Total Project Control Using the World Wide Web

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ABSTRACT

The use of the World Wide Web provides exciting opportunities to enhance project control by simplifying access to detailed and pertinent information and presenting a comprehensive picture of the project. A project Web site can be used as a dynamic tool for timely and more accurate cost/schedule forecasts and interactive communications with the right information at the right time.

The development of an interactive Project Command and Control Center Web Page is at the heart of this paper. This Web page will guide its users through the project life cycles and provide them with the ability to view a total project on a single screen with hyperlinks to other related databases and programs. This paper reflects the author's vision of future project control using a Project Web Page that contains several indicators and trends, similar to the gauges and instruments in an airplane cockpit, with the crew being the project team, and management serving as ground control constantly observing the trends and indicators.

Potential problems are instantly flashed to the team members to make suggestions and take proactive actions leading to possible solutions. Instant view of surprises eliminates monthly or quarterly surprises often too late for remedial action.

The paper also demonstrates integration of technologies interfaced with high-powered Web page, improving project planning, reporting, communicating, and controlling in terms of both tools and processes. This interactive process will stimulate a project team with candid communication in a win-win synergistic team approach. The concept as introduced in this paper will have a stimulating effect on increasing project cost/schedule-consciousness and commitment to total project control.

INTRODUCTION

The World Wide Web is revolutionizing information management by overcoming the sense of remoteness, and has huge potential for project control. The past few decades witnessed massive progress in communications technology, the most thrilling being the widespread use of the World Wide Web in the 1990s, greatly expanding the type of information one can access and share via the Internet.

Advances in information technology and computers exploded in the last 30 years, but total control of project cost, schedule and scope slipped from its high profile of the 1960s. The advent of CPM/PERT and its use on the Polaris Program and landing on the moon was the golden era of project control in the 1960s. During the 1960s, project control was a key management discipline, but it slipped from its high profile. In the 1970s and early 1980s, project control became associated with project failures. Study after study point to a pattern of cost and schedule overruns, increased litigation and catastrophes. The nuclear power construction, the supersonic air travel program, the Space Shuttle and a number of other projects helped portray a failure image. Studies conducted in the last 10 years have found that on average, engineering and construction projects overran by 11 to 17 percent on time and 1 4 to 88 percent on cost (Winch 1997). CII Benchmarking report that on the average, only one-third of projects complete

