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Framework of Construction Management Task Map for Integrated Project Management Systems

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Abstract
Due to the existance of various project delivery methods and contract delivery methods utilized in the construction industry, it is difficult to categorize the scope of Construction Management (CM) tasks and related contractual responsibility. E-Business solutions in construction are equipped with the tasks and associated procedures as programming logic. Inconsistency and reusability among these solutions have been a concern since the programming logics have been formulated depending on the purposes of the solutions. The primary objective of this research is develop a framework of construction management tasks including associated inputs, outputs, methods, and tools throughout the construction project life cycle. A System Integration (SI) methodology is adopted to develop the map because of its effectiveness in process modeling. This approach should be beneficial for construction managers as well as system integrators in the construction industry.

Keywords
Construction Business Process, System Integration (SI), Task Map, Functional Framework

1. Introduction

It has been more than a decade since construction companies started using Information Technology (IT). IT has become a formidable tool to improve management efficiency in home offices and at project sites. Recent surveys taken in the US construction market show that the construction industry is becoming increasingly dependent on IT (Berning 2000). IT has been typically applied to three major areas in the construction industry. They include (1) web-based project management through which construction projects can be centrally managed in a paperless format; (2) online bidding through which owners can solicit paperless project bids; and (3) online purchasing and sales of construction materials and equipment (Berning 2003). A recently conducted survey indicated that firms in the A/E/C industry in the United States have experienced web-based project management (59% of respondents), online bidding systems (14%) and online purchasing and sales of materials and equipment (89%) (Ahmed et al. 2003).

In the construction industry, business and management processes have been formulated as a part of system development. This formulation has been repetitively completed by system developers in the information technology industry based on System Integration (SI) methodologies. SI methodology is commonly used to help system integrators model construction processes, data, and associated user actions/events. Due to the nature of the SI methodology, often process models, data models, and event models do not represent construction management activities as practiced at project sites. Some construction associations have published standard construction management tasks but detailed instructions for the tasks have not yet been standardized (CMAA 2002).

Two types of management systems, enterprise management systems and construction management systems, are considered as essential systems in the construction industry. An enterprise management system is mainly designed for financial accounting and resources management at the enterprise level. A construction management system is intended for construction cost accounting and resources management at the project level. Enterprise Resource Planning (ERP) is considered as financial accounting management while a Construction Management System (CMS) is used for project management. Due to the differences in information structures adopted, it is complicated to integrate these two systems. These conflicts prevent the U.S. construction firms from utilizing the two systems together.

2. Problem and Objectives

Various project delivery methods have been practiced in the construction industry. The scope of work is defined based on the type of project delivery method utilized once a project is awarded. Due to the differing engineering and construction management services provided by contractors, lack of inconsistency and standardization in construction processes have become significant issues in construction project management. Consistency in scope of work between the owner's requests and contractor's proposals must be identified and studied in order to measure the contractor's degree of completion. Responsibility assignments for a predefined scope of work must be determined prior to construction. Thus, a logical way of formulating processes and responsibilities must be created.

Construction Management Systems (CMS) are the most common tools in engineering and construction management. Web-based CMS are now being frequently adopted by contractors but are limited in use because contractors each use their own CMS. As a result of the differences in functionality of CMS, data integration and exchange are difficult to accomplish. CMS only serve as an information portal where end-users can only acquire, edit and share real time information via the Internet rather than being able to manage the project throughout its life-cycle. Therefore, system integration is limited because such attempts have not been fully realized. It is necessary to develop a framework of a construction management task map that can represented as an industry standard.

The purpose of this paper is to define and develop a framework of construction management tasks and associated processes for owners and construction managers. A system integration methodology is adopted to tabulate them in an orderly manner. The task map from this research would give project owners and construction managers a structured outline of standard CM services that is applicable to all construction projects. It can also be used as either an on-line or an off-line project management guideline.

3. Current Trends and proposed Approach

3.1 Current Trends

Web based construction project management systems have gained a positive reputation due to their potential benefits in the area of reduced project costs and time savings, improved productivity and

partnerships, immediate and easy accessibility to project related documents, a forum for real time collaborative work, and more effective communications and collaborations (Villeneuve and Fayek 2003). Quantitative results from a survey conducted by a provider of these services show that use of this technology: (1) reduces communications costs by 20 to 60 percent; (2) reduces the need for site visits by 10 to 50 percent; (3) increases employee productivity by as much as 75 percent; and (4) decreases time spent on administrative matters by 30 percent (Southerland 2002). Even though web-based construction project management systems continue to grow in popularity, there are also growing concerns in the use of this technology, such as lack of project website standards, project website capacity, project website security, etc. (Berning 2003).

