CHAPTER 46
Computer-Aided Project Management

CARL N. BELACK
Oak Associates, Inc.

1. INTRODUCTION

Although the art of managing projects has existed for thousands of years, it is only relatively recently that modern project management techniques were developed, codified, and implemented in any consistent, methodological manner. Perhaps it is not totally coincidental that these techniques came about during the same period as the beginning of the commercial availability of computers as we know them today. As of the writing of this book, we have arrived at a point where hundreds of commercial software applications that address various aspects of the project management processes are available for purchase. For one who is unfamiliar with the wide variety of these tools on the market, the process of selecting and implementing these tools can be a daunting task. The purpose of this chapter is to help make that process somewhat more manageable.

The reader should note that the title of this chapter, ''Computer-Aided Project Management (CAPM),'' was specifically intended to allow for the discussion of the different types of tools available to facilitate the entire process of project management. To many people, the consideration of project management tools is unfortunately limited to what has become known as *project management software*. Granted, this type of tool was among the first applications developed with project management in mind, and it does address an important aspect of project management, namely scheduling and tracking. This author believes, however, that such a tool is but one among many in what we will refer to as a *computer-aided project management platform*. A CAPM platform is one that includes applications that automate many of the project management processes, not just scheduling and tracking, and it is this platform that we will discuss below.

The following pages will address the history of the development of CAPM, the use of computers in project management, and the implementation of CAPM platforms in business organizations, and will look at what we might expect of these tools in the years to come. It is hoped that this examination will help the reader better understand the use of CAPM tools while facilitating their selection and successful implementation.

2. THE HISTORY OF COMPUTER-AIDED PROJECT MANAGEMENT

While it may be difficult for some to believe (particularly for those to whom the slide rule is merely a curious artifact from an ancient civilization), modern project management techniques were at one time employed by those who did not have the advantage of using computers. In fact, some companies still don't use computers for project management in any organized fashion. And, as laborious as the work is, it is perfectly possible to put together a good project plan without the use of computers. However, having spent some time doing just that, the author can attest to the enormous amount of time and resources such an undertaking consumes. And, once changes are introduced to the initial project plan, the incremental use of time and resources expands exponentially.

In the late 1950s and early 1960s, a few companies began to develop their own internal software tools for managing projects, some of which are still in use today. With the apparent increasing need for such tools, commercial applications began to appear in the marketplace. Most of these tools were initially used by U.S. government contractors (who were required by the Department of the Energy or the Department of Defense to adhere to rules for managing government contracts) and were implemented on mainframe computers—the only computers commercially available at that time. These applications were the predecessors to tools that are still available today (although in a much different form), such as Artemis and Primavera. At the time, these tools were both difficult to learn and cumbersome to use. Since graphical user interfaces did not yet exist, command language was used to interface with the application. Nonetheless, since they enabled some automation of scheduling, tracking, and reporting activities, they were a welcome change for most project managers, who were used to performing these same tasks by hand.

The advent of commercially available PCs brought about the development of project management tools specifically aimed at the PC market. These tools (which we will refer to as low-end tools, as distinguished from the high-end tools that run on mainframes and minicomputers) were much less expensive than their high-end counterparts and were much easier to learn and to use, but also had far fewer capabilities. These tools also allowed the user to interface with the application through a rudimentary graphical user interface (GUI). These tools included software applications such as Harvard Project Manager, SuperProject, Project Manager's Workbench, and Microsoft Project. These tools were primarily aimed at the IBM-compatible marketplace. There were fewer tools available for Apple Macintosh computers, such as MacProject.

Over the past few years, the manufacturers of the high-end tools have incorporated GUIs and other devices to make their tools user friendly. At the same time, the makers of the low-end tools began building more capabilities into their applications that had previously been available only in the high-end tools. Some formerly low-end tools, such as Project Workbench, have migrated into the realm of high-end tools. And a number of high-end tool manufacturers have produced low-end tools for managing individual projects whose files can then be integrated into the high-end tools (such as Sure Trak for Primavera). As confusing as this all sounds, all of these software manufacturers have been trying to achieve the same end: to develop a tool that balances ease of learning and use with ever-increasing capabilities.

