Fourth International Conference on Construction in the 21st Century (CITC-IV)
"Accelerating Innovation in Engineering, Management and Technology"
July 11-13, 2007, Gold Coast, Australia

The impact of MTO feature on ERP application In construction industry

Yanming Zheng, Chin-Sheng Chen,
Industrial and System Engineering Department,
Florida International University, Miami, Florida,USA

Syed M. Ahmed
Associate Professor, Construction Management Department,
Florida International University, Miami, Florida,USA

Abstract

ERP systems have emerged as an effective tool for integrating enterprise information in the manufacturing industry but there are studies raising the question of their effectiveness for the construction industry; Due to the Make-To-Order (MTO) nature of construction business, the existing ERP system, typically tailored for Make-To-Stock (MTS) production, encounters the difficulties to implement directly in construction enterprise. This paper analyzes: the major impact of MTO feature on ERP application in construction industry, presents the potential barriers in the functionality realization of the system, and concludes with a list of suggestions for research and development of an ERP system for the construction industry. In the end, the system architecture of ERP solution for construction is presented.

Key words: Construction, ERP, MTO, MTS, Operation mode

1. Introduction

Although ERP has its origins in manufacturing and production planning systems, the achievement of widely information integration by ERP is also required by the Construction enterprise. The successful implementation of ERP in Construction enterprise will help realize information sharing, improve the transparency of management responsibility and management efficiency. It will also help achieve the goal of keeping balance in resources, enhance organizational flexibility, improve decision making capabilities, reduce project completion time, and lower costs (Jung-Ho Yu; Hyun-Soo Lee 2006). In recent years, more and more construction enterprises have begun to implement the ERP system, but currently there are only

a few cases of successful ERP implementation in Construction industry, and a few good softwares which is soley designed for construction enterprises.

The existing software for construction industry is usually designed for a single function. For example: Timberline for Estimating, Primavera Project Planner (P3) for scheduling and planning, and CMiC Enterprise by CMiC (Computer Methods international Corp.) for project management. But only a few software can integrate all the functions including estimating, scheduling, project management, and finance for construction enterprises in particular.

ML Payton Consultants conducted a study in 2003 to examine how U.S. and European construction firms currently use ERP systems and how its use will change over the next few years. The results revealed that while companies are pleased by the performance of their ERP systems, they would also like to see a more concentrated effort by the ERP vendors to meet the unique needs of the Construction industry (ML Payton Consultants 2003).

Compared with manufacturing industry, the unique characteristics of the construction industry have been widely recognized. From the business perspective, the operation mode of construction business is Make-to-order (MTO); this is different from that of manufacturing industry Make-to-stock (MTS). In this paper, the impact of MTO nature on construction ERP application will be analyzed, and feasible solution for construction ERP system will be discussed.

2. Unique Features of Construction Industry Based on Operation Mode Analysis

2.1 Concept of MTS and MTO

Operation modes are often classified as MTS and MTO. MTS is a manufacturing philosophy whereby finished goods are produced to stock. Incoming customer orders are then fulfilled from stock as opposed to being directly fulfilled from manufacturing. Manufacturing proactively maintains adequate stock levels for in-coming customer orders. MTS is a common operation mode for manufacturing industry, and usually based on predefined BOM and process. By contrast, MTO is a philosophy whereby finished goods are manufactured for specific customer orders, and meet the unique needs of specific customer. In this mode, product can only be made after receipt of a customer's order. MTO has several subcategories, including Design-to-order (DTC), Engineer-to-Order (ETO), Build-to-order (BTO), and Assemble-to-order (ATO).

From chart 1 we can find that MTO includes not only the production process, but also engineering process, i.e. product design, process design, etc. It usually applies in those industry in which customization is very important, for instance construction industry.