There is also a demand for SI in the construction industry since IT is widely used in project controlling and management. However, functional frameworks and system architectures of these systems are little known to users such as contractors or owners. Imbalance in on-line project management skills between system integrators and users is getting bigger. Thus, project owners and managers have little chance to improve business operations or management methods in off-line activities because of a lack of automated comprehensive control and functional management procedures.

3.2 Proposed Approach

The Construction Management Association of America (CMAA) has defined standard construction management activities and associated processes as standard CM services in practice (CMAA 2002). A list of these activities can be used as a guideline for defining scopes of work and contractual responsibility. Construction management activities and their processes will be formulated by a system integration methodology as a part of framework development. These processes will be classified by the types of CM services for the Construction Management System (CMS) because these services are widely used in engineering or construction projects.

System Integration (SI) methodologies are helpful to define the business processes for project owners and managers in construction project execution in a systematic manner. Most system integration companies have some type of methodology for developing computerized systems. These methodologies are useful for defining management activities and collecting data flow of a target business operation. A customization of the methodology is required since it has been created on behalf of a system integrator's point of view. For this research, a SI methodology is adopted and modified in order to define and show how business processes and information are collected and organized in a favorable manner from the construction management perspective. This has brought us the opportunity to organize activities and responsibility in a project life-cycle based on various project delivery methods.

This research has focused on the benefits and concerns in implementing Information Technology in construction. In order to remove inherent limitations of the implementation, the construction management (CM) perspective is more focused.

4. Framework and Architecture of Construction Management Task

4.1 Contractual relationship of construction documents

The scope of work of a project is commonly described in a request for proposal (RFP) by a project owner. The responsibilities are presented in a project proposal by a contractor. The proposal contains a project plan and an executive plan, based on the contractor's project procedure manuals. In construction management, construction documents include requests for proposals, proposals, the contract, the conditions of the contract, project plans, specifications, modifications, schedules and procedure manuals. These

documents are critical because they are considered as instructions for construction project management during the project life-cycle. A typical relationship among these documents is described in Figure 1. The figure shows how each document must consistently support each other document to verify contractual responsibilities.

According to this model, the scope of work described in the CM proposal must be the same as that in the CM request for proposal. The CM proposal contains a CM project plan for a target project. The management activities in the plan are detailed by the CM procedure manuals of a contractor. The scope of work, both in the request for proposal and the proposal itself, is then confirmed by a CM agreement prior to commencement of a project. Thus, all related documents are incorporated clearly. PMS is a computerized system combining CM activities, procedures, and data to offer project owners and managers a seamless project management tool through the utilization of computer networks.

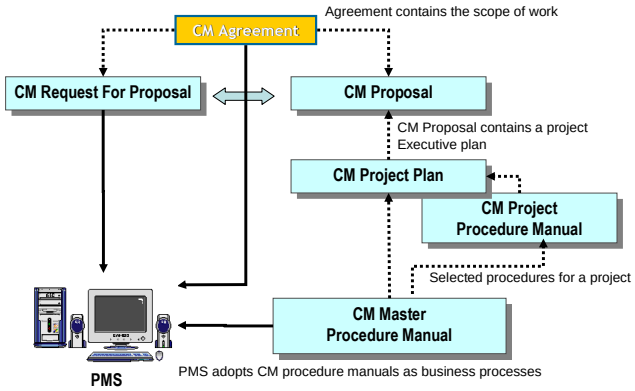

Figure 1 Relationship between CM Documents and PMS

4.2 A guide map for construction management

SDS has developed a methodology that can be used in system integration (SDS 1997). This methodology can be used to formulate construction management activities because it provides a comprehensive and systematic approach to system modeling and is extremely valuable if structuring of existing business processes and data flow is required during the system design phase.

A CM guide map has five major functions: CM Tasks, Sequence, Input/Output, Methods, and Tools as described in Table 1. CM Tasks and activities are defined based on the contractual scope of work demanded by public or private project owners. The combination of CM Tasks and Sequences produces a Task Schedule. The Task Schedule is a list of prioritized activities based on input or output documents. Deliverables show completed activities and expected results.

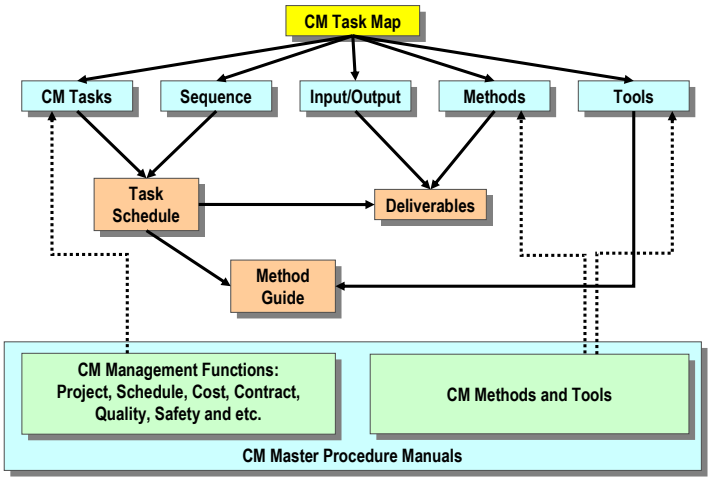

Figure 2 Internal Architecture of CM Task Map [Modified from (SDS 1997)]