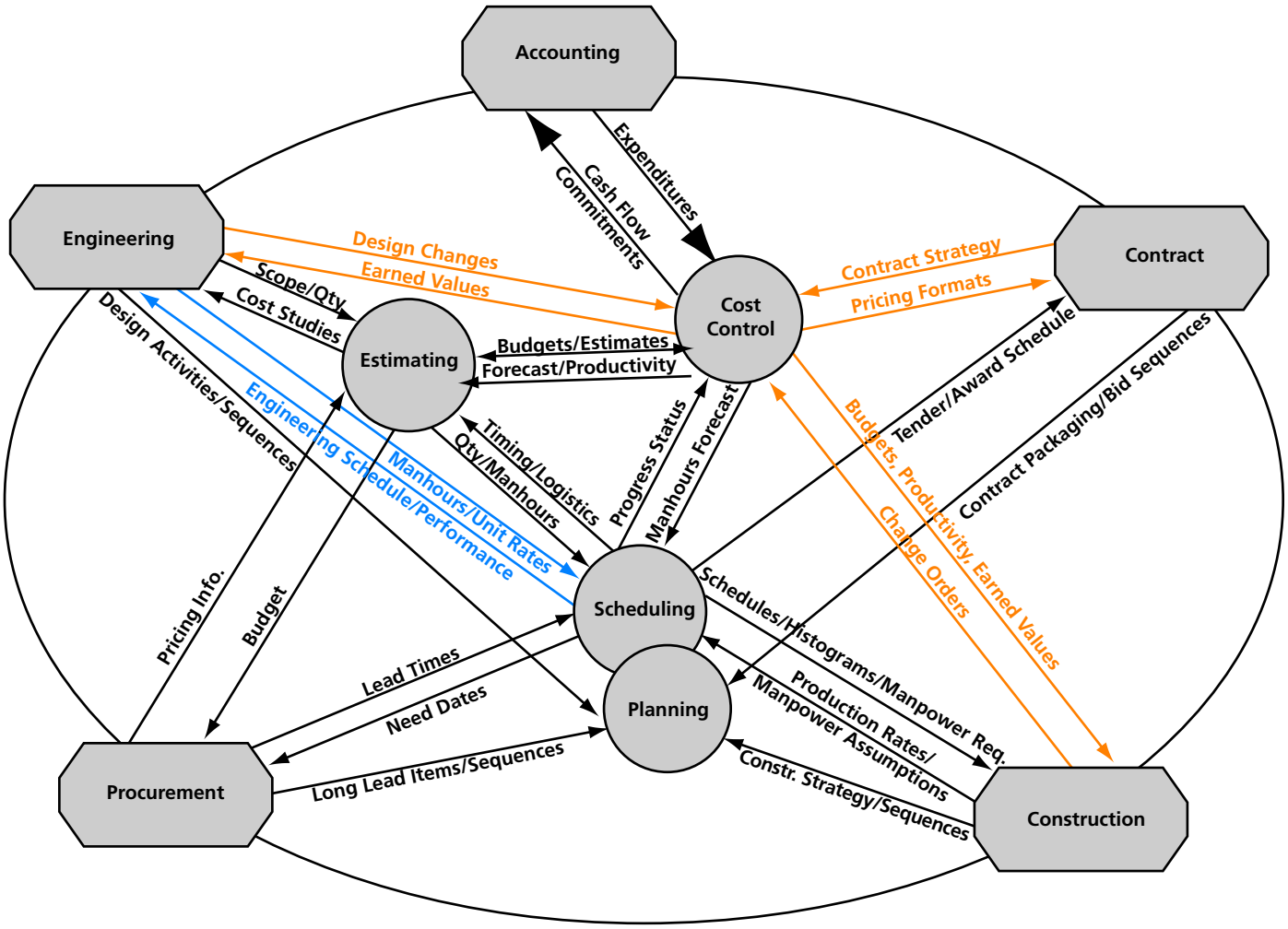

Fig. 1. Project control information flow

per their original plan. Some of the root causes of the delays and overruns include lack of a good project definition, not learning from past mistakes, vague project missions, rigid forms of contracts, no willingness to share risks, single point of decision making, and a general communication breakdown across the project team (Winch 1977).

The widespread use of personal computers with their user-friendly project-control applications in late 1980s and early 1990s gained popularity among project managers. The early 1990s witnessed a renaissance of interest in total project control. Several studies were launched to identify causes of delays, establish benchmarks, control cost/schedule overruns, apply innovations and learn lessons from past projects. The focus on improving the total project control process coincided with the application of the World Wide Web to many areas. The Internet created a unique opportunity for better communication, collaboration and accessibility of information throughout the corporate environment. Internet-based E-mail became an extremely popular mode of communication, encouraging more project managers to use the computer. According to the U.S. Department of Commerce, during 1995-1998 alone, the Internet Technology generated 33 percent of U.S. economic growth with companies such as Lockheed and U.S. West claiming that their use of the Intranet has resulted in over 1,000 percent return on investment (Marino and Schelp 1999). Can a technology have such an impact in such a short period? If so, how can it be utilized for managing and controlling projects?

IMPACT OF THE WORLD WIDE WEB ON PROJECT CONTROL

Communication is at the heart of project control. Collecting information and making decisions regarding this information is at the core of a project control system, with the project manager the nerve center in the middle of this process. The project team relies increasingly on information. The faster and more accurate the information, the better they can serve the project and meet its objectives. Information gathering is time consuming and requires considerable resources. This includes information search, analysis, processing of data, evaluating alternatives and decision making. The project control system must provide the right information to the project team, company management and the client, as well as identify problem areas and initiate corrective action (CII). An important part of this process is collaboration among the project team and other entities involved. Fig. 1 is an example of a project control information flow showing major interfaces of project planning, scheduling, cost control and estimating with other organization groups (Humphreys 1994).

The questions are how can project control benefit from all this overwhelming data exchange and why not extend the use of the Web to other applications? One of the first examples of this mode of thinking was to link the information stored in conventional databases so that it can be shared within departments and workgroups via desktop. The aging corporate systems do not cope with moving information in a consistent or efficient manner. Project managers who are held accountable for the status of the project are lucky to explain "what happened." Never mind "what will happen."

