MULTIMEDIA FOR CONSTRUCTION PROJECT MANAGEMENT: PROJECT NAVIGATOR

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ABSTRACT: The architectural, engineering, and construction industry (AEC) forms a major field of investment in both the public and private sectors, and it is essential to the proliferation of any other industry. The focus of the AEC industry is on providing new construction projects for its clients. Each project has a life cycle starting with the statement of objectives and the scope definition, and ending with project disposal and/or replacement. Throughout this life cycle, several project management tools are used and lessons are learned from the application of these tools. An effective method for storing these lessons learned for future reference, sorting them by type, and transferring the experience gained can be achieved through the application of multimedia technology. This paper describes a multimedia system called the Project Navigator, developed for tracking progress on a construction project as well as documenting the lessons learned from the project in a multimedia format for future reference by different project team members.

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INTRODUCTION

Each construction project has a life cycle, starting with the planning phase in which objectives and scope are defined. Second is the design phase, in which the objectives and scope are translated into drawings, specifications, quantities, and conditions of a contract. Then comes the procurement phase, in which the services of an experienced contractor are solicited. The contractor transforms the project from paper documents to a real and usable project in the fourth phase, the construction phase. Upon completion of construction, the project is handed over to its owner/users, thus starting the fifth and final phase in the project life cycle, the utilization or commissioning phase, which usually ends with the disposal or replacement of the project.

Along this life cycle, several project team members interact, as their roles fluctuate in importance and priority from one phase to the other. Among the team members are:

- The owners/users;
- The architect/engineer (A/E) and other designers;
- The contractor and subcontractors and/or suppliers and manufacturers; and
- Possibly a construction manager (CM), municipalities, local or federal government agencies, insurance companies and sureties, etc.

To ensure that the previously set objectives concerning time, money, and quality are met, various team members may apply several project management tools during the different project phases. The experience resulting from the application of these tools is sometimes documented in a text format as lessons learned for future reference in similar projects.

This paper illustrates an alternative method of collecting, documenting, storing, sorting, and retrieving these lessons using multimedia technology. This technology allows media other than text to be used—such as sound, video, graphics, animation, and digital photographs—to better explain and illustrate the lesson learned and to allow its distribution and transfer from one location to another and from one generation to another.

WHAT IS MULTIMEDIA?

Multimedia is a general term referring to the use of a computer as a controller of a variety of external media devices for input and/or output, such as cameras, microphones, video recorders and players, and compact disc (CD) and audiotape recorders and players. Another definition of *multimedia* is the use of a computer as an integrator, combining multiple audio and visual media with text and data into a single digital document that is presented directly through the computer's monitor and speakers, without emphasizing external equipment.

A different method of classifying multimedia is by its applications and the way the user interacts with these applications:

- Passive multimedia is generally the sequential presentation of material in different media to the user. The order in which these media are presented cannot be controlled or changed by the user (e.g., a slide presentation).
- Interactive multimedia, also known as hypermedia, is a nonlinear environment, enabling the user to select his or her own course and navigate through the subject matter according to his or her own needs and pace.

Multimedia systems allow huge collections of information in a variety of media to be stored in extremely compact forms, as well as to be accessed easily and quickly.

MULTIMEDIA APPLICATIONS IN ENGINEERING

Because of the richness of multimedia fields of application, one cannot mention all of them. This paper concentrates only on the engineering applications, particularly applications in the civil and construction engineering fields. These applications include both passive and interactive presentations (planning and design phases), architectural and structural animated renderings such as drive-throughs (design phase), comprehensive design and bid documentation (Vanegas 1994) (design and procurement phases), forensic engineering and failure analysis (construction phase and commissioning or utilization phase), constructibility reviews and lessons learned in highway construction (McCullouch 1993) (design and construction phases).

Each of these applications mainly addressed one or two particular phases of the project within its life cycle, neglecting