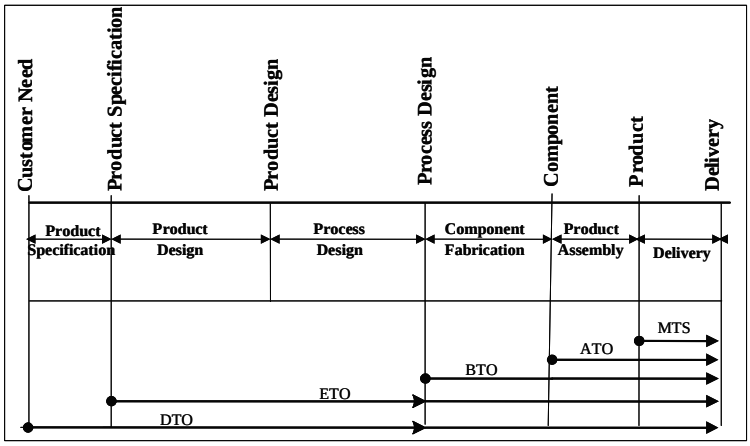

Chart 1. MTO and MTS (Gaither and Frazier 2001)

2.2 Unique features of Construction industry based on MTO analysis

Due to the difference in operation mode, construction industry has the unique features compared to MTS manufacturing as shown in Table 1.

MTS (manufacturing)	MTO (Construction)
Repetitive demand for a product	**Project-oriented**: Production process is project-oriented. Demand is not repetitive.
Product is optimally designed and thus a bill of materials (BOM) is available	**BOM is not predefined:** Every construction product is uniquely designed, thus BOM is also unique
Process plan is optimally designed for volume production of a fixed lot size	**Process is not predefined:** Process plan is designed according to product features, site conditions, technologies, etc
Real orders come from distribution centers	**Orders only from customers:** Construction can only be launched after the contract is signed with customer
Production facility is set up for continuous or repetitive (batch) production	**Dispersed construction sites:** The construction sites are dispersed, and can not be used repetitively.
Participants are mainly within the enterprise	**Many business partners involved**: Besides the contractor, many parties are involved in the construction project, including designers, owner, subcontractors, regulators, etc

Table 1. Unique Features of Construction Industry Compared to Manufacturing Industry

Project oriented: Traditional manufacturing is featured with mass-production-scale and repetitive operations, while the Construction business is operated around projects. Each project is an end product to be delivered and is expected to be completed on time and within budget. A construction ERP system needs the ability to manage ongoing projects by reporting and predicting progress status, cost status, profitability, and potential problems such as falling behind schedule and overrunning cost so that proper actions can be taken to avoid the problems. Furthermore, the profit and progress of a project have impact on the overall

performance of the enterprise. If there are resource conflicts among different projects, enterprise level decisions must be made to optimize the overall benefit of the enterprise. This feature does not apply to an ERP system for manufacturers (Shi and Halpin 2003).

BOM and process are not predefined: In traditional manufacturing, BOM of product is fixed and rigorous, and processes are precisely defined. The feature of standardization facilitates the ERP system to achieve business management automation. However, in Construction industry, the large amount of Construction component specification, and the variance of customer requirements makes it difficult to define the standard BOM (Lee and Shi 2006). Work operation and process also vary according to product features, sites conditions, technique applied, etc. For each project, product design and process design have to be carried out before the site works begin. The feature of non-standardization increases the difficulty for ERP application in Construction industry.

Orders only from customers: In MTS mode, product orders come principally from warehouse orders within the company. Theses orders are based on forecasts of future demand for products from many customers. Forecasts therefore tend to play a more important part in demand management in MTS mode. A balance must be struck between these costs in determining economic lot sizes in MTS mode. In construction industry, customer orders are the predominant focus in demand management, demand forecasts may not be applied, and product can only be made after receipt of customer order (Gaither and Frazier 2001).