Among the most dramatic implications of the Web to the field of project control is to envision a model in which virtually all the corporate information is stored on a Web server.

TABLE 1.
MATRIX OF CRITICAL FACTORS VERSUS POSSIBLE CAUSES

Area	Critical Factors	Possible Causes
1	TF = Positive	On or ahead of schedule per critical path
	PF>1	More work done than planned
	SPI>1	Budget underrun
		Better than plan productivity
		Favorable job conditions
2	TF = Positive	On or ahead of schedule per critical path
	PF>1	Shortfall in noncritical activities
	SPI<1	Budget underrun
		Better than plan productivity
		Possible undermanning
3	TF = Positive	On or ahead of schedule per critical path
	PF<1	More work done than planned
	SPI>1	Budget overrun
		Low productivity offset by fewer-than-planned activities
4	TF = Negative	Behind schedule on critical-path activities
	PF<1	More work done than planned
	SPI>1	Budget underrun
		Poor productivity
		Excess attention to noncritical tasks
5	TF = Negative	Behind schedule on critical-path activities
	PF>1	Total work less than plan — NEED MORE OVERALL EFFORT
	SPI<1	Budget underrun
		Better than plan productivity
		Possible undermanning
6	TF = Negative	Behind schedule on critical-path activities
	PF<1	Total work less than planned
	SPI<1	Budget overrun — TAKE IMMEDIATE CORRECTIVE ACTION
		Poor productivity
		Many causes

Benefits of this approach include the ability to share information with much less effort. Massive information resources will become available to almost anyone, almost anywhere, almost anytime. Web-based project control software is already available and used on some projects. The use of video conferencing and digital imaging will make collaboration and coordination easier and much faster among the project team, bypassing courier services and time delays. Team members can communicate and provide pictorial status of the project across the globe as if they were in the same building.

COLLABORATIVE PROJECT CONTROL

The Internet's most beneficial application to project control is its ability to bring together the members of a project team in a virtual environment. Geographic location is no longer a context for social interaction. A project manager can call the office and resolve a design problem discovered a thousand kilometers from the office. Communication can move beyond the restraints of text-only E-mails to a more vigorous presentation of text, graphics and application. Most Intranet uses are for information access not critical to business operation. With the application of the technology to both mainframe and client servers, Internet use will move beyond information access to become more responsive to business needs and changing technologies.

This evolution of project team interaction in a virtual environment has introduced new issues in project control, breaking traditional barriers of space and distance. A shift in decentralized communications impacts the manner in which we can communicate and coordinate a project life cycle. A recent study with Mobil Oil facilities in Calgary found that most of the project problems and issues are not technical but social in

Fig. 2. Engineering teaching and research complex site — Iowa State University

nature (Guss 1977). Georgia Tech conducted research using a project scenario in which students played architects, engineers and construction managers within a project team. They were assigned to complete the design, create a schedule and provide a cost estimate for a 1,858 sq m (20,000 sq ft) educational facility (Chinowsky 1977). They formed two consortiums, one using the Web and the other not using the Web. The study concludes that use of the Web encouraged more informal and open communication, resulting in a 12 percent drop of issues and a shift in direction from management issues to technical issues. The ease of conversation through the Web enabled the team to continue management discussions, whereas these discussions would have stopped in a strictly face-to-face scenario. Another study in the Tampa Bay Area using a $150 million construction project demonstrates that using the Web reduces personal influence and is more effective than face-to-face communication, as the project team is no longer bound by traditional communication rules (http://www.gen.net/overview.htm).

The above studies demonstrate that use of the Web resulted in substantial reduction in the traditional isolation that exists between design and construction. Application of the Web encourages more complete integration of the two processes. The Web promotes a team spirit between design and construction professionals, minimizing traditional confrontations and rigid procedures in resolving conflicts. This will naturally result in more design/construction overlap and shorter review cycles, reducing project durations. The same can be said about the relationship of proponent versus contractors, subcontractors and vendors. Additionally, global trends to outsource and downsize workers, combined with the widespread use of the Internet, will push more and more organizations to consider "virtual teams" (Guss 1997). The multidirectional flow of information is removing the psychological borders between professionals and departments, with communications being on an individual rather than a corporate level. This contributes to candid communications between the contractors and project proponents collaborating on topics like value engineering, resulting in the abandoning of non-value-adding projects.