As the profession of project management began to gain acceptance in the workplace, additional applications became commercially available. These range from tools that automate other project management processes (such as risk-management tools like @Risk) to tools that help manage areas that are ancillary to, but have a direct impact upon, project management (such as multiproject resource management tools like ResSolution). With the availability of all of these different types of tools, it is often a difficult proposition deciding which tools, if any, are appropriate for a specific organization. In the next sections, we will discuss the processes that are involved in, or have an impact upon, project management and see how the use of computer tools can facilitate these processes.

3. THE PROJECT CONCENTRIC CIRCLE MODEL

In any given organization, generally two types of work activities take place. The first type, the one with which most people are familiar, is *operations* work. The activities in operations work have the following characteristics:

- They are repetitive (they occur over and over from fiscal quarter to fiscal quarter and from fiscal year to fiscal year).
- Their end result is essentially the same (production of financial reports, operations reports, etc.).

The second type, which we are addressing in this chapter, is *project* work. As one might expect, project work is characterized by work that is (1) not repetitive, but rather time limited (it has a specific beginning and end), and (2) produces a unique product or service. Project management is the set of activities involved in managing project work.

When looking at the set of processes involved in or surrounding project management, it is useful to use a framework that the author has called the Project Concentric Circle Model.* This model is depicted in Figure 1.

The model consists of three concentric circles. Each circle represents a level at which project management processes, or processes affecting the project management processes, take place. Each will be briefly discussed below.

3.1. Project Management Core Processes

The center circle represents the project management core processes, or processes that function within individual projects. The reader can find a detailed description of these processes in (PMI 1996) (PMBOK Guide). In brief, these are areas that address the following project management activities at the individual project level:

- Time management
- Scope management
- Cost management
- Risk management
- Quality management
- Human resources management
- Procurement management
- Communications management
- Integration management

The *PMBOK Guide* also describes the five project management processes throughout which activities in each above-noted area of management need to be performed. These processes are portrayed in Figure 2. It is these management areas and processes that most organizations associate with project management. And some assume that attending to these alone will ensure successful organizational project work. That, however, is a fatal error for many organizations. In order to achieve a high level of competence in project management, two other levels must also be addressed.

3.2. Project Management Support Processes

The second circle represents the project management support processes level and includes processes that occur outside of the day-to-day activities of the individual project teams. The activities within these processes generally comprise operational activities, not project activities, that support project

Figure 1 Project Concentric Circle Model.

*The reader is advised that the Project Concentric Circle Model is a copyright of Oak Associates, Inc. Any reproduction or use of the model without the express consent of Oak Associates, Inc. and the publisher is strictly prohibited.

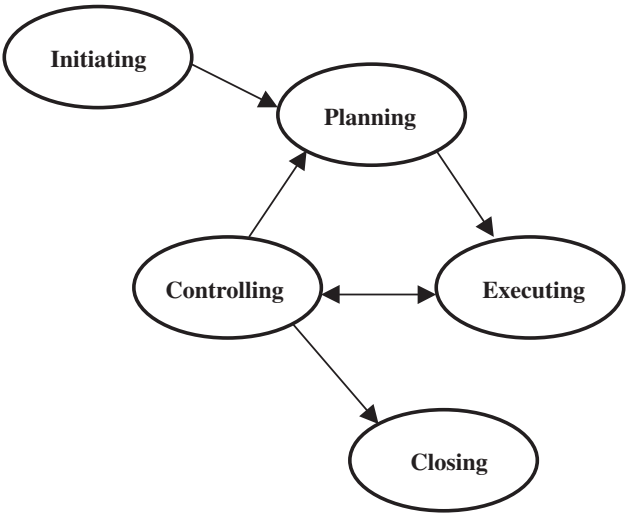


Figure 2 Project Management Processes.

work and project teams. In fact, these can best be described as processes that establish and maintain an environment in which project work can be successfully performed.

These processes can be grouped into two categories:

1. *Organizational development:* Activities that occur in these processes include assessing organizational and individual competency; development and updating of job descriptions for people at all levels of the project team; design of career paths for project managers and project team members; project manager selection and competency development; project team member selection and support; and training and mentoring.
2. *Communications and knowledge systems:* Activities that occur in the development and maintenance of these systems focus on interproject and intraproject communications; project reporting systems (for project team members, customers, and senior management); in-progress and postproject reviews and audits; development and maintenance of historical activity and estimating databases; capacity planning; project change management; and project and technical document/software configuration management.