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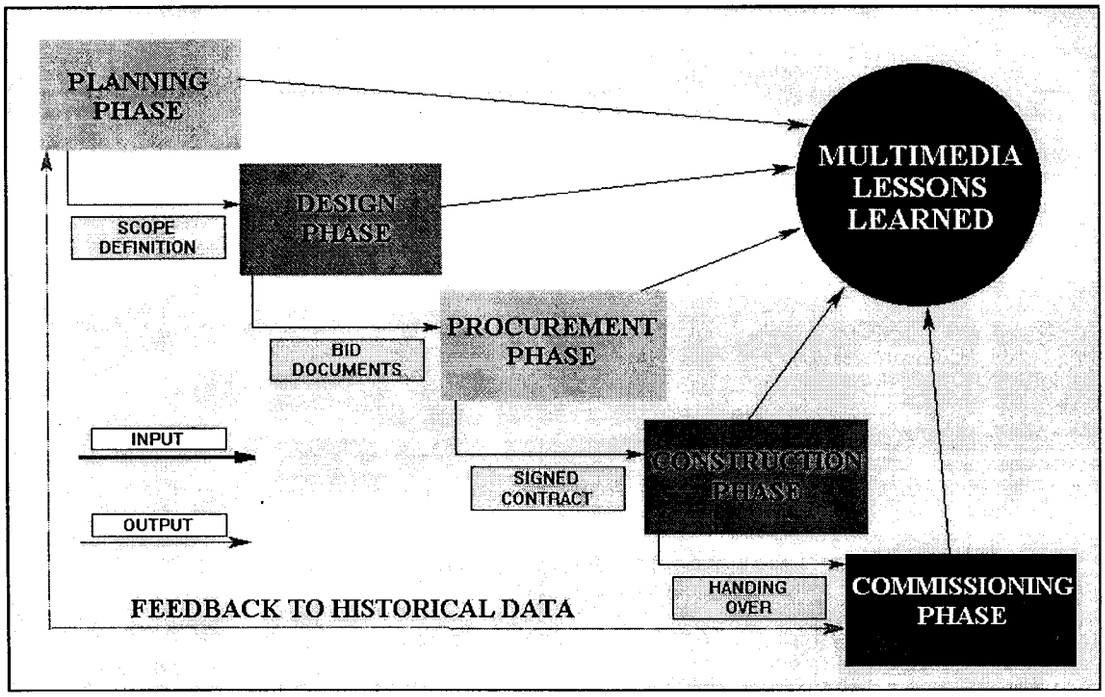

FIG. 1. Project Management Process Model Used in Project Navigator

the interaction with other phases and the interchanged input/output resulting from this interaction.

DOCUMENTATION OF LESSONS LEARNED

Many organizations have attempted different methods of collecting, storing, and later retrieving and using information related to performance, successes, and failures in specific disciplines and specialized fields. According to Kartam (1996), on an organizational level, Soil and Foundation Engineers (SFE), National Fire Protection Engineers (NFPA), the National Bureau of Standards (NBS), the ASCE Committee on Large Dams (COLD), and the National Transportation Safety Board (NTSB) of the Federal Aviation Administration (FAA) have all tried to use lessons learned from previous projects by formally documenting them.

Most of these efforts consisted of sorting these lessons learned according to some criteria (e.g., by project type, size, location, discipline, etc.) in a text format, which might be accompanied occasionally by photographs or illustrations and graphics in a further effort to explain what happened. The most advanced of these systems used microfilming and computer technology to create database systems, in which the user could search for a certain problem by typing a keyword to start the search process. This required the user to be familiar with databases and search techniques.

As a solution to the drawbacks of these systems, an interactive multimedia system was developed to assist any project team member in his or her decision-making process during any of the project phases, based on lessons learned from previous projects. This interactive system is called the Project Navigator, because it allows the users to freely navigate between different presentation media, within various project phases, to view any of the stored lessons learned without any constraints on users' movement from one module to another.

PROJECT NAVIGATOR LESSONS LEARNED MODEL

The model used in the construction of the Project Navigator displays the flow of information within project phases, the project management tools used and their phased method of application, and the feedback process resulting from each phase and transferred and stored in a central multimedia library. Fig. 1 shows a global view of the model, whereas Figs. 2–5 show the tools used within each phase.

Model Development

To develop the model used in building the Project Navigator, the following steps were taken:

1. Interviews were conducted with different project team members representing owners, contractors, architect/engineers, construction managers, suppliers, and end users. Interviews were also held with academics to investigate the possibility of using the Navigator as an instructional tool.
2. The project management tools to be used within the system were selected and evaluated for their potential to improve the performance of the main project functions: time, cost, quality, and safety.
3. Selected tools were assigned to different project phases, and their implementation was staged over the appropriate phases.
4. The selected tools were formulated into a computer software shell discussing their concepts and their cross-linking or interdependence.
5. The lessons learned from the application of each of the selected tools in existing projects were captured, then digitized for storage and replay, and the completed examples were tested for completeness and consistency.
6. Expert validation was made through application to two construction projects at the University of Kentucky in conjunction with the university's capital projects personnel.
7. The system was packaged for distribution in the form of a CD-ROM, including file compression and the required specifications for the computer system where the system is to be installed.