Dispersive Sites: In traditional manufacturing, concentrative production facility is set up for continuous or repetitive (batch) production. The resource allocation and rearrangement between different product lines and production orders can be realized timely and conveniently. While a Construction project is usually far away from other projects and head office. Allocating a resource from one project to another is greatly constrained, and it always involves extra costs and time losses (Shi and Halpin 2003). Furthermore, sometimes a project is in a remote place where the internet is unavailable. It brings difficulty to login ERP on site.

More participants involved: For manufacturing, production is mainly an inner process within the enterprise. However, in a construction project, many parties are involved, including designers, contractor, owner, subcontractors and regulators.

3. The impact of MTO Features on ERP Application in Construction.

The features of construction due to MTO nature discussed above have unavoidable impact on the ERP application in construction enterprise. The system architectures might not be the same, and the significance of supply chain management of traditional ERP might be greatly deducted.

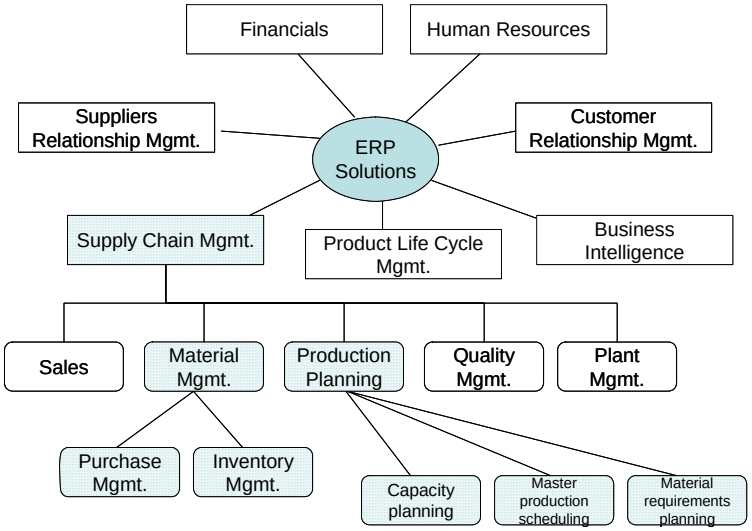

Chart 2. ERP modules which are greatly impacted by MTO nature

3.1 Difference in System Architectures

Due to the project-oriented nature of construction business, a contractor faces totally different business complexities and challenges compared to a manufacturer. On the production level, a manufacturer's challenges are to effectively manage a complex supply chain around its products, including coordinating material suppliers, production plants, inventory facilities, distribution network, and costumers' demands; but a contractor's challenges are to win new projects and to ensure that all projects can achieve the objectives of cost, schedule and quality. Many management functions essential to manufacturers are not necessary for contractors, for example production ordering, inventory, and distribution. On the other hand, running a construction business requires many functions that are not essential to manufacturers, such as estimating and scheduling (Shi and Halpin 2003). In a word, construction ERP architecture should be developed to fit the construction nature.

3.2 Unapplicable MRP Function

MRP is the major function of Supply Chain Management in ERP. MRP help to shorten lead time, reduce inventory investment, and improve plant operation efficiency. However, effective application of MRP is based on following assumptions: a) Accurately computerized BOM and inventory status files for all end items and materials; b) Batch and repetitive production; c) Concentrative production lines; d) Reliable forecast. As discussed above, construction industry doesn't meet these assumptions. In construction industry, there can be uncountable different types of products because customers have their requirement for each building. An MRP system that attempts to develop an MPS for such unique end items would be swamped with the burden of trying to explode millions of bills of material. Furthermore, when BOM are inaccurate, MPS are undependable, and it will generate greater volumes of inaccurate and unused information than previously thought possible (Gaither and Frazier 2001).

Thus, the differences in operation mode have prevented the direct implementation of traditional MRP developed in the manufacturing industry.