3.3. Senior Management Leadership

The outermost circle represents processes that senior management must undertake in order to promote project-friendly corporate environments. This involves:

- Championing project management within the organization: This is done by understanding project management and project work within the organizational context; leading the change effort to enhance the role of projects and project management; prioritizing project work to enable effective resource management; and managing the portfolio of projects to ensure alignment with corporate goals.
- Creating and enabling the culture of project success: This includes fostering open and honest communication; promoting rational risk taking; supporting the need for project planning; valuing the differences of project and functional management; and encouraging ''quiet'' projects (and discouraging ''heroic'' projects).

Now that we have constructed a framework for the processes that need to work effectively in order for projects to be successful, let us look at the types of software applications that could automate many of these processes.

4. THE CAPM PLATFORM

An organization needs to have available for project managers, project teams, line managers, and senior managers a tool set that facilitates the activities of the management processes noted above.

An example of one type of tool frequently used in project management is a list of items that, when completed, would signify the completion of a project deliverable—a punch list is one such list that is regularly used to this day in construction projects. More and more, these tools are being incorporated into computer applications. In this section, we will take a look at tools that are available, or are being constructed, to automate the concentric circle processes.

4.1. Automating the Project Management Core Processes

Before proceeding, a brief word of caution is in order. It is the mistaken belief of many that in order to manage projects effectively, one merely needs to purchase a project management tool and become trained in use of the tool (the ''buy 'em a tool and send 'em to school'' approach). This is possibly the worst approach that could be taken to improve the effectiveness of project management in an organization. We have already noted that project management predated the commercially available tools to aid that endeavor, so we know that it is possible to manage projects effectively without the use of automation. The single most important thing to remember about these tools is that it is not the tool, but rather the people using the tool, who manage the projects. *In order for people to use the tools properly, they must first master the techniques upon which these tools are based.*

As an example, to develop useful data for scope, time, and cost management, the successful tool user must have a working knowledge of scope statement development; work definition (through work breakdown structures or other such techniques): activity estimating (three-point estimating of both effort and duration); precedence diagramming method (also known as project network diagramming); and progress-evaluation techniques (such as earned value). Expecting success through the use of a tool without a thorough prior grounding in these techniques is like expecting someone who has no grounding in the basics of writing (grammar, syntax, writing technique) to use a word-processing application to produce a novel. Some novels on the market notwithstanding, it just does not happen that way. With this firmly in mind, let's look at the types of tools one might use in modern project management.

4.1.1. Scope, Time, Cost, and Resource Management

The preponderance of tools on the market today are those that aid project managers in time and cost management (commonly called schedule and budget management). In addition, many of these tools include resource management. These tools can be helpful in:

- Developing activity lists (project scope) and displaying work breakdown structures
- Noting activity estimates (in some cases, calculating ''most likely'' estimates for three-point estimating techniques)
- Assigning dependencies (precedence structure) among activities
- Calculating and displaying precedence diagrams (PERT charts)
- Calculating and displaying project schedules (Gantt charts)
- Assigning individual or group resources
- Setting and displaying calendars (both for the project and for individual resources)
- Calculating project costs (for various types of resources)
- Entering time card and resource usage data

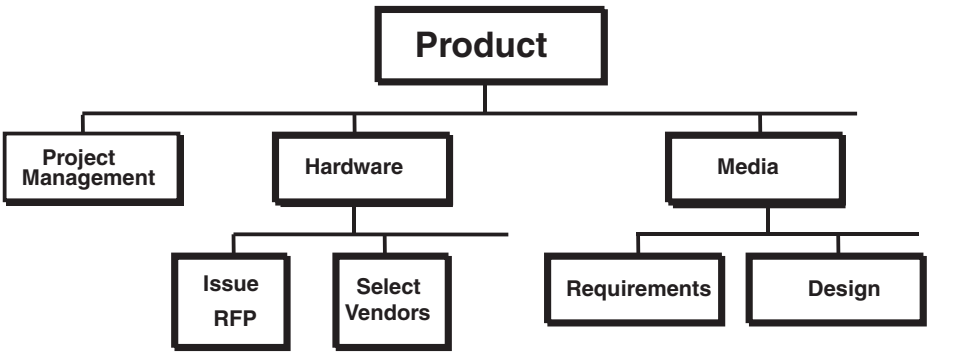


Figure 3 Work Breakdown Structure.