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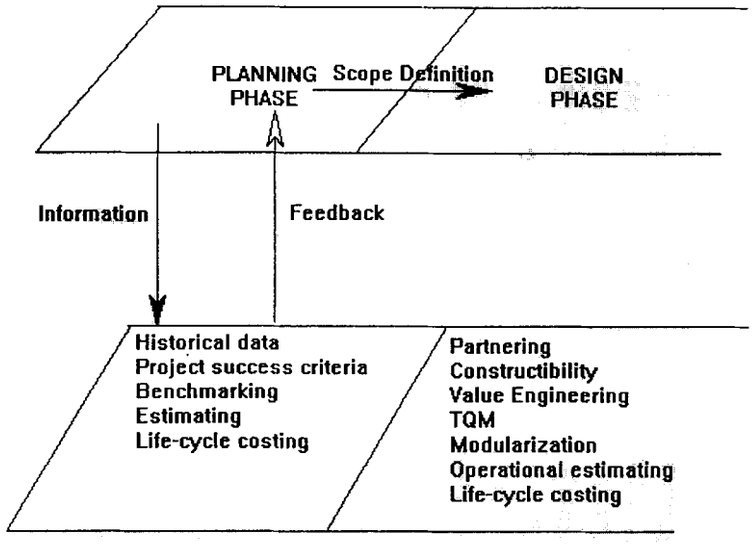

FIG. 2. Tools within Planning Phase

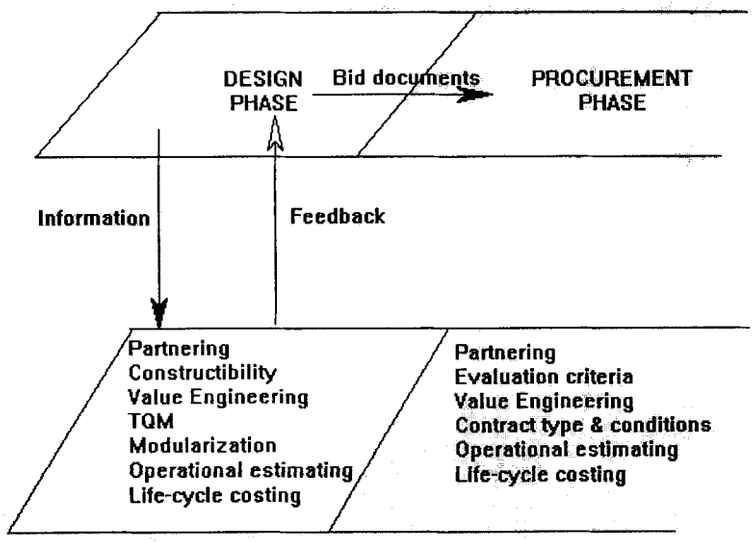

FIG. 3. Tools within Design Phase

Project Navigator

The Project Navigator is an interactive system that uses the state-of-the-art in multimedia technology to capture, store, retrieve, and replay lessons learned from past projects. It is basically a decision support tool for project team members. It was developed for PC-based platforms using a CD-ROM, a sound card, and speakers.

The Project Navigator is divided into nine main modules, shown in Fig. 6, representing:

- A tutorial on how to use the program;
- A guided tour for a brief look at its different features;
- A library of available lessons learned;
- A glossary of terminology; and
- Five modules, each representing one of the project life cycle phases.

The software was developed using Multimedia Toolbook by Asymetrix as the main shell. Each screen of the Navigator consists of at least one page consisting of a foreground, a background, navigation buttons, hyperlinks or hot words, and buttons for playing different media files: video, audio, text, and graphics or viewers. The pages included in the same module share the same background, to help the user recognize his or her location at any time.

Each module starts with an introductory page containing buttons leading to the description of the phase, as well as the tools used within the phase. Hyperlinking (i.e., linking one of the words to a different page through a button) is used to move back and forth between different pages of the Navigator. Fig. 7 shows a model for processing the lessons learned within the Project Navigator. Seven steps were followed to process a certain concept as a lesson learned.