Table 1 Description of CM Task Map

	Function	Description
1	CM Tasks	Activity that is classified by Phase, Task, and Activity
2	Sequence	Desired relationship between activities depending on work precedence
3	Input/Output	Required input or output deliverables from activity
4	Methods	Methodology that is applicable to activity
5	Tools	Applications or solutions that are applicable to activity based on selected Methods
6	Task Schedule	Activities that are arranged or approved by project owners or managers
7	Deliverables	Collection of inputs, outputs, forms, templates that are produced from activity
8	Method Guide	Implementation guideline

4.3 Classification of construction management tasks and activities

The principles of the execution of a construction project are defined by the Construction management Association of America (CMAA) (CMAA 2002). CMAA classifies six management functions in five construction phases. Major tasks in the five phases, considered as contractual responsibilities or construction management activities, are classified according to the CMAA standard services. There are twenty-four tasks in the Pre-design Phase, twenty-five in the Design Phase, twenty one in the Procurement Phase, forty-six in the Construction Phase, and twelve in the Post-Construction Phase (Na, et al. 2001; Na, et al. 2002A; Na, et al 2002B).

Each task contains several activities as sub-tasks. This model allows up to three levels below the task level in order to avoid redundant managerial intricacy. The lowest activities under each task are then ordered based on input and output sequence. It is also suggested to identify detailed steps, lower than ACTIVITY LEVEL 3, if there are additional sub-sub tasks which are necessary. It is useful when the sequences of tasks and activities are inter-related with each other. Preferential order is adopted to show a sequence of activities across the field of tasks and functions. This outlines the precedence diagram of selected activities within a project. Construction management procedure manuals can be used to explain PROCESS. METHODS are techniques that are used to produce acceptable solutions for a task or an activity. TOOLS are either computerized or conventional means to help construction engineers to complete a specific task or activity. INPUTS is the required information to produce expected deliverables and OUTPUTS is the deliverables required. Figure 3 shows the fields of the CM Task Map. A selection is checked as "mandatory" if this activity is required by project owners and "selective" if it is selected by project managers.

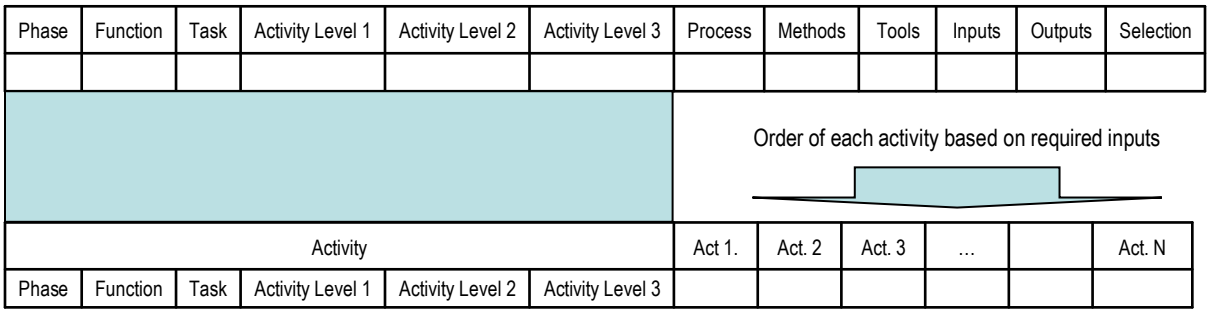

Figure 3 Type of Information Fields used in Method Guide and Sequence

5. Implementation

The proposed task map was recently implemented on an international airport project in Korea. Upon the development of a Construction Management (CM) guide by the government, the CM team developed CM procedure manuals to define and determine CM tasks for the project. With the accomplishment of the proposed framework, the task map illustrates the profile of all management activities from the commencement of the project to completion of the project. As a result of the implementation of the framework, it was concluded that this research provides a systematic way to define interfaces between off-line and on-line construction management tasks in order to to integrate existing CMS and applications into the construction process.