EXAMPLES OF WEB-BASED PROJECT CONTROL APPLICATIONS

Several practices are already taking advantage of these new tools and applying them in the management and control of projects. Some of these include single-line communication. This occurs when a company posts project highlights, accomplishments and key features on a Web page primarily for their employees' information or public relations. Examples of more interactive applications include having on-line ability to track material procurement, timesheet entries, and project scheduling and cost updates on the Web. Some practices have Web pages on which project monitoring information is readily and constantly available to project team members, including the client, consultants and project staff on Internet-based project Web sites. These sites show financial data, have video camera links on the site to monitor progress, and have bulletin-board discussions and archived graphic files of project progress.

The University of Illinois at Urbana-Champaign, along with the U.S. Army Construction Engineering Research Laboratory, have jointly developed a computerized daily log-management system using the multimedia technology allowing text storing and manipulation, sound, images and video in a digital format (Liu 1996). Iowa State University has developed a project Web site to report progress on a new $61 million Engineering Teaching and Research Complex (ETRC). The 24,526 sq m (264,000 sq ft) project is being built in two phases. The Web site http://www.eng.iastate.edu/etrc/core.html provides a great deal of information including building description, donors, press coverage, construction schedule, photo albums, movie archives and a live shot of construction progress using a sophisticated system incorporating an SGI O2 workstation with 128MB RAM and 31GB total disk space, and a Hitachi KPD50 digital-processing CCD camera. The system captures pictures at intervals from 5 to 30 seconds, and generates movies at various stages of the ETRC construction (fig. 2).

These uses of the Web are comparatively straightforward and are proving to be of high value. Use of pictorial daily logs is a powerful means of capturing a multidimensional progress record to be used as audit trails that can result in reduced claims and more enhanced communications. Everyone on the team can be informed of the project at the individual's own convenience, as often as needed. With the development of

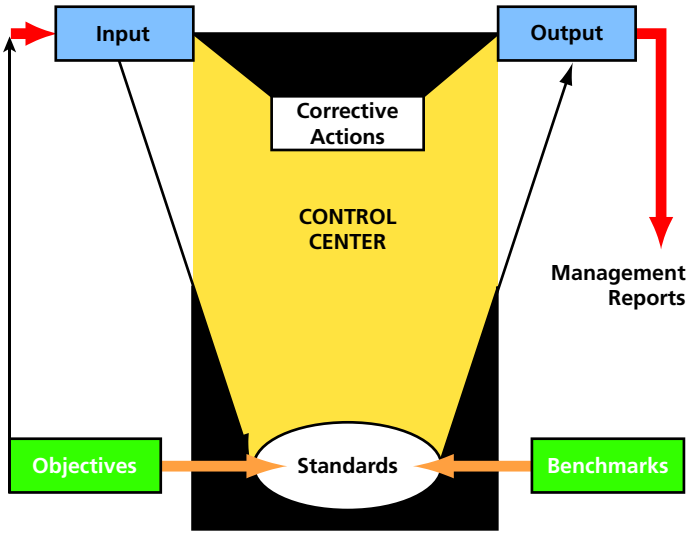

Fig. 3. Project control center

computer-based video conferencing systems and Internet telephone tools, a project manager can call up the office and resolve a design problem.

Several knowledge-based project control-related software programs are designed to provide decision support to project managers who would benefit enormously from this kind of Internet access. Architect/engineering firms are adopting these at a rapid pace. A number of Web sites act as a project home page where users can access drawing files and specifications, shop drawing logs and request information and additional services, with CAD becoming the new desktop for engineers. What is appealing is the fact that contractors will not need CAD programs to view, print or redline CAD drawings (Doherty 1999). Although some of the Web-based products are still at the grass-roots level, programs such as Primavera's Webster and Enterprise (http://www.primavera.com) or Welcome Technology's Spider (http://www.welcom.com) are promising. Most of these state-of-the-art project control software programs let the users publish project data and reports on the Web. A few have the capability of "Real Time" or "Virtual Scheduling" by allowing users to build the schedule and update it on-line. Web-Project Plan-Track and Communicator (http://www.wproj.com) and Netmosphere's Action Plan (http://www.netmosphere.com) are on the leading edge. The author envisions that most project control software will follow this trend. A partial list of these Web sites is posted in http://www.pubs.asce.org/ceonline/0599feat.html.

