RESEARCH AND DEVELOPMENT PLAN FOR THE AEC INDUSTRY

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Introduction

The Architecture-Engineering-Construction (AEC) industry is growing at a fast pace—new project delivery methodologies are being adopted, design of facilities is continuously improving, newer means, methods, and materials of construction are being produced. In addition globalization, skilled labor shortages, and environmental issues are creating fresh challenges for the growing industry. All these market forces have made the AEC business more and more challenging. Agencies involved in the AEC industry have to work together to respond to these changing forces and to prepare for the next century. The Construction Engineering and Management (CEM) profession will definitely play a strong role in these initiatives. Owners, constructors, construction management consultants, federal agencies, state agencies, and universities that form the core of the CEM profession will have to join hands with other agencies of the AEC industry to develop strategies for continuous improvement of the industry. The author feels that research and development in the following three key streams will benefit the AEC industry.

1. Flexible Enterprise Management Systems for the AEC Industry

The delivery of a facility is information intensive. It is a mutli-phase task that begins with conceptual design and continues through detailed design, planning, implementation, construction, and maintenance phases. A major complicating factor is the involvement of a number of agencies including the architect, engineering consultants, general contractor/construction manager, electrical contractor, mechanical contractor, other specialty contractors, and owner's representative. The successful delivery of facilities requires a multitude of input including information and decisions from each of the participating agencies, numerous resources such as architectural drawings, construction crews, heavy equipment, and materials. Improving the efficiency and accuracy of information exchange is fundamental to the improvement of the project delivery process. Members of the industry and academia have recognized the importance of strategies for the best possible management of information. Owners and constructors in collaboration with universities have developed excellent tools for the management of information. The problem with the current tools is that they are focussed on one-aspect of the facility delivery process such as cost management, time management, quality management etc. There is a need to develop/adopt systems that can provide real-time access to information on project costs, materials, equipment, schedules, payroll, sub-contractor availability, owner etc. Such type of systems—called Enterprise Management Systems—are available and are extensively used by other industries. CEM agencies need to conduct research in this area to determine the framework of such an Enterprise Management System that can be beneficially adopted for the AEC industry. Figure 1 shows the framework of a proposed Enterprise Management System and helps in identifying some of the research issues in this area.