4. Suggested Solution for Construction ERP

4.1 Enhance project management function

Due to the project oriented nature of construction business, project management function should be enhanced in construction ERP system. In the life cycle of a construction project, project management usually involves estimating, bidding, scheduling, cost controlling, resource planning, etc. Corresponding functions need to be embedded to facilitate real time project management.

An alternate solution is Enterprise Application Integration (EAI) (Whitten, Bentley et al. 2004). Legacy ERP system can be integrated with professional construction project management application, for instance Timberline and P3, to realize unrestricted sharing of data and business processes among ERP and project management applications. The major benefits of this solution are: a) taking advantage of the existing professional project management applications, and b) without making change to existing data structure or applications. In this case, interfaces should be coded to establish linkage between different systems.

In a construction enterprise, there are usually several ongoing projects at the same time, therefore the link between project level and enterprise level should be established to allocate resource among different projects, aiming at improving overall benefit of enterprise (Shi and Halpin 2003).

Moreover, the interaction between ERP and external systems of business partners are also important. In a project, there are many participants besides the contractor involved, including designer, owner, engineer, subcontractor, regulator, etc. Construction ERP should provide a friendly interface for the communication between contractor and its business partners, as shown in chart 3.

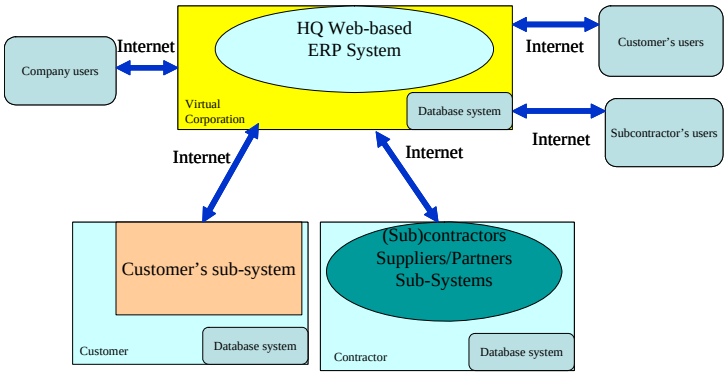

Chart 3. Interaction between construction ERP and business partners' system

4.2 Improve the flexibility of BOM and processes configuration

As discussed above, the large amount of Construction component specification, and the variance of customer requirements makes it difficult to define the standard BOM. Work operation and process also vary according to product nature, site conditions, techniques applied, etc. Every project has unique BOM and processes. Therefore BOM and process configuration should be the first step to create a project in the system.

As shown in Chart 4, construction ERP should provide flexible function for BOM and process configuration, in order to build the specific BOM for final deliverables, and to figure out the quantities of tasks to be carried out in the project. In this function, drawings and construction schemes are input, and the repository of building components and construction tasks are embedded in database.

Hence, research is needed to be done to improve the standardization in Construction industry. The standardization should at least include following aspects: (1) Construction components; and (2) Definition of work operations.

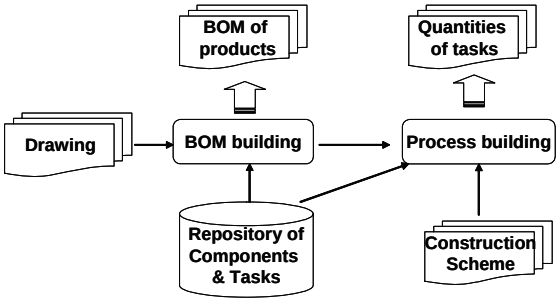

Chart 4. BOM and process building

4.3 Suggested construction ERP architecture

Based on above discussion, the construction ERP architecture is presented as chart 5. In this architecture, construction applications can be organized into two categories: (1) enterprise-level applications; and (2) project-level applications. The enterprise-level applications mainly aim at planning corporate resources, bidding management and decision making, procurement and subcontracting, and providing corporate management tools. The project-level applications serve the following project functions: BOM building, process building, estimating, scheduling, resources management, change management, quality assurance, etc. Project level should be cohesively integrated with enterprise level through predefined correlation.

