything correctly. In such a case, the PM is somewhat “off the hook,” but may still be asked to try to make up for these cost increases. This type of risk may be called an administrative risk, but its effect results in a cost risk. Another type of administrative cost risk involves the failure of the company to hire on time for the project, or the unexpected loss of a key person to another firm halfway through the project.

As suggested by this discussion, there are often many risks to the success of the project and it behooves the project triumvirate to attempt to anticipate these risks and establish risk-mitigation strategies. Therefore, the risk-analysis portion of the project plan would consider the previous four types of risks in terms of the following questions:

1. What specific risks are present for this project?
2. What are the likelihoods of experiencing these risks?
3. What are the likely consequences if indeed the risks occur?
4. Based on 2 and 3, how can we prioritize the risks that have been identified?
5. What can we do to minimize the likelihood of occurrence as well as the consequences of high-priority risks?

The answers to the last question represent the risk-mitigation strategies.

3.9 THE PROPOSAL

The Project Manager is often faced with the matter of writing a proposal in order to have the opportunity to be awarded the project contract. In such a case, it is recommended that the previous project plan be constructed, in rough form, as a precursor to the actual proposal-writing process. Thus, the project plan becomes a critical input to proposal preparation because it deals with most of the crucial issues.

The format of the proposal is very often structured as follows:

1. A technical proposal
2. A cost proposal
3. A management proposal

It is very important that the proposal manager, often but not always the proposed Project Manager, follow the request-for-proposal (RFP) instructions to the letter in order to score as high as possible. The bases for evaluating proposals are usually described in a portion of the RFP citing the “evaluation criteria.”

Writing a high-quality and winning proposal is a complex matter that is likely to be a part of the careers of the Project Manager, the Chief Systems Engineer, and the Project Controller. Some of the rules and vagaries of developing high-quality proposals are examined in greater detail in Chapter 6.

3.10 SEMP AND SEP

The project plan, discussed in some detail at the beginning of this chapter, is a generic document that describes the seven elements of an overview plan at the project level. Some attention is paid to technical matters of the project, but the systems engineering approach is not the main focus of the plan at the project level. One might say, however, that the Chief Systems Engineer (CSE) must take on the challenge of producing, with the approval of the Project Manager (PM), a technical systems engineering plan. In the remainder of this chapter we look at two related plans, one called the SEMP (systems engineering management plan) and the other is the SEP (systems engineering plan).

3.10.1 SEMP

In Exhibit 2.4 of Chapter 2 we cited the key elements of the SEMP, from the perspective of the Department of Defense (DoD). In Exhibit 3.8, we list a DoD and a NASA view of the SEMP. In this format we are able to look briefly at the similarities and differences between these two views.

Exhibit 3.8: DoD and NASA Views of a SEMP

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a. DoD View (see Exhibit 2.4)

   1. Systems Engineering Process

   2. Systems Analysis and Control

      - 2.1 Systems Analysis

      - 2.2 Technical Performance Measurement (TPM)

      - 2.3 Technical Reviews

   3. Technology Transition

   4. Technical Integration Teams

b. NASA View [3.13]

   1. Purpose and Scope

   2. Applicable Documents

   3. Technical Summary

   4. Technical Effort Integration

   5. Common Technical Processes Implementation

   6. Technology Insertion

   7. Additional SE (systems engineering) Functions and Activities

   8. Integration with the Project Plan Resource Allocation

   9. Waivers

   10. Appendices

The DoD and the NASA views are by no means the same, nor are they entirely different. Both emphasize *process* and, to that extent, are in line with many project and systems engineering notions. For example, the DoD leads off with an overview of the systems engineering process, and NASA looks at the (seventeen-element) set of common technical processes and their implementation. In Chapter 2 we cited the ISO/IEC 15288 standard that also emphasized processes (twenty-five of them). Getting the process correct is now an important ingredient in achieving success in our program endeavors.

Both the DoD and NASA also deal with technology issues in an explicit way in their SEMPs. The DoD calls it “Technology Transition” whereas NASA refers to it as “Technology Insertion.” As we will see in Chapter 12, our approach to system acquisition emphasizes technology and its role in building better systems. This is especially important as new technologies seem to be appearing at faster rates and are crucial in order to be competitive in both military and commercial worlds.

