Project-Controls Systems Opportunities

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Abstract: The current generation of project-control systems provides useful information, but has several problems that limit the effectiveness and efficiency in controlling projects. The current generation of project-control systems has focused on the increased use of the microcomputer for sorting, computing, and storing data. This increased use of the microcomputer has not been without the introduction of difficulties to the process. The problems include input inefficiencies (e.g., multiple input of the same data) and output problems (e.g., extensive tabular listings of data). These problems lead to wasted or ineffective use of time to support the project-control systems. Potential opportunities and advancements to address these deficiencies are presented. These opportunities include input technologies, analysis techniques, and systems integration. Specific examples discussed include scanning and digitizing technology, holography, artificial intelligence, remote-sensing technologies, voice-recognition systems, and enhanced software-systems development. The areas discussed in this paper are intended to provide direction for future research and development of project-control software for the next generation of project-control systems for the construction industry.

Introduction

Computerization of project-control functions is commonplace in the construction industry today. The term *project management system* has become almost synonymous with microcomputer-based scheduling systems. While project management should describe a far broader and more complex system, the term has been coined by software vendors to enhance the appeal for their product. Those involved in the management of projects recognize that project management involves far more than scheduling. Scheduling is but one element of project control along with cost, quality, safety, productivity, and change management. Project control, in turn, is but one of several functions of project management. The other functions of project management, such as personnel management, do not lend themselves as readily to the use of computers. There is limited software available for the other elements of project control, namely, cost and quality. Many software packages related to cost are actually cost-accounting software rather than cost-control oriented as a jobsite manager would practice it.

Cost accounting involves the collection and assignment of costs to a predetermined structure for measurement. Cost control utilizes cost-accounting data to identify variations between the budgets and performance for the purpose of taking remedial actions.

The use of computers has made possible the quick processing of enormous amounts of project information. Along with this opportunity has come the demand for increased quantities of data to support development and updating of the information presented in the systems. Critics question the usefulness of much of the information for project-control purposes and the shear volume of paper generated.

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Many problems exist with the current software. A study of the software to identify problem areas highlight where improvements can be made. It is the purpose of this paper to identify some of the major problem areas in the current schedule and cost-related software and to propose directions for improvements and opportunities for advances. It is hoped that this paper will trigger thought, study, evaluation, advancement, and dissemination of knowledge related to project-control systems. It is not the intent of this paper to focus on specific software packages but to rather deal with generic problems in the current construction-oriented software for scheduling and cost control.

CURRENT PROBLEMS

Currently, the software that exists for use in project control has limitations and problems that need to be addressed to make the software more efficient and more effective in controlling projects. These problems are generic to almost all of the current generation of software and project-control systems rather than specific to a particular item of software. These limitations and problems can best be viewed as deficiencies rather than faults, as the current software is functional, but could be more useful to the construction industry if these problems were addressed.

One of the major criticisms of project-control software is the harshness of the input and output. The term harshness refers to two issues—a problem of reentry of data and a problem of numeric-only data. Imputing data often requires entering data in several files or reentry of portions of the data. Typically, in scheduling, sketches are used to develop logic. From these sketches, the activities must be coded, and the codes, descriptions, relationships, and resource data entered as input. This input process is often cumbersome due to either the sequence of data entry or the duplicate entry of activity codes for specific files related to descriptions, relationships, and resources. With only limited exception, data cannot be entered in sketch form or from designated library files of activities.

The software currently available provides harsh output. Scheduling reports rely too heavily on tabular presentation of large quantities of information. Much of this is not pertinent or appropriate to the set of management decisions necessary at the time of processing. The listings do not lend themselves to quick review for problem areas and swift analysis to determine corrective action. The output is usually segregated by the work-breakdown system, and it becomes difficult to evaluate trends across several activities. Where schedule information is presented in a bar chart or time-scaled network format, the output is often 10 ft or longer and in multiple sections. These cumbersome hard copies do not lend themselves to a clear presentation, and do not afford an easy mechanism for schedule review. Typical cost-control output provides spreadsheets of data rather than focused comparisons on critical cost elements. The outputs, in extreme cases, simply display all data entered rather than provide meaningful information used for control. Much valuable information is nonnumeric and qualitative or even symbolic. With recent flexible report writers and related software, this problem is disappearing.