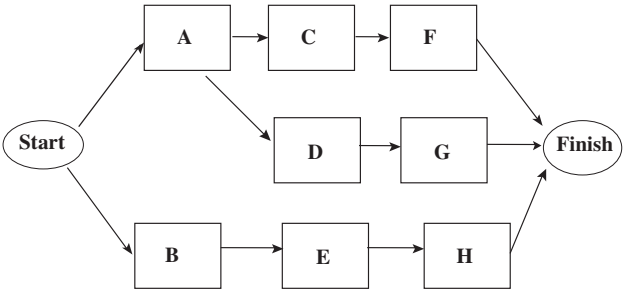


Figure 4 Precedence Diagram.

- Tracking project cost, schedule, and resource data
- Rescheduling and recalculating schedule and cost data after input of activity actual data
- Calculating and displaying project progress
- Leveling resources
- Displaying resource histograms
- Sorting and filtering for various scenarios
- Generating reports for use by various project stakeholders

These are just some of the capabilities that can be found in these tools (see the section on selecting tools below for a citation of an extended list of these capabilities). The tools that can be used for such an effort are too numerous to list. Examples of these are Microsoft Project 98, PS7, and Artemis. For some of the low-end tools (particularly for MS Project 98), there is an after-market of tools that can be used in conjunction with the primary tool to help it do its job more effectively. These range from tools like GRANEDA Dynamic (which provides an excellent graphical interface to print professional-looking precedence diagrams, Gantt charts, and work breakdown structures) to tools such as Project 98 Plus (which provides a very user-friendly interface for sorting and filtering for MS Project 98).

4.1.2. Risk Management

Since two characteristics that we have attributed to project work are its unique nature and its time limitations, projects are inherently risky. Many projects run into problems or fail altogether because an inadequate job was done around risk management. Project risk management is a three-step process that involves:

1. Identifying, assessing, and documenting all potential project risks
2. Developing risk avoidance and mitigation plans
3. Implementing these plans when the risks occur

Clearly, this is not a process that ends once the project-planning activities have been completed. Rather, project managers need to monitor and assess potential project risk throughout the entire conduct of the project.

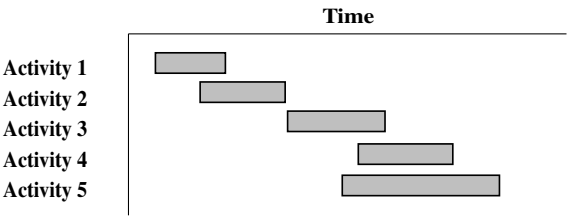
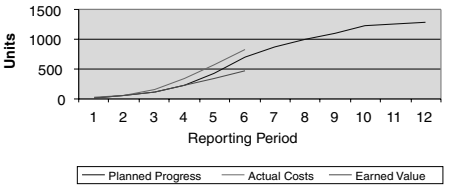


Figure 5 Gantt Chart.



	1	2	3	4	5	6	7	8	9	10	11	12
Planned Progress	20	50	110	225	425	695	875	1005	1105	1230	1260	1280
Actual Costs	30	60	151	337	567	827						
Earned Value	20	50	110	225	345	475						

Figure 6 Earned Value S Curves.

One type of risk that all project managers face is that associated with project schedules. A typical method for handling this risk is to run Monte Carlo simulations on the project precedence diagram (PERT chart). This is done by (1) assigning random durations (within predefined three-point activity estimates) to individual activities, (2) calculating project duration over and over for hundreds (sometimes thousands) of repetitions, and (3) analyzing the distribution of probable outcomes of project duration. There are a number of tools on the market that perform these tasks. Two of the most popular are @Risk and Risk+. Other fine tools are also available that perform similarly. These tools can perform simulations on practically any project calculations that lend themselves to numerical analysis. The output of these tools is the analysis of probable project durations in both numerical and graphical formats (see Figure 7).