An impressive effect of the Internet evolution is the impact on employee productivity. When an employer provides full Internet access to employees, he is trusting that the employee will utilize the technology for business purposes. Studies show that this special "trust" leads to employee empowerment through the free use of the Internet (Marino and Shelp 1999). The employee has personal control over information needs and is empowered to act decisively. It also creates synergy among the employees, who will have the information at their fingertips. The more the employees are empowered, the more they are motivated, resulting in higher productivity and company profits.

LIMITATIONS

Project management has always been slow and cautious in adopting new technologies. This will make the application of the Internet to project control areas very challenging. One of the inherent problems associated with the Internet is its slow

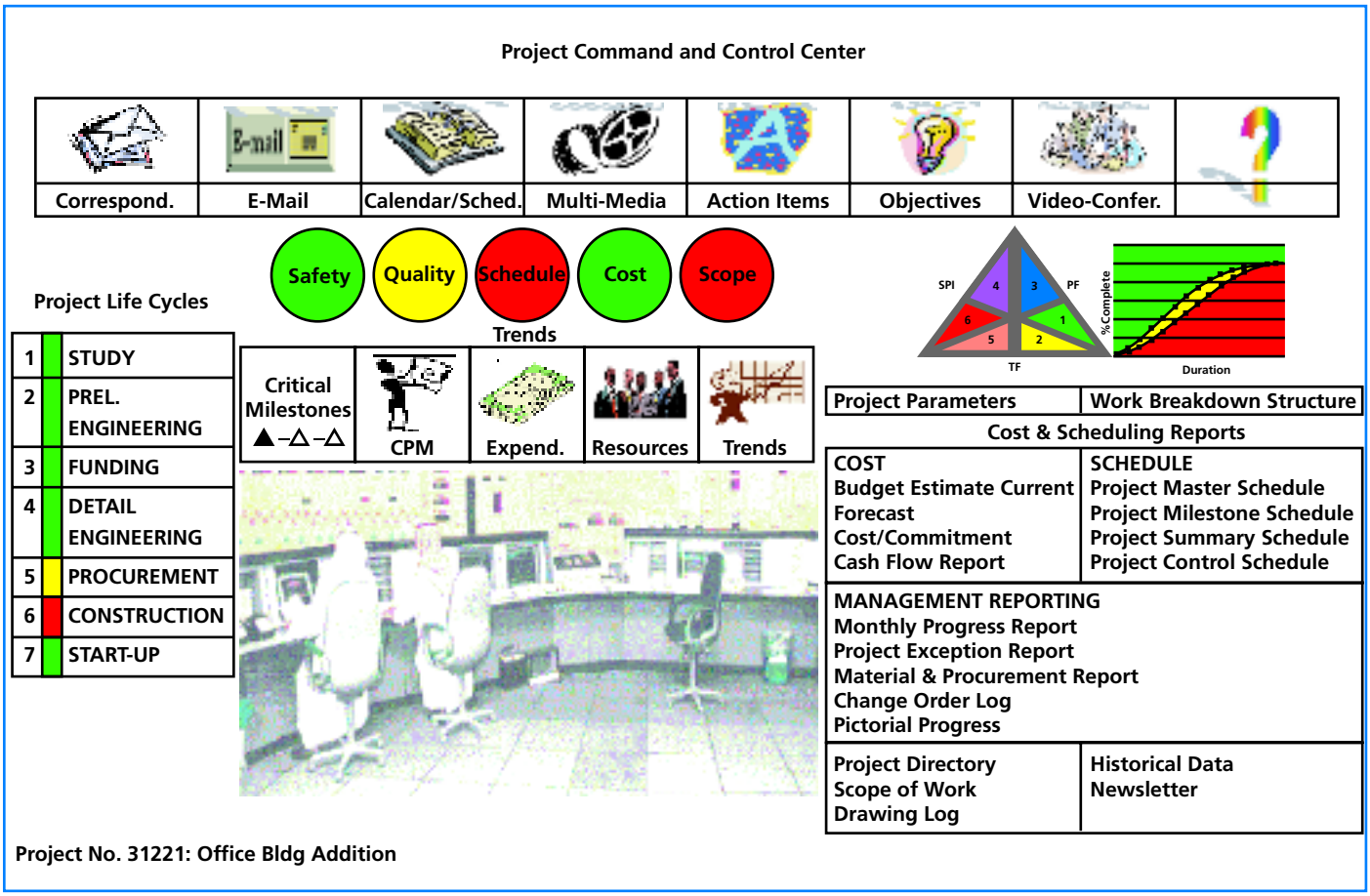

Fig. 4. Command and control center

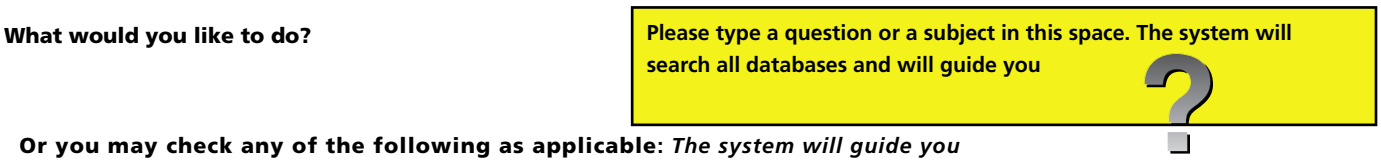

Fig. 5. User dialogue box

connection because of heavy traffic or service problems. Due to painfully slow navigation, one can easily become frustrated and associate the Internet with a waste of time, and the WWW with World Wide Wait!

There will be periods of transition in learning the application of the new tool. A major concern is that not all project teams will have access to the Internet and some of the users will be highly computer literate while others are less so. It is important to note that face-to-face meetings, eye contact, personal touch and feedback are an important part of traditional communication within project management, and one should not expect that the application of the Internet will totally replace face-to-face communications.

There is also the legal question of electronically transmitted schedules, drawings and correspondence and whether they can serve as legal documents in disputes. Although the problem of data security and confidentiality is being minimized, it must still be taken care of.

A GLIMPSE INTO THE FUTURE

Imagine sitting in your hotel room in Singapore or at poolside in Spain, watching the progress of your project in Bahrain live on your hand-held computer using an Internet connection 100 times faster than what you use now. Research projects are already well under way to make this a reality in the not too distant future. Researchers anticipate that they will soon overcome most, if not all, of the current limitations associated with applying the Internet to project control.