Step 1. Acquire

This step consisted of acquiring the necessary information about the problem, process, or technique to be considered a lesson learned. For this purpose, the problem, process, or technique had to exhibit:

- A direct and measurable effect on the project performance, particularly its time, cost, and/or quality.
- A repetitive nature. (Unique problems or problems with a very low probability of occurrence were not targeted.)
- The capability of being demonstrated in multimedia for-

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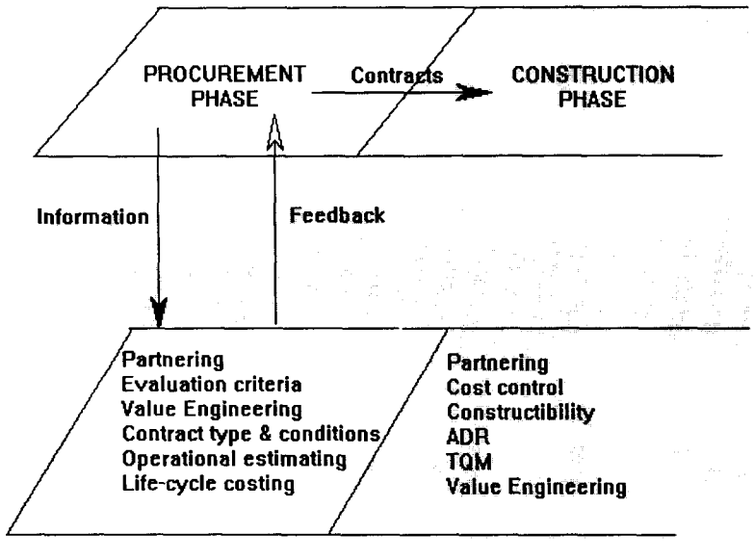

FIG. 4. Tools within Procurement Phase

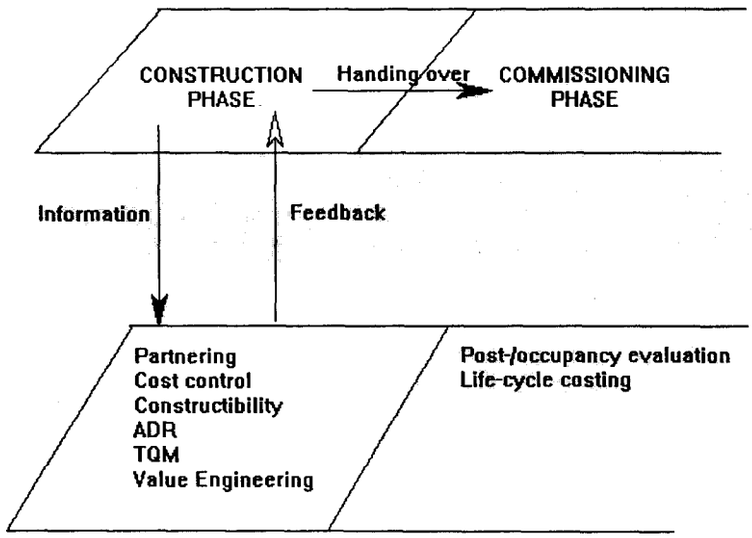

FIG. 5. Tools within Construction Phase

mat. (Problems that could be explained only textually were not targeted.)
- Ease of assignment and allocation to a certain project phase or a specific project management tool.

Step 2. Digitize

This step consisted of converting the collected information from analog, paper, or text format to a digital format that could be read by the computer and easily stored on its hard drive.

A special language, Openscript, was used for programming (scripting) the transition movements between pages, as well as playing different media clips. These clips included:

- Digital sound files, which were recorded using a microphone connected to the computer sound card and edited using sound-files editing software. Other sound files were directly downloaded from music CDs or even regular cassette tapes.
- Digital video files, which were recorded using a camcorder, or played directly from a VCR, and digitized using a video capture board to convert the analog video signals to a digital format for storage and replay from the hard drive. Video editing software was used to enhance the quality of the digitized files, as well as to cut and edit the video clips. Digital camcorders, currently available, can automatically digitize the recorded video footage and save it to the hard drive in the form of a digitized video clip without the need for a video capture board.
- Graphics, which were captured using a digital camera, or scanned from photographic pictures using a color scanner. Graphics editing software was also used to enhance the quality of the scanned pictures, cropping them to fit within the required borders, and rotate them for better appearance when needed. Digital cameras were used to capture digital pictures, which were directly downloaded to the hard drive and saved in one of the popular picture formats (BMP, TIFF, GIF, and JPEG). Other graphics were imported from existing software packages, such as clip-art libraries or Microsoft PowerPoint, or directly linked and embedded using the object linking and embedding (OLE) feature (e.g., Excel Graphs, Adobe PhotoShop pictures, etc.)
- Text files, which were imported directly from word-processing software in rich-text format and edited to change