Another problem area with current project-control software is that the software is vastly deficient in providing meaningful analysis. The software does not perform the analysis that would provide the information useful for management such as trends, exceptions, comparisons, and the context of the information. While basic data reporting is useful, it leaves the entire analysis of data to the manager. The manager is usually bombarded with information, and needs to have a major portion of the analysis performed, including a list of exceptions and comparisons of line items on the current project with performance as well as the baseline or budget for the project. The analysis should include a representation of the trend of performance, and should provide a forecast. Current software systems fall short in these areas. Where the software has analysis built into it, the systems do not provide easy tracing of information through the analysis. The black-box approach is not desirable because it does not allow for flexibility in analysis systems design.

Project-control software suffers from a lack of integration. Separate software has been developed for cost-control purposes and for schedule-control purposes. The development of software for cost control has been driven by the need for accounting systems rather than for control purposes. Schedules and cost estimates are often developed in entirely different ways by different people. The software systems are separate, stand-alone systems, and integration can only be achieved in a summary level between cost and schedule. Lack of integration causes the manager difficulty in making decisions due to the inherent trade-offs between cost and schedule in construction. This places an additional analytical task on the manager that could be accomplished with an integrated system for schedule and cost control.

A limited technology base is utilized in project-control systems. Input devices are limited to keyboards, and output devices are printers, plotters, and displays. There is a broad range of hardware technology that has not been utilized in the systems. Similarly, the systems software does not perform all of the functions it might. The software lacks the ability to learn, to store past data and constraints, and utilize this information in future applications. The systems lack intelligence to propose alternative solutions, to test these against criteria and constraints, and to assist with trial and error solutions and corrective action.

Potential Advancements

The current project-control software serves as a valuable tool to assure planning is being done, and provides a source of information for control purposes. The problems just identified with current software systems create several opportunities for advancing the state of the art beyond that of the current generation of software. Presented next are potential areas for improvement.

To address the problem of input and output, several improvements could be made in the way data are entered. Data should be entered in a manner similar to the way they are developed. If, for example, schedules are developed by sketching, it would make sense to use the sketching process to develop the data base. The current generation of computer-aided drafting software has the capability to deliver the symbols used in network diagrams and the ability to code these symbols and store data about them. Therefore, it seems that the technology is available to develop the schedule data base directly from the sketch. The other common approach for schedule development is the use of a reference schedule and schedule data base. Again, using the current technology, it would be desirable, and possible to develop a way to graphically modify the relationships, descriptions, and other data to suit the requirements for the project being planned.

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The harshness of output results from the vendor's uncertainty as to what the type of information and the level of detail the manager will want. Programs are typically designed to produce everything, so as to have the broadest market appeal. In fact, it would be desirable to have more selective output. The first improvement for harsh output would be to add a flexible report-writer feature to the software to allow for flexibility yet maintain a limited display of information needed for control. A second improvement would be the addition of icons, color, and alternate printing size features. These would provide a way to highlight in reports those items related to control. A third improvement would be the development of a multilayer exception report to not only identify exceptions but provide a trail to trace the causes back to the data source. The manager needs information related to the data source such as crew mix, weather, supervisor, and any unusual circumstances. Obviously, graphics could be used more widely. Current technology could even make it possible to develop three-dimensional images on screen of the planned progress and the actual progress. Where hard copy is necessary, care should be taken to develop the size of drawings so that they are legible and provide a relative perspective on time instead of being limited by the width of the printer carriage. Where narrow printers are used, the graphics should be developed around multiple sheets, and match lines should be provided for ease of assembly into a complete graphic representation. Choices in size of graphical representations would also be a desirable improvement. Larger versions could be used for presentations and posting, and the smaller versions could be used as a part of a summary report designed by the user of the flexible report writer.

A second major area for improvement is the area of analysis. Future generations of software could do far more to provide meaningful analysis, including trends, comparisons, exceptions, the context of the information, and information and data trails to problem areas. The software should be capable of calculating and presenting trends in production rates across the project for various activities, such as concrete placement. The control software should be capable of making comparisons and determine variances from past performance and expected performance. The systems should be able to sort items that are exceptions (by a user-defined criteria) from expected performance, and trace the cause of the variation to the data elements (i.e., crews, supervisor, and circumstances) causing the major deviation. The software should accommodate data that might be more subjective in nature such as strikes, weather, rework, etc., which causes variation in performance. Where problem areas are identified, the system should provide the avenue for a solution. An example of this is scheduling with negative float, where the negative float path should be noted for corrective action. Analysis should include forecasting; the software should assist with the prediction of future performance based on data provided by past performance. Forecasting should incorporate planned changes in the character of the work and seasonal performance variations. This is done to some extent with scheduling programs, but they usually do not apply performance variations in activities to future activities in making predictions, which would give more realistic predictions.

