

# A Smart Construction Project Management System

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**ABSTRACT:** Project management process is revolutionized by the Invent of project management software. Computerized planning and scheduling renders efficient and probable plan for enormous projects. The key features of any project management software includes producing and manipulating a schedule, resource planning, possible delay estimates, allocation of budgets and communication within the team. This work provides information about steps in construction management, traditional methods of construction management, need for e- construction management, difference between manual and e- construction management, problems improvements in e- construction management and ideal e- construction management.

**KEYWORDS:** Project management, CPMS, e-procurement, e- construction management, difference between manual and e- construction management, problems improvements in e- construction management, ideal e- construction management. effective dynamic scheduling.

## I. INTRODUCTION

Construction Management or Construction Project Management (CPM) is the overall planning, coordination, and control of a project from beginning to completion. CPM is aimed at meeting a client's requirement in order to produce a functionally and financially viable project. Construction industries throughout the world are challenged to improve performance if they are to contribute fully to the achievement of economic prosperity, sustainable environments and healthy fulfilled populations.

With the advent of internet era, smart construction management is dependent upon internet based integrated project management systems. Construction project management software (CPMS) refers to the systems that help project owner/operators, program managers, and construction managers, control and manage the vast amount of information that capital construction projects create. These systems, available from vendors, not only manage capital projects but also the entire project portfolio.

Procurement of construction materials is a multidisciplinary process spanning through the entire project life-cycle. Social e-procurement involves the usage of online collaborative networks that is effective and discovers new prospects of construction business. The features of ideal internet based smart construction management software are suggested. Some of these include calculating earned value check, effective dynamic scheduling with algorithms and e-procurement.

## II. LITERATURE REVIEW

Project management process is revolutionized by the invent of project management software. Computerized planning and scheduling renders efficient and probable plan for enormous projects. The key features of any project management software includes producing and manipulating a schedule, resource planning, possible delay estimates, allocation of budgets and communication within the team.

Conlin.J and Retik.A (1997) classifies the procurement software characteristics into general, technical and specialist features. General features are the basic information about the software while technical features perform the examination

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of particular features. Specialist features indicate the key features uniquely offered by the software. The critical path algorithm is frequently used in the implementation of various planning and scheduling software. In rare scenarios, earned value is used for controlling the overhead occurred during the scheduling phase.

Liberatore.M.J et al. (2009) emphasizes the need for project management software to provide near-optimal schedules. An option to maximize the net present value of cash flow is advisable. The project management software should be inter-operable with other enterprise wide software packages facilitating cross platform functioning. Since the system involves the usage of various protocols, the speed and quality of communication has been improved. This enhances collaboration and coordination between firms in construction companies.

Costa.A.A and Tavares.L.V (2014) discusses two game theory based models for analysis of e-procurement network dynamics. The simulation for procurers and administrative environments reveal that with constant rules and features of the network, the benefits for administrators diminish over time. Unbalanced equilibrium between existing and new users and suppliers derails the growth of the network.

### III. THEORETICAL BACKGROUND

Project management is the discipline of planning, organizing, securing, and managing resources to achieve specific goals. A project is a temporary endeavour with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables), undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. The temporary nature of projects stands in contrast with business as usual (or operations), which are repetitive, permanent, or semi-permanent functional activities to produce products or services. Project management includes developing a project plan, which includes defining and confirming the project goals and objectives, identifying tasks and how goals will be achieved, quantifying the resources needed, and determining budgets and timelines for completion. It also includes managing the implementation of the project plan, along with operating regular 'controls' to ensure that there is accurate and objective information on 'performance' relative to the plan, and the mechanisms to implement recovery actions where necessary.

E-procurement (electronic procurement, sometimes also known as supplier exchange) is the business-to-business or business-to-consumer or business-to-government purchase and sale of supplies, work, and services through the Internet as well as other information and networking systems, such as electronic data interchange and enterprise resource planning.