Why is it important to use tools like these to help us manage risk? Quite simply, single-point project estimates are rarely, if ever, met. Project managers need to understand the probable range of outcomes of both project cost and duration so they can make informed decisions around a host of project issues (e.g., setting project team goals, deciding when to hire project personnel). They also need this information to set proper expectations and conduct intelligent discussions with the project team members, senior managers, and customers. The correct use of such tools can help project managers do just that.

In addition to these tools, other tools are available to help track the status of potential risk events over the course of a project. One such tool, Risk Radar, was designed to help managers of software-intensive development programs. Regardless of the intended target audience, this tool can be quite helpful for any type of project risk-tracking effort. With the proper input of risk data, it displays a

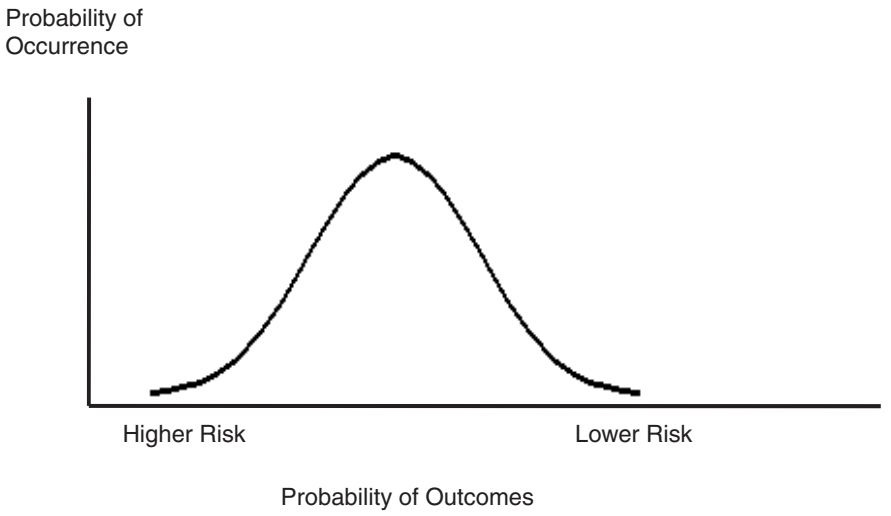


Figure 7 Project Outcome Probability Curve.

graphic depicting the number of risk events with similar risk exposure and lays them out on an easily understood grid. This is a common way to track risk. An example of a similar grid is shown below (see Figure 8).

4.1.3. Change Management

As noted earlier, there are two types of changes with which project managers need be concerned. The first is a change in the scope of work of the project. Most projects encounter scope changes during the evolution of work on the project. Since scope changes almost always result in budget and schedule changes, it is very important to track them accurately. This can usually be done by using the scope, time, cost, and resource-management software discussed above.

The second type of change is one that addresses changes in technical project documentation. Technical drawings, quality documents, and electrical wiring diagrams are examples of such documents. There are a number of tools available for these efforts, and they are as diverse as the technical functions that might employ them. They are generically known as configuration management tools. While these will not be addressed in this chapter, project functional teams should make every effort to select tools like these that will help them manage these documents so that current versions are available to all project members who need them.

4.1.4. Communications Management

Communications skills are arguably the most important skill of project management. Similarly, communications tools can be considered among the most important project tools. As noted in the *PMBOK Guide,*

> Project Communications Management includes the processes required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. It provides the critical links among people, ideas, and information that are necessary for success. Everyone involved in the project must be prepared to send and receive communications in the project ''language'' and must understand how the communications they are involved in as individuals affect the project as a whole.