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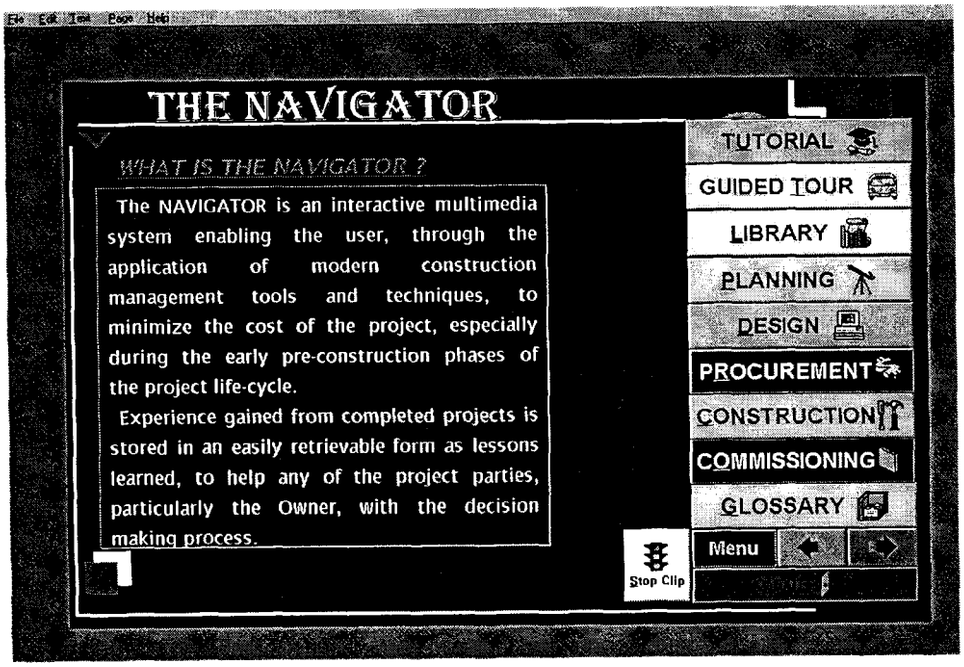

FIG. 6. Project Navigator's Main Menu

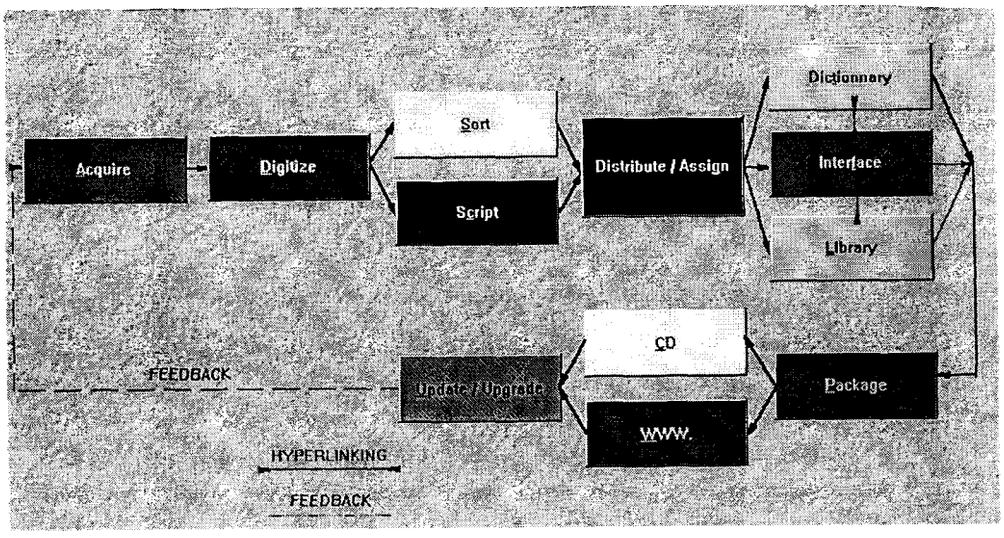

FIG. 7. Project Navigator Model for Processing Lessons Learned

the character font, size, and color. Tables from spreadsheets were imported through the same method, using the object linking and embedding (OLE) capabilities of the Toolbook, so that any change in the original document will automatically be reflected in the Navigator. This proved to be an important and usable function, especially for updating schedule and cost data.

Step 3. Sort

This step consisted of grouping and sorting the digitized lessons learned based on common characteristics. These lessons were sorted by:

- Type of file: text, video, audio, etc.;
- Project phase where the lesson learned is to be used: planning, design, procurement, construction, and commissioning; and
- Project management tool: What is the direct application of this lesson learned (e.g., partnering, value engineering, constructibility, benchmarking, etc.)?

Step 4. Script

This step consisted of writing a short program, called "Script," in Toolbook's own programming language, Openscript, to activate a button, play a clip, pause or stop a clip, move from one page to another, or hyperlink various pages in different modules. Such a script controls each action in the Project Navigator.