Earned Value Analysis (EVA) is an industry standard method of measuring a project's progress at any given point in time, forecasting its completion date and final cost, and analyzing variances in the schedule and budget as the project proceeds. It compares the planned amount of work with what has actually been completed, to determine if the cost, schedule, and work accomplished are progressing in accordance with the plan. As work is completed, it is considered "earned". EVA is a snapshot in time, which can be used as a management tool as an early warning system to detect deficient or endangered progress. It ensures a clear definition of work prior to beginning that work. It provides an objective measure of accomplishments, and an early and accurate picture of the contract status.

### IV. NEED FOR e- CONSTRUCTION MANAGEMENT

The management of construction projects requires knowledge of modern management as well as an understanding of the design and construction process. Construction projects have a specific set of objectives and constraints such as a required time frame for completion. While the relevant technology, institutional arrangements or processes will differ, the management of such projects has much in common with the management of similar types of projects in other specialty or technology domains such as aerospace, pharmaceutical and energy developments.

The convergence of information services, communication, and computing functionality in the Web technologies allows practitioners in construction to perform Web-based project management over the Internet. More than 100 software developers have developed web-based project management software and services for the construction industry (Extranet World 2000). A number of construction companies all over the world adopted this technology either because they realized its competitive advantages or they were being forced to adopt it by their clients. When a construction

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company commits to adopt a Web-based project management system, there are two possible strategies that the company can choose in developing the system: in-house development or outsourcing this activity to a professional consultant.

Regarding the first option, construction firms that decide on in-house development should keep in mind the substantial financial, technical, and human resources necessary to develop and maintain the system. The company can host a Web server internally and customize its functionality to fulfil the corporate needs and those of the project operations. Also commercially available Web-enabled project management software can be customized into proprietary systems. On the other hand, the second option to outsource is useful for companies with limited resources to develop their own Web-based project management systems, and there are a variety of opportunities in outsourcing. Consultants may be hired to build a web site to fulfil the company's Internet advertising needs, solicit job applications, or conduct comprehensive project management over the Internet.

Many Internet-based information services for the construction industry provide a capability to build one's own free limited web page residing on the provider's server. However, to implement Internet-based applications in construction project activities successfully, the applications should be acceptable in the construction environment and the utility assessment of such applications is needed. The assessment will determine whether the Internet-based applications in construction industry can perform as intended and provide an optimal configuration of Internet-based services for supporting construction project activities.

## **V. DIFFERENCE: MANUAL AND e- CONSTRUCTION MANAGEMENT**

Traditional procurement and electronic procurement both have advantages and disadvantages. Procurement is generally done face-to-face, or via telephone, while e-procurement is generally done online. Procurement is really a collection of processes that involve many steps and interactions with the other departments of a company and with suppliers. Because purchasing costs typically run to 50% of operational costs, the procurement process provides many opportunities for cost savings that can make a great difference to a company's bottom line. The rule of thumb is that a 5% savings in purchasing costs can increase profit by 50%, and would equal an increase in revenue of 50%, or a reduction in overhead costs of about 20%. Traditionally, procurement was paper- and conversation-based, usually with procurement officers interacting with long-time partners or well-known suppliers and purchasing at fixed prices. In recent years, this has changed to become a strategic function: Procurement officers seek suppliers that fit with a company's overall strategy.

E-procurement involves moving the procurement process online to cut out steps and save money. For example, traditional procurement involves getting quotes and then approval, probably from finance, as well as a purchase order, which could take more than a week. With e-procurement, this process is simplified and speeded up considerably, thanks to real-time interaction with pre-approved suppliers and trading partners, who can be anywhere in the world. With online purchasing, the purchase can be approved online and the order completed within minutes; the required item often arrives within days.

In business, time is money, so the more a company can reduce staff time involved in purchasing, and the more quickly it issues a purchase order, the more it can reduce operational costs.