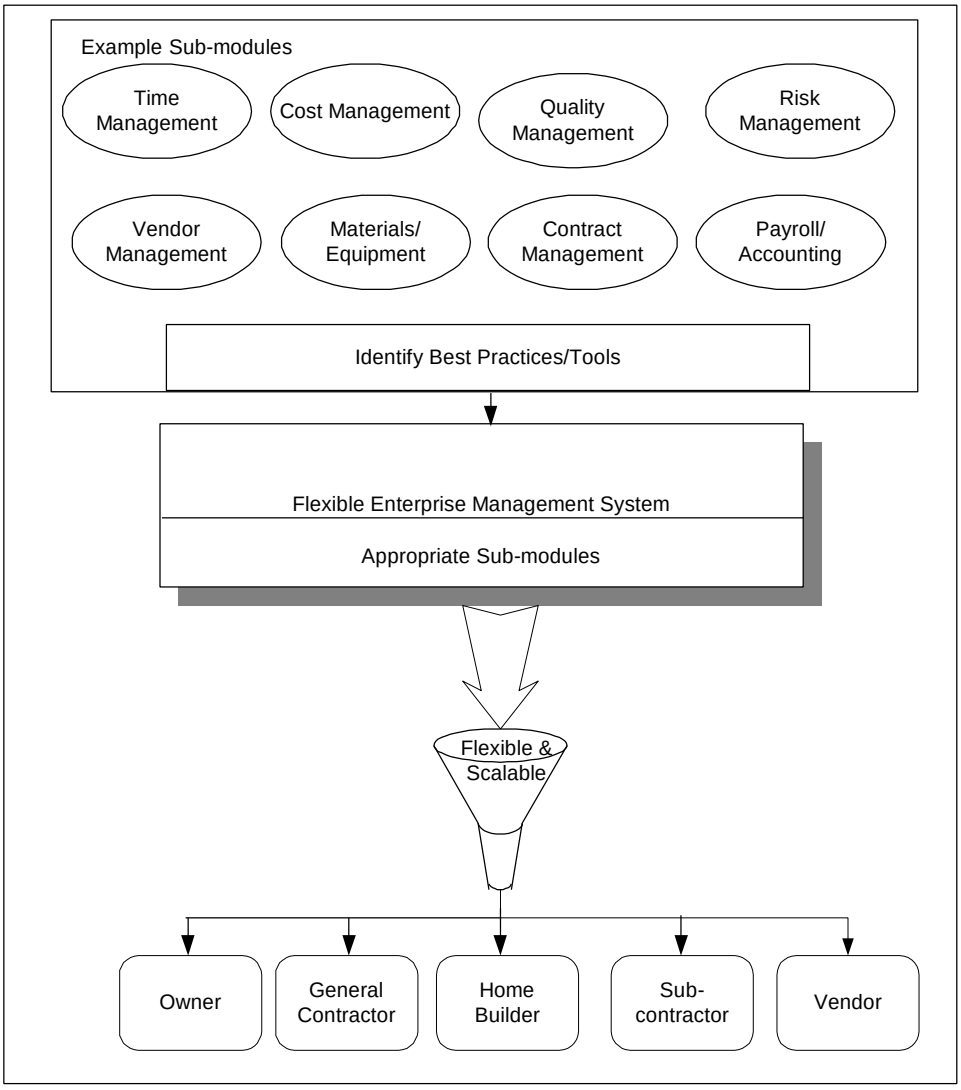

Figure 1: Flexible Enterprise Management Systems

The Enterprise Management System will consist of a number of sub-modules—each focussing on a particular aspect of the facility delivery process. The system itself will be a flexible, scalable, and plug-n-play "shell". It will provide agencies involved in the AEC business an integrated platform to manage information from project conception to completion.

A number of answers are needed to successfully understand the application of Flexible Enterprise Management Systems for the AEC industry. Research has to be conducted to determine answers to the following questions:

1. Are Enterprise Management Systems suitable for the AEC industry?
2. Can the currently available systems such as SAP/R3 Engineering and Construction Solution meet the needs of the AEC industry?
3. Which sub-modules should be incorporated in the Enterprise Management Systems?
4. How to identify best practices and tools for each of the identified sub-modules? Once identified how to integrate the best practices and tools?
5. What are the costs and benefits of such systems?

Recently, the development of Internet, Intranet, and Extranet has greatly influenced the methods adopted by an enterprise for the management of information. Researchers planning to undertake studies in the area of Flexible Enterprise Management Systems will have to understand the role of the Internet, Intranet, and Extranet. Figure 2 provides a schematic view of a proposed Flexible Enterprise Management System using Internet as its backbone.