Step 5. Distribute and Assign

After the collection, digitization, sorting, and scripting of the lessons learned, the lessons had to be assigned to different pages and different concepts within each phase. If a certain lesson learned was used more than once (i.e., in more than one technique or more than one phase), it was repeated ac-

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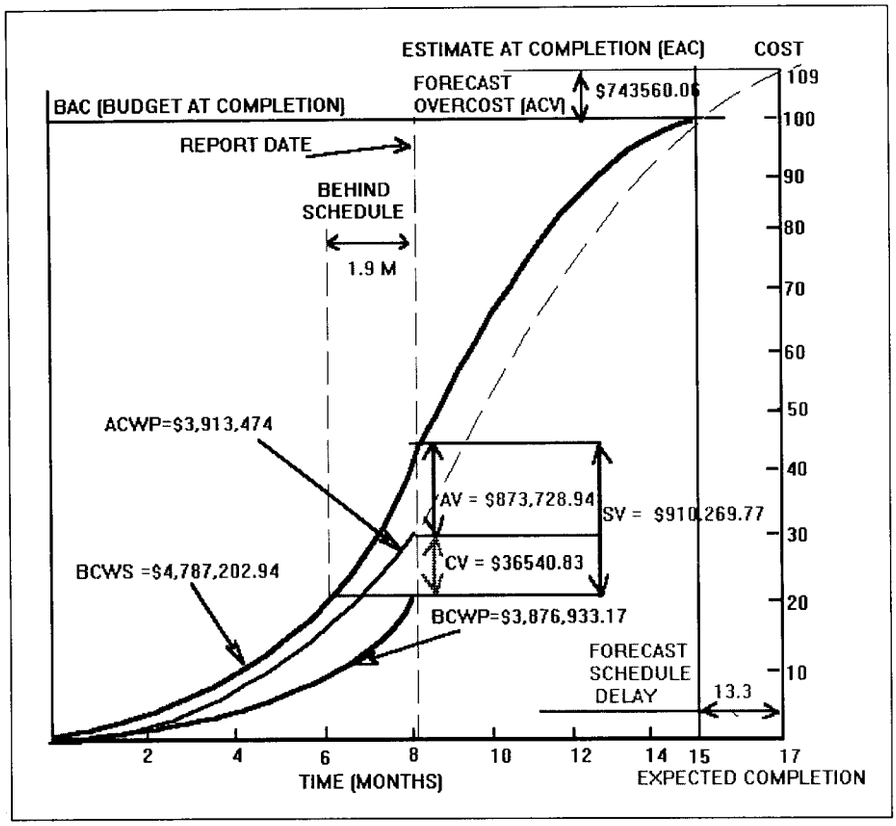

FIG. 8. Earned Value Approach to Cost Control

cordingly, with a different script for each usage. The lessons learned were assigned to:

- The user interface, through the different pages of the Project Navigator;
- The dictionary, which includes definitions and theoretical concepts; or
- The library, which includes a list of all the lessons learned sorted according to the aforementioned criteria.

Step 6. Package and Distribute

This step consisted of packaging the Project Navigator in the form of a software package that can be distributed to the users in one of several formats.

CD-ROM format holds all program files saved as Toolbook files (extension .TBK) or as executable files (extension .EXE), all media files (.AVI, .WAV, .MID, .BMP, .GIF, .JPEG, etc.), as well as a run-time version of the Toolbook that enables the user to install the Project Navigator and browse through its contents without being able to edit or modify these contents. To be able to modify or update the Navigator by adding his or her own lessons learned, the user must own a full, working version of the Toolbook. The CD was selected as a distribution medium because of its durability (expected life is 30 years), low price ($8 for a recordable CD and $26 for a rewritable CD), and the abundance of CD drives, which have almost become a standard feature in any computer. The only drawback of this choice is that these files can be installed only on the same type of platform as the one on which they were developed (in this case a PC).

Alternatively the packaged application can be saved as an HTML file and uploaded to the Internet. This format option allows cross-platform usage of the application. The only known drawback is the low speed of downloading using a modem, especially when downloading large media files.

Step 7. Update and Upgrade

This is the last step in the processing of the lessons learned. It includes maintaining the knowledge base of the Project Navigator and updating the knowledge base by adding new lessons learned acquired from the application of new technologies and/or techniques. The suggested method for performing this task is to use a clearinghouse or a repository where different users can exchange lessons learned with other users.