## **VI. BENEFITS OF e- CONSTRUCTION MANAGEMENT**

Small and large companies around the world choose Web-based software to manage their projects today. Web-based project management software brings more usability, convenience and value to companies of any size and industry. Web-based project management software doesn't require dedicated technical specialists to maintain and support. It is up and running in seconds. Web-based project management tools improve your project communications and the overall productivity of your team. Information Technology (IT) is now routinely used in the construction industry as a tool to reduce some of the problems generated by fragmentation. The use of IT improves coordination and collaboration between firms participating in a construction project, leading to better communication practices. Its benefits include an increase in the quality of documents and the speed of the work, better financial control and communications, and simpler and faster access to common data as well as a decrease in documentation errors.

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Web-based project management software gives you access to your data from any computer: Unlike traditional tools, hosted project management software requires no installation and can be used at any computer. You only need a Web browser and an internet connection. You can access your data from the office, at home, in a hotel room or in the airport. As a Web-based project management software is cross-platform, so you can manage your projects using different computers and operating systems.

Web-based project management software makes collaboration easy: Collaboration is an intrinsic part of project management. When you work in the same office, it might not be a problem. However, if you need to share a project plan with your international partners, delegate tasks to your offshore team or control contractors across the country, you need a reliable platform for collaboration. Web-based project management software helps you keep the project plan in a central place, so all of you have up-to-the-minute access to the business-critical project information. Teams can share knowledge and collaborate smoothly to complete tasks and deliverables. Online project management software can help you adjust activities quickly to accommodate project changes and updates. If your project plans change often, you need to keep everybody in the loop. Online project management software's help is vitally important to you. Smart notifications via email keep team members well-informed on newly assigned and updated tasks, making your team able to work efficiently. Online project management software allows you to work on tasks together, communicate on issues and discuss problems as efficiently as if you were working in the same office.

Web-based project management software increases productivity: Keeping project information in single place makes collaboration smooth and reduces misunderstanding. Online project management software helps people to work together more effectively and increase organizational productivity. Web-based project management software saves the project manager's time on routine operations like updating plans, collecting reports and reminding people about what needs to be done. The project manager can always see who is responsible for each task, instantly keep track of changes and evaluate project progress. Each team member knows exactly what needs to be done. Hosted project management software puts you in control and your team on the same page.

Web-based project management software is affordable: Instead of a thousand dollars, you pay only a few dollars per month. You pay for the period of time when you run your project and use the project management software. Web-based project management software does not require installation and maintenance costs. This allows you to start using online software as soon as possible without additional investment or rescheduling your budget.

Web-based project management software is updated automatically: When using a Web-based project management solution, you are always using its latest version. All software updates are made automatically, so you don't need to worry about it. Besides, such software updates are made for free, so you save time and money.

Web-based project management software is easy to use: When you buy hosted project management software, you save time and money on employee training. Even inexperienced users can be quickly plunged into collaboration.

## VII. PROBLEMS IN e- CONSTRUCTION MANAGEMENT

Besides the benefits that s may provide, some important barriers to implementation still exist and should not be overlooked. These barriers need to be addressed in order to increase public confidence in adopting e-CMs in construction projects. The literature shows that these barriers include a wide range of issues that can be summarized as follows.

**DIFFICULTIES IN QUANTIFYING COSTS AND BENEFITS:** It is difficult to persuade every organization participating in a construction project to make the necessary level of investment to fully implement a e-CM, which is due in part to the fact that there is still no reliable data on the economic impact of e-CM s for projects or firms. The temporary nature of relationships in a construction project also provides little or nor incentive for investing in innovative technologies. A/E/C firms have been slow to commit to the adoption of e-CMs on the mere suspicion that e-CMs reduce cost or improve overall project performance. Many of them are still taking a “wait and see” approach to the use of e-CMs until more definitive cost and benefit data are available.

**SYSTEM RELIABILITY:** Ideally, a PM-ASP should be available to users at all time to ensure its high reliability. However, this is rarely the case. When servers are down, users become disconnected and unable to work online. Data can also be lost if the system is not backed up or is improperly housed. With hundreds of new ventures competing for

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the industry's attention, a PM-ASP provider may not be able to adequately take care of users' needs or could even go out of business, leaving users without recourse in the middle of a project.