Tools that aid managers in project communications are not terribly different from those that are used in operations communications. They include:

- Word processors (e.g., WordPerfect, MS Word)
- Presentation tools (e.g., MS PowerPoint, Corel PRESENTS)
- Spreadsheets (e.g., Lotus 1-2-3, MS Excel)
- Individual and workgroup communications tools (e.g., e-mail, Lotus Notes)

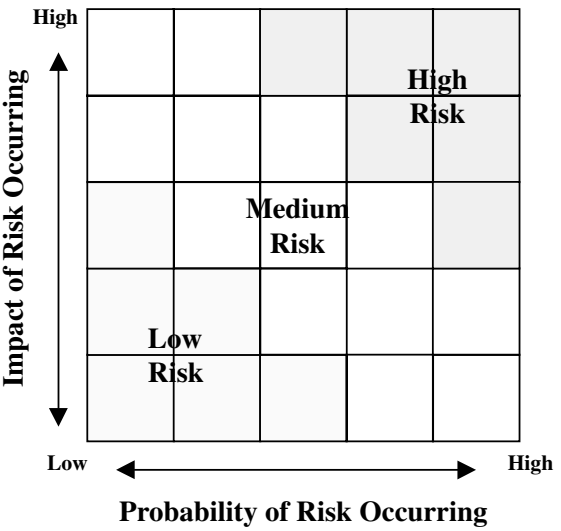


Figure 8 Project Risk Grid.

With the availability of Internet communications and the advent of tools similar to those noted above, tool sets such as these should be readily available for use by project teams.

4.2. Automating the Organizational Support Processes

Like the communications tools discussed above, tools that are useful in the organizational support processes are those that have been used for some time in operations management. Operations management processes are, after all, operations work (line or functional management) as opposed to project work (project management). Since operations management has been taught in business schools for decades, there are tools on the market that can aid in various aspects of these endeavors. While these tools are too numerous to discuss here, some have been designed with the express purpose of supporting project management activity. Among them are:

- *Multiproject resource-management tools:* These tools help line managers manage scarce resources across the many projects in which their organizations are involved. They include tools such as ResSolution* and Business Engine.
- *Project portfolio management tools:* These are tools that help senior managers balance the accomplishment of their organizational goals across the range of projects, both ongoing and potential, in their organizations. They address issues such as budget, benefits, market, product line, probability of success, technical objectives, and ROI to help them prioritize and undertake projects. One such tool that does this is the project portfolio module of Portfolio Plus.
- *Activity and project historical databases:* These are tools that help a project team and all managers more accurately estimate the outcomes of their projects. Among the many problems that arise in projects, an unrealistic expectation about project outcomes is one of the most flagrant. One reason for these unrealistic expectations is the poor quality of activity-level estimates. One way to increase the accuracy of these estimates is to employ three-point estimating techniques, which have been referred to above. An even better way of increasing the accuracy of estimates is to base them on historical data. Were one to examine the activities that are performed over time in an organization's projects, it would become apparent that many of the same types of activities are performed over and over from one project to another. In some cases, nearly 80% of these activities are repeated from one project to another. Unfortunately, in many organizations, such historical data is rarely available for project team members to use for estimating. Consequently, three-point estimating techniques need to be universally employed, project after project. Once organizations develop, maintain, and properly employ accurate activity historical databases, the need for the relatively less accurate three-point estimates (remember that single-point estimates are much less accurate than three-point estimates) will be reduced, thereby resulting in more accurate estimates at both the activity and project levels.

Finally, we should mention that while integration of all the types of tools discussed is probably technologically possible, it is not always either necessary or desirable. In fact, it is the author's belief that in some instances, particularly in the case of multiple-project resource management, it is better to do detailed management of project resources within the context of the center circle and less detailed management at a higher level within the context of the outer circles without daily integration of the two activities.

5. IMPLEMENTING CAPM

The selection, implementation, and use of these tools are not tasks to be taken lightly. And while the process may at first seem daunting, there are ways to make it easier. A number of sources can aid in the selection process. At least two publications presently do annual software surveys in which they compare the capabilities of various project management tools. Many of these tools perform the functions discussed above. These publications are *IIE Solutions,* a monthly publication of the Institute of Industrial Engineers, and *PMnet,* a monthly publication of the Project Management Institute. The National Software Testing Laboratories (NTSL) also tests and compares software programs. It makes these comparisons in over 50 categories of tool capabilities for project management software. The major areas of comparison include:

- Performance
- Versatility

*In the interest of fairness and full disclosure, the author must acknowledge that the organization in which he is a principal is a reseller of both ResSolution and Project 98 Plus software, both of which are cited in this chapter.