Problems Faced During Development of Project Navigator

Because multimedia technology is relatively new, and the advancements within are very fast, some problems resulting from software/hardware interface were encountered. These were dealt with one at a time. Among these problems were:

- Video capture board incompatibility with the high CPU speed. The computer used to develop this system had a Pentium processor, with an internal speed of 120 MHz. The video capture board, however, could not work consistently at such a high speed. Therefore, the internal speed had to be reduced to 90 MHz so that the video capture board would be able to read the video signals and digitize them.
- Video capture board incompatibility with high RAM video card. The same symptoms just mentioned—inconsistent performance from the video capture board—also appeared when a 4 MB VRAM video ram card was installed, which necessitated its replacement with a 2 MB DRAM card.
- Bugs in the shell. The original shell upon which the Navigator was built, Multimedia Toolbook, contained an error in the original programming that caused the system to halt each time a specific step was attempted. After long dis-

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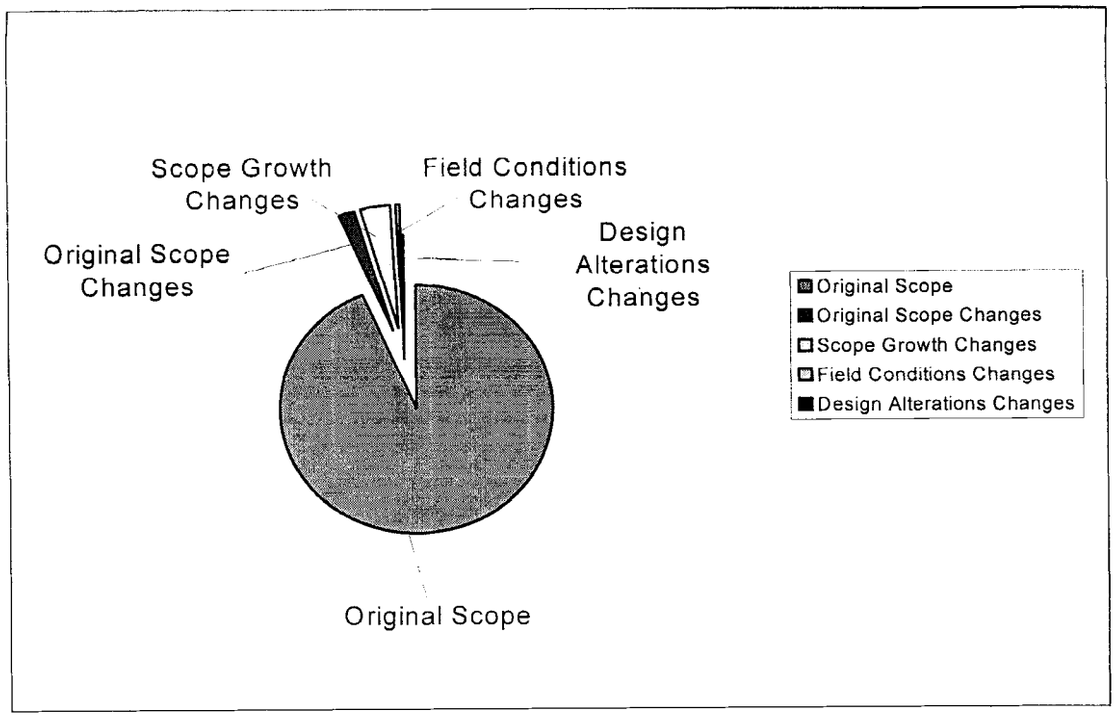