Having a single source to access information regarding the status of a project is very appealing. A Web-based project control model can provide users with the ability to view a total project on a single screen with hyperlinks to multiple databases. The model referred to as the Project Command and Control Center uses a simple concept first introduced by Shlomo and refined by the author. It consists of a series of input and output commands with a control center that compares the input information against standards, as shown in fig. 3. The project control center compares input on the status of a project with a set of standards derived from project objectives and benchmarks from similar historical projects. The model can instantly identify and highlight cost and schedule deviation and specify corrective actions for management's immediate review and action.

PROJECT COMMAND AND CONTROL CENTER

A Project Command and Control Center is simply a project Web page that acts as a single source of information from which a project manager, members of the project team or anyone who has an interest are authorized to easily access the information and provide inquiry or feedback from anywhere in the world. An example of a Project Command and Control Center is shown in fig. 4. Key features of this model include:

1) User Interaction
2) Project Information
3) Project Life Cycles
4) Project Trends
5) Instant Status

User Interaction: Across the top of the project Web page one can find a number of user-interactive icons. For example, if the user is sending an E-mail, he clicks on the e-mail icon, or if he wants to know what meetings are scheduled or make an appointment, he clicks on the calendar/schedule button. Similarly, the user can click on "videoconferencing" to communicate with other team members and on "correspondence" to review project correspondence. The multimedia icon provides a range of digital pictures, panoramic shots, video clips of the progress of various construction operations and live camera shots of the project progress. The Action Items button alerts the project team of critical project items along with responsibility and due dates. If the user is not sure what to choose or if he is a first-time user, he clicks on the "?" button.

The system will then guide him through a set of user dialogues, as shown in fig. 5.

First-time users must enter basic project parameters, as shown in fig. 6. After the user defines project parameters, a Project Command and Control Center Web Page is generated, based on the parameters and best-matched historical data. The user can then customize the information for the project at hand.