**SYSTEM SECURITY:** System security is probably the most important issue considered by A/E/C firms when implementing PM-ASPs and e-commerce. This issue is well founded, especially in the wake of recent, highly publicized "hacking" break-ins. A high-security PM-ASP is a system with low or no chance of unauthorized users or competitors accessing the system and data. Although most PM-ASPs currently employ a "user name and password" scheme to protect an unauthorized access to their sites, this scheme is too simple and still inadequate in satisfying the security requirements of electronic transactions in construction projects. Users still rely mostly on mutual trust between parties, as well as paper-based in parallel when using this scheme. This inadequacy has prevented the creation of complete confidence in the construction industry to adopt PM-ASPs.

**LEGAL ISSUES OF ELECTRONIC TRANSACTIONS:** Although the existing legal environment may provide essentially clear guidelines for construction practitioners to manage a contract in a paper-based environment, new collaborative tools such as PMASPs change the work method, making legal responsibilities in this new environment unclear. In fact, an online contract enabled by PM-ASPs is still a new approach that may pose risks, particularly in the area of jurisdiction and enforcement. Since the Internet marketplace is global, e-commerce participants potentially are subjecting themselves to the laws of distant states and countries. A simple solution is to use the forum selection and choice of law provisions in online contracts. However, there is no guarantee that a court will always enforce such language.

**LACK OF SOFTWARE INTEROPERABILITY:** An important inhibitor to the adoption of PMASPs is the technical difficulties caused by the incompatibility of systems. Companies participating in a construction project usually deploy different software programs to manage their enterprises, resulting in inter-organizational incompatibility and creating an inherent barrier to information sharing when implementing a PM-ASP. Although this problem has been overcome by the adoption of common standards for the construction industry, such as IFC and aecXML, incompatibility often remains a problem in international transactions. It is expected that a widespread adoption of PM-ASPs will be more likely when universal standards are defined and users are able to seamlessly share data between multiple systems.

**DATA OWNERSHIP AFTER PROJECT COMPLETION:** The actual ownership and control of data after project completion is of considerable importance when implementing PM-ASPs. Although most ASPs allow project owners to archive the entire project record on CD-ROM after project completion, there is still debate on who should get copies of the project record and what information should be included or excluded from each party's version.

## VIII. IMPROVEMENTS IN e- CONSTRUCTION MANAGEMENT

Lean construction is a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. The most important determinants of construction are supposed to be workflow reliability and labour flow, but lean construction has changed the traditional view of the project as transformation, and embraces the concept of flow and value generation. Lean construction is composed of the following techniques:

(1) **Concurrent Engineering:** Concurrent engineering can be described as parallel execution of various tasks by multidisciplinary teams with the goal of obtaining most favourable products concerning functionality, quality, and productivity. Scheduling could be recovered by network analysis (CPM and PERT). Many other opportunities can be achieved through overlapping activities, splitting activities and reducing the transfer time between different activities. The important planning parameters for scheduling concurrent activities are lead time, quantity, and risk under ambiguity. Concurrent engineering is focusing on the team efforts; communication and information sharing are the keys for discovering new ideas. While partnering with subcontractors and suppliers can also be good changes regarding concurrent engineering, the success of lean production is depending on the involvement of all participants in the early stages of the design;

(2) **Last planner:** The last planner is the person or group of people responsible for production unit control, which means completion of individual tasks at the operational level. Last planner necessitates work flow control, ascertaining the stream of supply, design, and installation throughout production units. This can only be done by using look-ahead schedule, which determines the progression and rate of work. It carves up the master schedule into many packages,

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specifying the techniques of check capacity, execution, and establishes a stockpile of standing by work. The scope of look-ahead schedule ranges from 2 to 6 weeks and should be put in order by team work;

(3) Daily huddle meetings: Daily huddle meetings provides a platform for the team members to share their views and to share what has been achieved, at the same time, discuss problems they are facing during the production process;