FIG. 9. Magnitude and Type of Change Orders

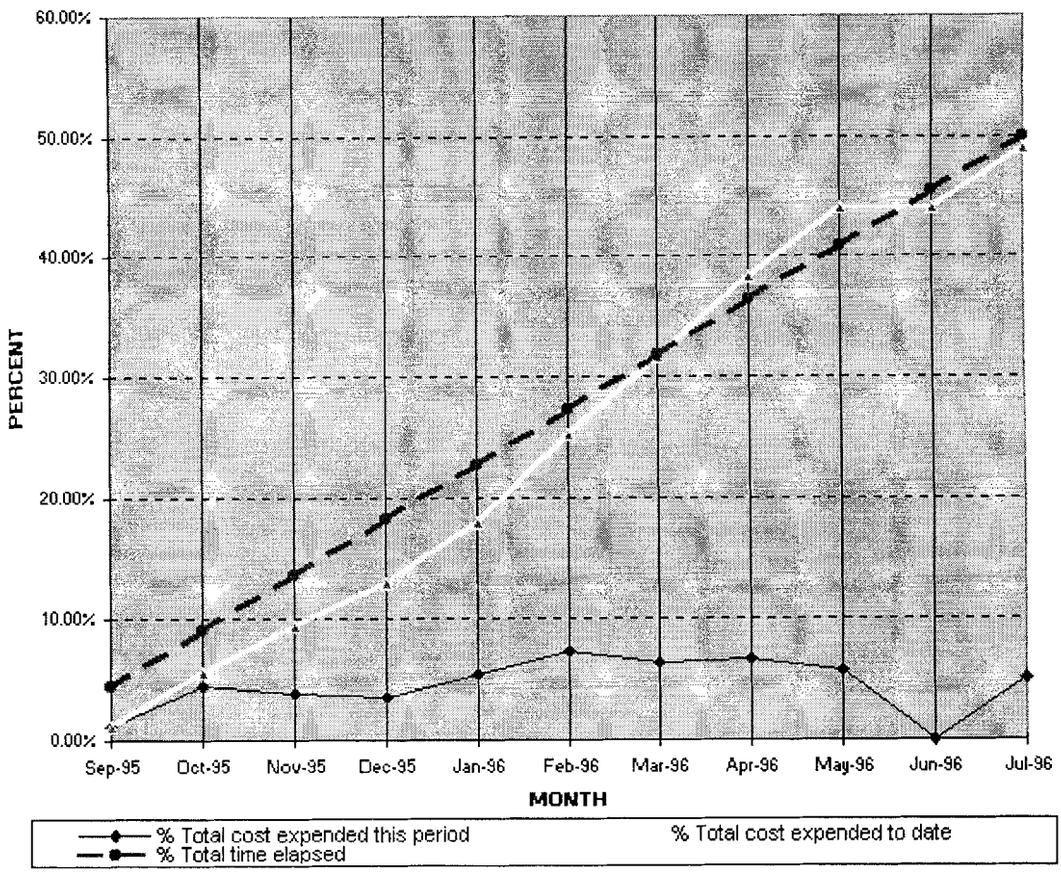

FIG. 10. Time/Cost Interface

cussions, the software manufacturer found the bug in the software, which was corrected in the following version.

Since the Project Navigator was completed, video capture board technology has found solutions to the first two problems.

Potential Uses of Project Navigator

The prospective users of the project Navigator are any of the project team members: owners, designers, contractors, and construction managers, as well as educators in academic in-

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stitutions and human resource development departments in construction industry organizations. The owners' role was overemphasized because of their presence and active involvement in the decision-making process during all of the project phases. The Project Navigator's multiple uses include:

- Recording and documenting the project history and the problem-solving process during the project life cycle in the form of lessons learned, which can be transferred from one generation to another and from one project to another.
- Recording and tracking project progress, especially cost and schedule. The earned value or C/SCSC system was implemented to determine at any time whether the project is over- or underbudget, and ahead of or behind schedule. Graphs generated through spreadsheets and scheduling software (Primavera) were imported into the Project Navigator to illustrate progress. Fig. 8 shows an example of the generated graphs.
- Orientating and training newly appointed engineers. This quick orientation will enable new appointees to become familiar with the organization's procedures, policies, and processes in a very short time.
- Developing interactive instruction manuals and training course material, in addition to testing students or trainees in the form of computer-based training (CBT).
- Providing information on new construction techniques, methodologies, equipment, and materials. This can be distributed through a central library within an academic institution or a professional organization.
- Developing 100% digital project bid packages, including a video site visit, graphically produced topographic maps, electronic specifications and bills of quantities, video-recorded instructions to bidders, electronic bid forms, CAD drawings, digital pictures of material samples and specifications, and lists of nominated subcontractors/suppliers. Any further modifications or addenda can be issued to the bidders in the same format, guaranteeing instant notification of these changes.

Figs. 9 and 10 display some of the data generated through linking the Project Navigator with Microsoft Excel spreadsheets, showing how cost information was tracked and the quantification of change orders in two projects used as case studies.

CONCLUSION

Multimedia technology can be used to record project performance and save this experience in the form of lessons learned in different formats: audio, video, text, animation, and graphics. This knowledge can be updated from time to time to reflect the new innovations in construction methods, materials, and equipment. It can also be used to track the performance of the project main functions: time, cost, quality, and safety. Lessons learned can be classified by project type, project size, project team member, project phase, CSI section, or any other criterion for easy reference and updating. Sharing of the acquired lessons learned on an interorganizational or intraorganizational level will create a large database that can help the construction industry to improve its productivity and profitability. The Project Navigator system described in this paper is a working model for using multimedia technology in construction.

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