Project Information: This section of the Web page provides information related to the project such as project directory and organization chart, scope of work, work breakdown structure, drawing and document logs, project newsletter, historical data, engineering and building standards, and various types of project control and management reporting. The CPM software will normally process scheduling data and then extract the results and hyperlink them to the Command/Control Center Web site.

Project Life Cycles: The Project Command and Control Center Web page provides users with a road map to browse through a project's life cycles from engineering study through the on-stream. It provides a "big picture" showing typical sequences of activities in a project and a baseline model to assist in streamlining and improving existing process (fig. 7). Project cost influence curve and physical progress are displayed at various phases. For each phase or project cycle the user is provided with activities and sequences, latest status, plan-versus-actual detail report and the final deliverables. For example, during the early planning and study phase, the user is provided with historical data and risk analysis models in order to establish reasonable, yet challenging, durations.

Project Trends: This is the most appealing part of the Web page. It lists several indicators and trends similar to the gauges and cockpit instruments in an airplane, with the cockpit crew being the project team, and management serving as ground control constantly observing the indicators. The indicators include critical milestones, Critical Path, actual expenditure, project resources and trends. The critical gauges are Safety, Quality, Schedule, Cost and Scope. A system of blinking colors and alarm is used to flash any potential or actual problems. The baseline plan combined with industry benchmarks are saved as "standards" for comparison. Any deviations from the standards will be highlighted using red, yellow and green colors. Items in red require immediate attention, yellow is for