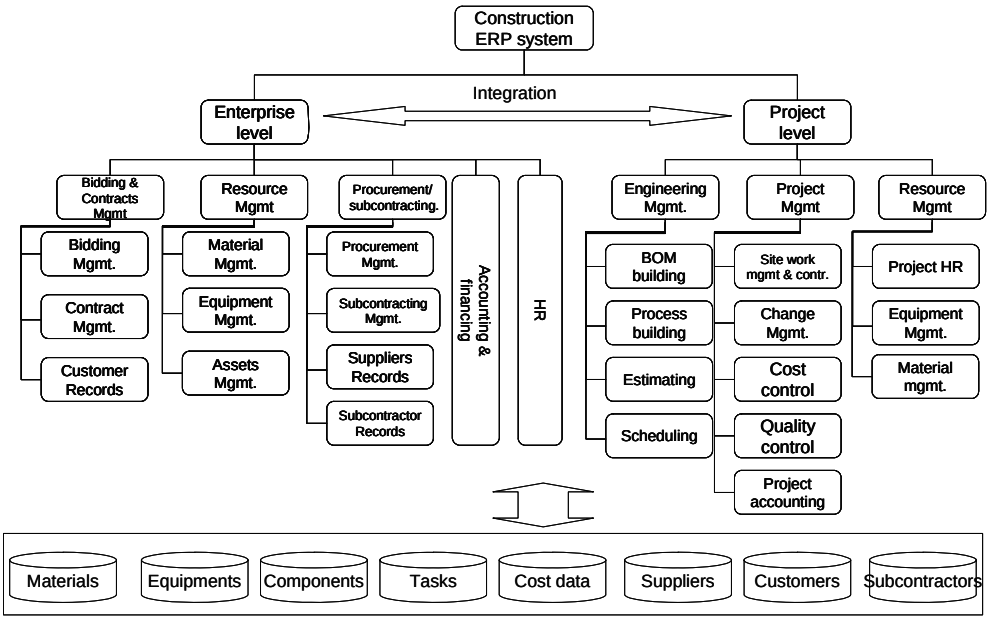

Chart 5. Suggested architecture of Construction ERP

The central database contains information of equipment, material, customer, suppliers, and subcontractors, and cost data and any other enterprise-level information are included as well.

5. Conclusion

MTO nature awards the construction business unique features to prevent the direct implementation of existing ERP which originated from manufacturing industry. In construction business, production is project-oriented, BOM and process are not predefined, orders are only from customers, construction sites are dispersed, and many business partners are involved in the project. These features have great impacts on the ERP application in construction enterprise, especially on the system architecture, and supply chain management module which is the core function of ERP. To develop a feasible ERP system for construction enterprises, suggestions are presented to enhance project management function of ERP, and improve the flexibility of BOM and process configuration. In the end, system architecture is proposed for construction ERP.

6. Reference

1. Gaither, N. and G. Frazier (2001). "Production and Operations Management." Duxbury Press **9th Edition**.

2. Jung-Ho Yu; Hyun-Soo Lee, M. A. a. W. K. (2006). "Evaluation Model for Information Systems Benefits in Construction Management Processes." Journal of Construction Engineering and Management, ASCE **132**: 8.

3. Lee, D.-E. and J. J. Shi (2006). "Construction Business Automation System." Journal of Construction Engineering and Management, ASCE **132**(1): 9.

4. ML Payton Consultants. (2000). "Use of Enterprise Resource Planning in the Construction Industry –Summary of Findings."

5. Shi, J. J. and D. W. Halpin (2003). "Enterprise Resource Planning for Construction Business Management." Journal of Construction Engineering and Management, ASCE **129**: 8.

6. Whitten, J. L., L. D. Bentley, et al. (2004). "Systems Analysis and Design Methods." Irwin Professional Publishing(6th Edition).