Integration needs to be improved in project-control software. Integration between estimating and scheduling is lacking, and integration with design, especially conceptual design and conceptual estimating, is needed. Integration between production-control systems, cost-control systems, and schedule-control systems is an area for improvement. Integration requires the sharing instead of passing of information. To achieve integration, the systems must be designed around a single common data base rather than separate data bases to support particular functions. Thus, integration first requires the development of a a comprehensive data base for control. Then, data to support control can be defined and will dictate the way in which estimates and schedules are developed. The current approach of using an estimate and schedule to determine how a project is controlled is the cause of the lack of integration. Working back from control needs will create a system capable of full integration. There is an immediate requirement to develop interface software between stand-alone, popular estimating, and scheduling programs. These would not provide full integration, but would facilitate machine transfer of data rather than the current cumbersome, problematic, and costly manual interfaces between control modules.

New technologies should be examined and applied more widely in project control, including:

- Voice recognition systems for field data entry and program control.
- Scanning and digitizing technology for field-data entry.
- Holography and video representation of progress.
- Three-dimensional, graphic representation for control.
- Artificial intelligence such as expert systems, decision-support systems, natural-language programming, and machine learning for project-control applications.
- Remote sensing technologies for progress measurement.
- Automated data-collection technologies such as machine vision and acoustical interpretation to make possible real-time project control.

This list is by no means complete. New technologies are constantly being developed and existing ones are becoming more refined, expanded, and economical. Technologies in use in manufacturing control should be continually evaluated for suitability in the construction industry.

Voice recognition could be used to enter data in the estimate and schedule at the time it is being sketched utilizing a computer-aided drafting system. The same voice-actuated system could be used for quantity surveying of work in place and for updating of schedules.

Scanning technology in the form of bar-code readers could be used to enter material data for procurement scheduling into a data base. The same scanning technology can be applied to jobsite inventory and materials tracking. Digitizing scanners could be used to build schedules from sketches and to enter additional information concerning work packages into an activities-schedule data base. As an example, the data base for place concrete would have a file attached to it, which would contain the specifications. As materials were received related to the particular activity, the packing lists would be read into an attached file. All this information would be available electronically by referring to the activity designation.

Holography has the potential to replace models for major projects. This technology would also offer the advantage of allowing the model to be instantly updated to reflect actual progress. Similarly, video technology would provide a two-dimensional dynamic representation of progress.

Three-dimensional graphic representations would offer an added dimension and add to the information that could be presented for project control in a simple sketch, graph, or chart.

Use of artificial intelligence would greatly enhance the project-control

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software currently being used. The addition of system learning would enable the automatic capturing of experience data for use in future planning. Intelligence in the systems would afford the manager assistance in identifying alternate schemes when contingencies arise. Decision-support systems would provide the manager with a consistent and more complete set of inputs upon which to formulate decisions. Care should be exercised to build transparency into these systems and develop flexible mechanisms for the user to adjust to the particular system of management desired.

Within remote sensing there are many technologies which can be used, including machine vision and image recognition, audio pattern recognition, and a variety of other electronic and acoustical sensing devices. These technologies would generally be applicable in developing a real-time data entry process for progress measurement.

Machine vision systems can be used to monitor crane and hoist movements, alignments, vertical and horizontal controls, and equipment-utilization cycles. Acoustical measurements have potential for use in production measurements and quality control. Thermography offers potential in quality control, for example, in monitoring mat temperatures on asphalt pavements and degree of curing on concrete pours.

Conclusions

Project management has been greatly enhanced with the introduction of the microcomputer. The software systems provide a meaningful tool for project control. However, several problems exist with current software that should be addressed, and solutions and enhancements should be developed. Opportunities for advancement include reducing the harshness of inputs and outputs, providing meaningful analysis, developing integrated systems, and applying new technologies. These opportunities define and provide directions for research work and development of project-control software for the next generation of project-control systems for the construction industry.

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