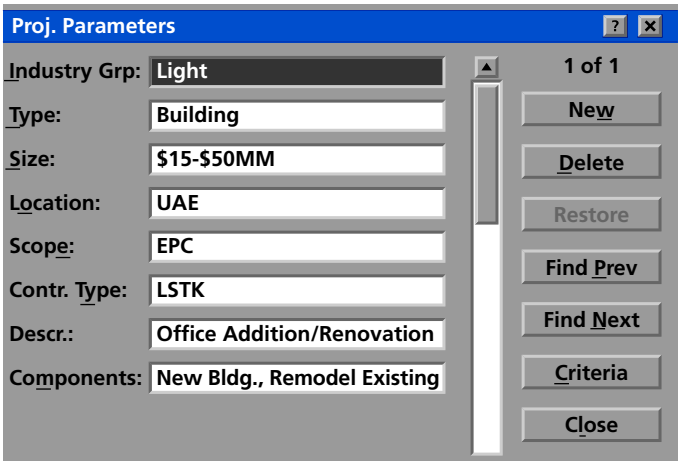

Fig. 6. Project parameters

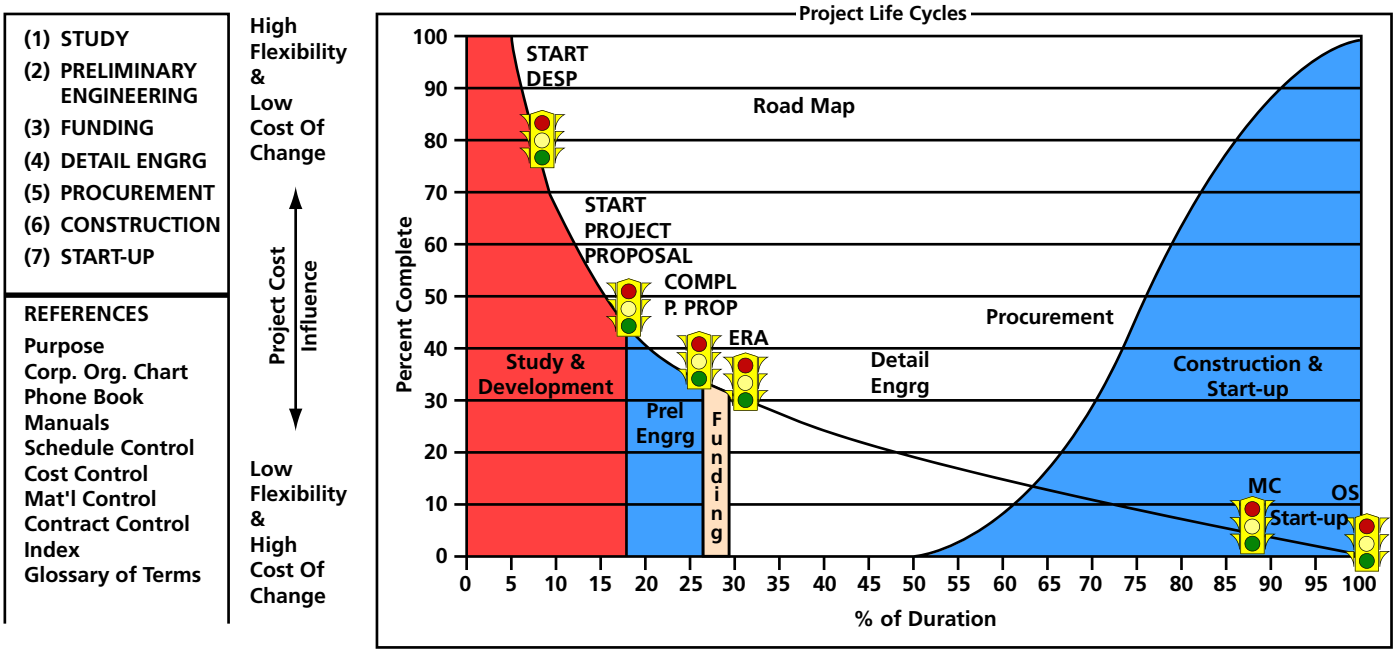

Fig. 7. Project life cycles

warning and caution, while green indicates normal progress. These will be visible to all team members as well as management, who will be able to collaborate in a positive spirit to solve them. The system will encourage everyone in a participative manner to make suggestions and recommend actions leading to possible solutions. At times it is possible that, due to technical errors, the system may generate a "false alarm." However, every problem area should be looked into, and the system facilitates the analysis. The user simply clicks on the blinking yellow or red colors and browses through the problem in a top-down approach to pinpoint the root causes. Management can then prepare action items to address the problems.

Instant Status: The Command and Control Center has another important feature that provides the users with the project status at a glance. This feature was designed based on an earlier model developed by the author, known as PMKES, or Project Management Knowledge Engineering System (Rahbar et al. 1991). It consists of two important measurements: a progress "envelope" and "triangular" status (fig. 8). The area within the envelope represents a warning zone based on early and late-start planned-progress "S" curves. When a project's actual percent complete falls within the envelope, it indicates a warning, and when it falls below the envelope, it requires corrective action. The triangular status is based on a combination of the Critical Path (Total Float), Schedule Performance Index (SPI) and Cost Performance Index (CPI). SPI is the actual percent complete divided by the planned percent complete. CPI is the earned cost (actual % complete × current budget) divided by the actual expended cost to date.

CONCLUSION

The potential for using Internet technology in the management and control of projects is clear. This paper presented the author's future perspective and demonstrated how recent developments in the World Wide Web can change the way we manage and control projects. The innovative concept of a Project Command and Control Center will guide a project team through the project life cycles and provide it the ability to view a total project on a single screen, viewing instant project status.

The application of the Internet can result in more candid and improved communications with the information at the right level at the right time. This will positively impact project productivity, employee empowerment, increasing cost/schedule consciousness and commitment to total project control.

The application of the World Wide Web to our industry provides a unique form of competitive advantage. Although it is hard to present the benefits of using the Internet in terms of

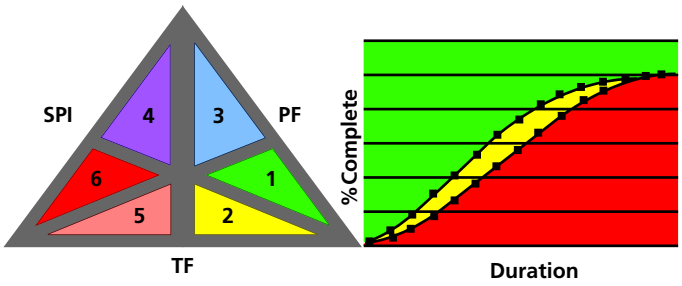

Fig. 8. Instant status gadgets

percentage of savings, the author is convinced that projects can save at least 30 percent in time and cost by implementing the concepts as outlined in this paper. True, Project Management is cautious in applying new techniques, but it must be willing to take more risks by adapting to technological change. Management must have the vision to steer the organization in this direction. The time to capitalize on these tools is now. The consequence of not acting now will negatively affect productivity and innovation.

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