(4) The Kanban System: The strategy of Kanban is grounded on key components, i.e., market place, supplier kanbans, collection vehicle, satellite stores, and inventory management system. Market places are site warehouse that allocate different materials and small tools to the workers. Similarly, satellite stores are situated on site, where they get products from market places. Collection vehicle collects materials from preferred suppliers to the operational site. Kanban use plastic bins as a signal to pull materials from suppliers to site, using the concept of Just In Time. Request forms are normally used as kanban signals between market place and satellite stores. The system of kanban starts normally with open doors, so that the site can pull materials from the supplier up to certain perimeters. Subsequently, the material requested from suppliers arrives at market, and products are later on picked from the stores, which are usually managed by recorder points;

(5) Plan Conditions and Work Environment in the Construction Industry (PCMAT): The purpose is to introduce a plan of health and safety into the project execution, called "Plan of Condition and Work Environment." These safety activities can generate limitations for scheduled tasks and that is why it should be embraced as a part of assignments. All safety practices are therefore amalgamated in short-term planning, which can be analyzed through daily feedback from crew and subcontractors respectively and

(6) Visual Inspection: Visual inspection shows the uneven nature of the construction and leads to the application of visual tools for material, work and information flow, etc. Identification of materials can accelerate repetitive processes and diminishes the risk of selecting wrong product. Progress charts and schedules can implement the dedication to the completion of tasks. Information and technology can also improve the communication between decision maker and executer, and can accelerate the process as well.

## IX. IDEAL E- CONSTRUCTION MANAGEMENT

**CALCULATING EARNED VALUE:** Earned Value Management measures progress against a baseline. It involves calculating three key values for each activity in the WBS: The Planned Value (PV), (formerly known as the budgeted cost of work scheduled or BCWS)—that portion of the approved cost estimate planned to be spent on the given activity during a given period. The Actual Cost (AC), (formerly known as the actual cost of work performed or ACWP)—the total of the costs incurred in accomplishing work on the activity in a given period. This Actual Cost must correspond to whatever was budgeted for the Planned Value and the Earned Value (e.g. all labor, material, equipment, and indirect costs). The Earned Value (EV), (formerly known as the budget cost of work performed or BCWP)—the value of the work actually completed.

These three values are combined to determine at that point in time whether or not work is being accomplished as planned. The most commonly used measures are the cost variance:  $\text{Cost Variance (CV)} = \text{EV} - \text{AC}$  and the schedule variance:  $\text{Schedule Variance (SV)} = \text{EV} - \text{PV}$ . These two values can be converted to efficiency indicators to reflect the cost and schedule performance of the project. The most commonly used cost-efficiency indicator is the cost performance index (CPI). It is calculated thus:  $\text{CPI} = \text{EV} / \text{AC}$  The sum of all individual EV budgets divided by the sum of all individual AC's is known as the cumulative CPI, and is generally used to forecast the cost to complete a project. The schedule performance index (SPI), calculated thus:  $\text{SPI} = \text{EV} / \text{PV}$  is often used with the CPI to forecast overall project completion estimates.

A negative schedule variance (SV) calculated at a given point in time means the project is behind schedule, while a negative cost variance (CV) means the project is over budget.

**EARNED VALUE MANAGEMENT SYSTEM (EVMS):** A list of guidelines is provided which covers areas such as planning, scheduling & budgeting; accounting issues; management reports, and so forth, however there are no "approved" systems identified. But the basics of any EVMS are: A methodical, organized, thorough, and complete WBS A baseline schedule A baseline budget, organized into control accounts Measurement of the work by control account (e.g. \$, units in place, man-hours, etc.) Scheduling the authorized work is no different than in any large construction project—it is a necessary activity for the success of the project. However in an EVMS the schedule will

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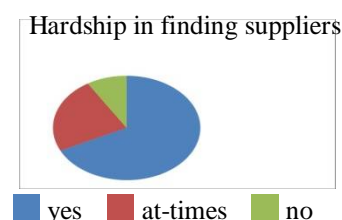
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integrate all of the technical, cost, and schedule aspects of the work, resulting in the expected sequence of work. Interdependencies are established that result in the total work time and reveal the critical path, which is also the shortest project duration. Within each task it is then necessary to identify objective interim measures to allow for accurate performance assessment each month. A sufficient number of these interim measures will be defined after the detailed schedule is established to ensure the performance is measured as accurately as possible.