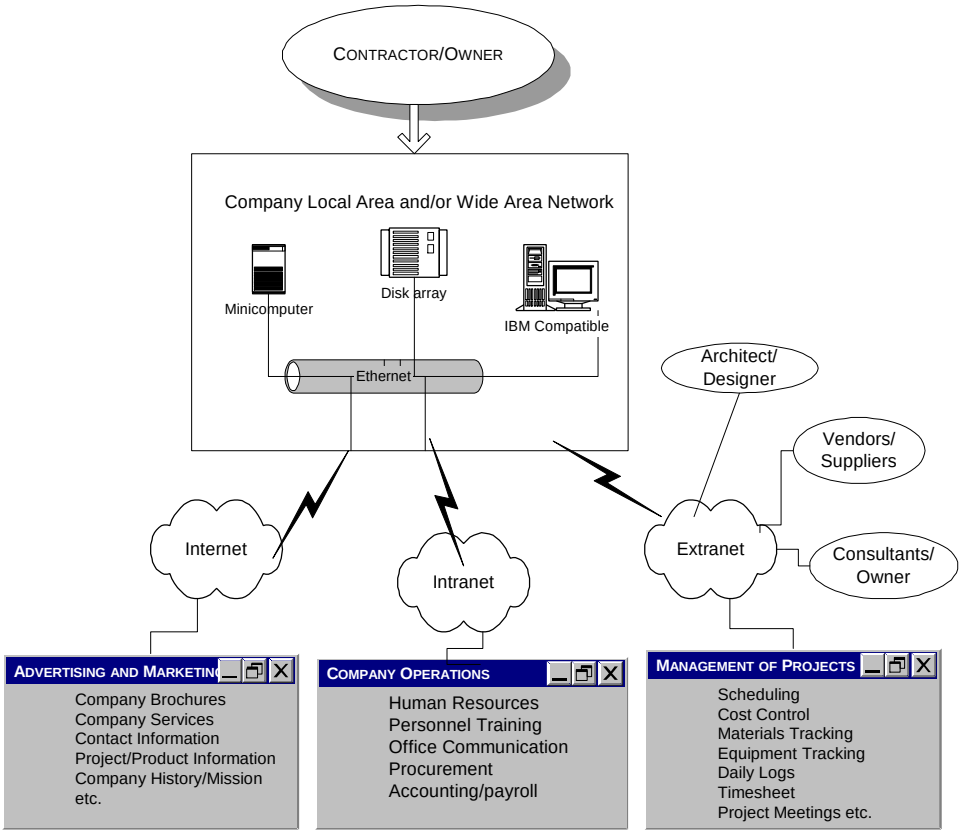

Figure 2: Internet based Enterprise Management System

2. Simulation based Construction Scheduling System

Construction simulation has been a topic of interest for the CEM profession for the last two decades. Simulation is a powerful tool that can be used by a construction manager for the analysis of the various complex construction tasks. The application of construction simulation ranges from productivity measurement and risk analysis to resource allocation and site planning. Despite the continued effort, construction simulation has found limited application in the AEC industry. One of the reasons for the limited application is the fact that current applications of simulation are focussed at the process level. The author feels that simulation can be beneficially applied if the focus is changed to the project level. One such approach would be to use simulation for the scheduling of construction projects.

Scheduling of construction projects using traditional network-based techniques has a number of drawbacks. Three major characteristics of the construction projects that reduce the effectiveness of the network-based techniques include:

1. The task of delivering a facility can be decomposed into sub-tasks requiring efforts of a number of agencies such as architects, structural engineers, mechanical engineers, construction engineers, etc. These specialists normally belong to different

agencies that are related to each other by contractual arrangements. The resultant decision making and the flow of information are as such complicated making the task of scheduling complex.

2. Construction projects are performed in a dynamic environment that is characterized by stochastic phenomenon such as weather changes, labor productivity and skill fluctuations, and variation in site conditions.
3. Resources that control the progress of work tasks are dynamically allocated, for example, a tower crane assigned to a high-rise building project. The tower crane is dynamically allocated to perform functions such as lifting a concrete bucket, arranging structural steel members, and unloading fabricated members from trucks.

Traditional network based planning methods do not consider these important characteristics of construction projects during schedule development. Furthermore, scheduling of construction projects can be made efficient by electronically storing and reusing portions of the schedule. For example, a construction company specializing in the construction of highway bridges can develop process model based schedules for bridge components and reuse them for future projects. The above discussion clearly indicates that there is a need to develop a scheduling methodology that better captures the features of construction projects. In addition, there is also a need to include in the development of the proposed methodology, features that will "make it fit" into any proposed Computer Integrated Construction (CIC) system or an Enterprise Management System.

The author proposes to launch an effort to develop an advanced construction scheduling system by using simulation as its backbone. Under the proposed methodology, a project will be first divided into manageable components by identifying the operations, processes and work tasks involved in it. All the resources will then be defined in a common resource library to allow project-wide dynamic allocation and utilization. The operations will be linked to each other to define project implementation strategy and process models will be developed using simulation methodology to define the work tasks. This will provide an efficient and realistic approach to scheduling of construction projects.

3. Human Factors Engineering for the AEC Industry

Human beings play an important role in the AEC industry. In order to accomplish continued improvements in the facility delivery process the AEC industry needs to focus on the application of human factors engineering—a field of study that focuses on how humans interact with the elements in their workplace. One area of beneficial application of human factors engineering is the methods used for instructing workers on a construction site. The AEC industry and academia are rapidly producing new tools for site instruction such as electronic drawings, 4D-CAD models, process animations etc. However, little or no attention is paid to the beneficial utilization of such tools at the skilled worker level. There is a strong need to undertake a study from the perspective of the skilled worker on the appropriate design and utilization of these tools. Clearly, as the facilities of the future become more complex the effectiveness of the site instruction methods will have to be improved. Improvements of the site instruction process can be accomplished by applying the principles of human factors engineering.

Conclusions

The author feels that investment in the research and development in the three above-mentioned areas will greatly benefit the AEC industry. Network of core agencies of the CEM profession involved in these research issues will not only benefit the AEC industry but will also benefit the Construction Engineering and Management education.

Background of the Author

Dr. Anil Sawhney has been involved in the construction engineering and management research and education for the last ten years. After completing his Ph.D. at the University of Alberta in 1994, he joined Western Michigan University as an Assistant Professor. He will join the Del E. Webb School of Construction at Arizona State University as an Associate Professor in August 1999. Dr. Sawhney's research program was focused for the last ten years on the application of computers and information technology in construction to improve the efficiency of construction and related businesses. He has been involved in a number of research projects that were geared to address this issue. Dr. Sawhney has published over 30 technical and conference papers on areas ranging from bidding support system to computer simulation. He has developed and implemented methods for planning of projects, incorporating risk and uncertainty in construction, energy-efficiency in residential construction, and pre-purchase inspection of houses. Dr. Sawhney's current research interests focus on the use of simulation in planning and controlling construction projects. The main feature of his research is to transfer the developed simulation concepts to the construction industry. He is also involved in the development of teaching aids that utilize simulation and gaming to enhance construction engineering and management education.