NASA also emphasizes technical effort integration, recognizing that this is a critical part of how to approach systems engineering and project management. It also leaves room for additional systems engineering functions and activities. On the DoD side, special attention is paid to technical integration teams. The full flavor of the DoD and the NASA approaches can be gained only by reading, in some detail, the full documentation provided by these two agencies with respect to a SEMP.

3.10.2 SEP

The DoD, in 2004, continued down the road of explaining its needs in terms of a SEP. In the policy statement for systems engineering, the office of the Under Secretary of Defense declared that programs will have an SEP such that each plan [3.14]:

> [S]hall describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It shall also detail the timing, conduct and success criteria of technical reviews.

In a SEP preparation guide [3.15], eight points were articulated:

1. The SEP is the blueprint for the conduct, management, and control of the technical aspects of an acquisition program.
2. The SEP defines the methods by which system requirements, technical staffing, and technical management are to be implemented.
3. A sound systems engineering strategy needs to be defined.
4. The SEP shall be updated continuously.
5. Linkages are to be established between other technical and programmatic efforts (e.g., test and evaluation, risk management, etc.).
6. The SEP should be tailored to the specific needs of the individual program or project.
7. Technical questions need to be set forth and answered, such as: What are the key technical issues, and how are these issues to be solved and managed?
8. The SEP shall be submitted for approval at each major program milestone.

There is a preferred format (which can be tailored) for the SEP. That format is reproduced here [3.15] as Exhibit 3.9.

Exhibit 3.9: Preferred Format for DoD's SEP

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1. Title and Coordination Pages
2. Table of Contents
3. Introduction
    - 3.1 Program Description and Applicable Documents
    - 3.2 Program Status as of Date of this SEP
    - 3.3 Approach for SEP Updates
4. Systems Engineering Application to Life Cycle Phases
    - 4.1 System Capabilities, Requirements, and Design Considerations
        - Capabilities to Be Achieved
        - Key Performance Parameters
        - Certification Requirements
        - Design Considerations
    - 4.2 SE Organizational Integration
        - Organization of IPTs (Integrated Product Teams)
        - Organizational Responsibilities
        - Integration of SE into Program IPTs
        - Technical Staffing and Hiring Plans

- 4.3 Systems Engineering Process
    - Process Selection
    - Process Improvement
    - Tools and Resources
    - Approach for Trades
- 4.4 Technical Management and Control
    - Technical Baseline Management and Control (Strategy and Approach)
    - Technical Review Plan (Strategy and Approach)
- 4.5 Integration with Other Program Management Control Efforts
    - Acquisition Strategy
    - Risk Management
    - Integrated Master Plan
    - Earned Value Management
    - Contract Management

By comparing Exhibits 3.8 and 3.9, we can see how DoD thinking may have changed in proceeding from the SEMP to the SEP. Such a comparison is posed as question 3.10 below.

QUESTIONS/EXERCISES

- **3.1** Identify additional elements you might add to a project plan. Explain why.
- **3.2** Compare the work breakdown structure (WBS) in Figure 3.1 with the project structure in Figure 1.2. Should the latter be more or less the same as the former? Why?
- **3.3** Cite three features of the PERT approach that are not present for Gantt charting. When and why are these features significant?
- **3.4** Calculate the fully loaded hourly rate for each of the four labor categories in Table 3.4. What is the average hourly rate for the entire project?
- **3.5** From Table 3.5, enter the person-week and cost expenditures for each week into a spreadsheet and print out graphs showing:
    a. expenditures each week
    b. cumulative expenditures by week
- **3.6** Identify and discuss three areas of significant cost risk. What might be done to mitigate these risks?
- **3.7** Identify and discuss three areas of significant for schedule risk. What might be done to mitigate these risks?
- **3.8** Cite and discuss three suggestions for writing an outstanding proposal.
- **3.9** Define a numerical approach to evaluating a proposal. Show by example how a given proposal might receive a set of evaluation scores. See if you can compare your approach to that taken by a government agency on a real procurement.
- **3.10** In this chapter we see how the Department of Defense approached both a systems engineering management plan and a system engineering plan. Write a two-page discussion of similarities and differences between these two plans.

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