- Quality
- Ease of learning
- Ease of use

Individuals responsible for such selection need to ask the following types of questions:

- What is my organization trying to accomplish with this software? Will the software tools being considered meet those needs?
- How many people will be using the software—one person, a group of people, or an entire organization?
- Have the users of the software previously used any other type of project management software before? If so, what were the tools, and were they similar to any of the tools presently being considered?
- Have the users of the software been trained in project management methods, tools, and techniques?
- Are the tools being considered both easy to learn and easy to use?
- Can the tool be used as is or are modifications required?
- What type of postinstallation support is required? Will the vendor do the support or does it require an in-house support group?
- Does the tool need to be integrated with other tools being used in the organization? If so, how difficult will that integration be?
- What are the implications of introducing software of this sort into my organization? Do I need to develop a formal change management plan to get organizational buy-in for its introduction and use?

The answers to all of these questions can have a profound impact on the success of the tool in an organization. One needs to be especially careful in considering the last question. The human implications of introducing software tools in an organization are frequently underestimated. This underestimation has caused organizations to be unsuccessful in the introduction and implementation of these tools, resulting in wasted effort and dollars and in the frustration of those project stakeholders who were affected by the failed effort.

For many reasons, tool-selection processes can at times resemble religious wars. Participation in such a process is not for the fainthearted. Anyone contemplating the introduction of these tools into an organization would be well advised to develop a detailed project plan. Included in this project plan should be a plan to ease the introduction of the tool into the organization, thereby allowing for the greatest probability of a successful introduction and implementation. As with any project, a competent project team needs to be assembled with a specific individual assigned responsibility to manage the project. There should be senior management support and involvement appropriate to the effort. Expectations of all organizational stakeholders need to be set and met throughout the conduct of the project. These expectations should include (1) a detailed description of what will be done during the project, (2) who needs to be involved, and (3) how the implementation of the tool will affect members of the organization. Once project execution has begun, and throughout the course of the project, frequent progress reviews need to take place to ensure that the implementation is on schedule, on budget, and meets the needs of the project stakeholders. These efforts will go far in aiding in the integration of the tool into regular use in project and operations work

6. CAPM IN THE 21st CENTURY

With the rapid development and introduction of software onto the marketplace, some of what has been described above may soon be out of date. One thing that will surely not vanish, however, is the ever-increasing need of project managers and organizations for tools to help them accomplish their complex and difficult jobs. While once just nice to have, these tools are now a necessity. So what does the future hold for computer-aided project management?

More and more tools are expanding from those aimed at individual use to those available for workgroups. Projects are, after all, team endeavors. MS Project 2000 includes an Internet browser module called Microsoft Project Central that is aimed at allowing the collaborative involvement of project stakeholders in planning and tracking projects, as well as access to important project information. With the ever-increasing demand for accurate project information, coupled with the cross-geographical nature of many project efforts, Web-based project communications tools will surely also become a requirement and not just a convenience. The author has worked with a few companies that have already developed these tools for their internal use. It is also inevitable that at some point in the not too distant future, complete tool sets that incorporate and integrate many of the varied ca-

pabilities described in the paragraphs above will also become available for commercial use. It is only a matter of time before such software applications will be developed and appear on the shelves of your electronic shopping sites.

However, despite the advances in technology that will inevitably lead to this availability, the age-old problems of successful selection, introduction, and implementation of these tools will remain. If organizations take the time to accomplish these tasks in a cogent and supportive way, the tools will continue to be a significant benefit in the successful implementation of the project management processes.

REFERENCES

Project Management Institute (PMI) (1996), *A Guide to the Project Management Body of Knowledge,* PMI, Upper Darby, PA.

ADDITIONAL READING

Graham, R. J., and Englund, R. L., *Creating an Environment for Successful Projects,* Jossey-Bass, San Francisco, 1977.

Kerzner, H., *Project Management: A Systems Approach to Planning, Scheduling, and Controlling,* 5th Ed., Van Nostrand Reinhold, New York, 1995.

Martin, J., *An Information Systems Manifesto*, Prentice Hall, Englewood Cliffs, NJ, 1984.

National Software Testing Laboratory (NTSL), "Project Management Programs," *Software Digest,* Vol. 7, No. 16, 1990.

Oak Associates, Inc., *Winning Project Management*, Course Notebook, Maynard, MA, 1999.

APPENDIX
Trademark Notices