**DYNAMIC SCHEDULING:** Dynamic project scheduling and the network diagram of a project predecessor network show us the task sequence and allow us to design concurrent or parallel tasks which can significantly shorten a project's duration. Successful project managers use dynamic project scheduling because it saves them significant amounts of time and also because it allows them to quickly model the impact of changes in resources work or cost. Dynamic scheduling saves this time because it automatically recalculates the duration and budget for the project every time we make a change in the resources, hourly rates, hours of work, predecessor relationships with a number of people working on the project. Many commercial software scheduling products allow for dynamic scheduling and there are a couple of critical elements that we need to have for the dynamic schedule to work. First our scheduling needs to be based on the use of predecessor relationships between tasks, not the use of fixed start and finish dates. There are three primary kinds of predecessor relationships and the entire schedule has to be built on these relationships. The second requirement is that the schedule needs to be based on durations which are calculated from resource availability and work estimates. As an example, we enter the amount of work and the resource's availability, say 80 hours of work for a person working half-time, or four hours a day. The project manager enters that date and the software calculates the duration of 25 working days because the half-time team member can only complete four hours a day. Having this data available means we need to tell the software how many hours a day each resource can work. We use dynamic scheduling with predecessor relationships to control the sequencing of the tasks in our project plan. So as an example, we may specify a finish-to-finish predecessor relationship. That tells our project management software that we want two tasks and their resources to be scheduled so that both tasks finish at the same time. When we are finished specifying all our predecessors, our project plan becomes a network of tasks, linked by the predecessor relationships. The end result is often called a PERT chart and it displays our project plan and its network of tasks. Each of the task bars is linked to the project network which allows our dynamic scheduling to control the sequencing of tasks based on the predecessor relationships and the amount of work in the task.

## X.RESULTS

The survey contained 20 questions about various construction management software used in the industry, practical difficulties and the need of the industry in construction project management. About 51 responses were received for the survey and the results were analysed using available online data analysis tools.



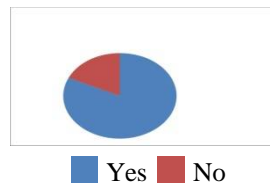
Pie chart depicting the percentage of companies who have hardship in finding suppliers.

Does e-procurement increase efficiency?

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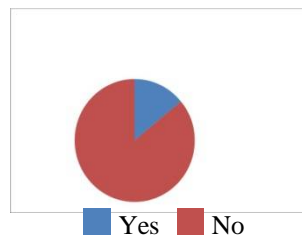
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Pie chart to depict the of increase in the efficiency using e-procurement

Does your software have dynamic scheduling?



Pie chart revealing the percentage of industries using dynamic scheduling software

## XI. CONCLUSION

The importance of web- based developments in the construction industry has increased manifolds in the internet era. Capital project management software (CPMS) refers to the systems that are currently available that help capital project owner/operators, program managers, and construction managers, control and manage the vast amount of information that capital construction projects create. A collection or portfolio of projects only makes this a bigger challenge. These systems go by different names: capital project management software, construction management software, project management information systems. Usually Construction Management can be referred as subset of CPMS where the scope of CPMS is not limited to construction phases of project. There are systems available from vendors which will not only manage capital projects but also the entire project portfolio (Program). This work lists the various features of construction management software currently used by the construction project managers. Procurement management and scheduling are the two basic needs catered by the project management software. The procurement process in web-based scenario is degraded due to lack of availability of collective resources which further adds to human intervention. The delay in the construction schedule can be further decreased with the adoption of e-commerce. The security and negotiation through the electronic agent is an optimized solution to increase the efficiency of the construction. Scheduling processes should be designed to manage all possible delays on-site and in procurement. CPMS is a critical component of overall IT strategy for Capital project owners and capital project owners are realizing it now, more than ever. The need of the hour is a new software that can provide dynamic scheduling evolutionary procurement strategies to minimize the expenditure.

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