A CM task map was derived from a newly completed international airport constructed in Korea. Twenty-two construction procedure manuals were developed. Twelve of them were CM procedure manuals and ten of them were construction operation procedure manuals. Three phases, such as Planning, Design and Construction, were considered. One hundred thirty-nine manageable activities for thirteen tasks were selected as CM activities. The activities were first grouped based on the parties in charge. More than one hundred forty types of inputs/outputs were identified. Forms were developed prior to project commencement to provide project participants with a consistent system of information distribution and control. Each activity employed a course of action that was appropriate to complete that activity. The sections of the twelve CM procedure manuals were linked to related CM activities so that the execution of an activity was steady among project participants. An activity was assigned to project owners, project managers, designers, or contractors based on contractual duty.

The Ministry of Construction and Transportation (MOCT) announced the "Executive Ordinance on Construction Management Practice" in 2001 (MOCT 2001). The ordinance contains a list of construction management tasks and contractual instructions. The ordinance clearly defines the responsibility of project participants such as project owners, project managers or construction managers, designers, and contractors. This ordinance is being used as a contractual document in the public and private sectors of Korea. Activities that belong to a task should be managed by the project participant in charge. Four types of duties are assigned to project participants. They are APPROVE (AP), EXECUTE (EX), ASISST (AS), and REVIEW (RE) as shown in Table 2. In the public sector, this responsibility guideline must be followed. For the new international airport construction project, a total of 367 construction management activities were identified as shown in Table 3. Table 4 shows selected CM tasks and activities of scheduling along with input information and output deliverables during the construction phase. Recommended methods and tools are listed in Table 5.

Table 2 Major CM Tasks and Responsibility Proposed by the Korean Government (MOCT 2001)

Phase	Task	Responsibility				Remark
		Owner	CM	A/E	Contrac-tor	
CM Start-up	CM Project Plan	AP	EX	-	-	
	CM Project Procedure Manual	AP	EX	-	-	
	WBS/PNS	AP	EX	-	-	
	PMIS Operation	AP	EX	AS	AS	Whole Phase
	Operation & Management of CM Plan, CM Procedure, WBS/PNS Management	AS (AP)	EX	AS	AS	Whole Phase
	Allocation of Each Parties' Duties	AS	EX	AS	AS	Whole Phase
	Report of CM Task	RE	EX	AS	AS	Whole Phase
Basic Design	Selection of A/E	EX	AS	-	-	
	Value Engineering	AP	EX	AS	-	
	Cost Analysis	AP	EX	AS	-	

	Design Schedule Control	AP	EX	AS	-	
	Design Coordination	RE	EX	AS	-	
	Quality Management	AP	EX	AS	-	
Detail Design	Selection of A/E	EX	AS	-	-	
	Delivery Plan	AP	EX	AS	-	
	Value Engineering	AP	EX	AS	-	
	Cost Analysis	AP	EX	AS	-	
	Plan of Control of Schedule & Cost	AP	EX	AS	-	
	Design Schedule Control	AP	EX	AS	-	
	Design Coordination	RE	EX	AS	-	
	Quality Management	AP	EX	AS	-	

Table 2 Major CM Tasks and Responsibility Proposed by the Korean Government (MOCT 2001) (continued)

Phase	Task	Responsibility				Remark
		Owner	CM	A/E	Contrac-tor	
	Owner supply Resources Management Plan	AP	EX	AS	-	
	Selection of General Contractor	EX	AS	-	-	
Construction	Control of Schedule & Cost	AP	EX	-	AS	
	Claim Analysis & Dispute Confrontation	AP	EX	AS	AS	
	Final Report	AP	EX	-	AS	

Table 3 Number of items designed for New International Airport

Phase	Tasks	Activity Level 1	Activity Level 2	Activity Level 3
3	13	53	159	139

Table 4 Construction Management Tasks of Schedule Function during Construction Phase

Task	Activity	Input Data	Output Data
Control of Schedule	Daily Work Plan and Report	• Plan of Schedule control • Plan of Detail Schedule • Retrieval Plan and Revised Schedule	• Documents of Detail Work Result • Documents Daily Report • Documents Daily Plan
	Review & Check of Plan & Result	• Documents of Detail Work Result • Documents Daily Report • Documents Daily Plan • Actual Schedule	• Progressive Payment Breakdown • Completion Payment Breakdown • Documents of Work • Inspection Report
	Monthly (Quarterly) Report	• Documents of Detail Work Result • Documents Daily Report • Documents Daily Plan	• Monthly Schedule
	Monthly (Quarterly) Report	• Monthly Schedule • Inspection Report	• Progressive Payment Breakdown • Completion Payment Breakdown • Feedback Document of Monthly Schedule • Monthly Schedule
	Monitoring of Progress	• Inspection Report	• Retrieval Plan
	Operation of Progress Meeting	• Feedback Document of Monthly Schedule	• Revised Schedule

Table 5 Method and Tools for Scheduling

Function	Task	Methods	Tools
Schedule	Control of Schedule	• CPM/PERT • Bar chart • Milestone chart • LOB • ADM/PDM • GERT	• P3/SureTrak • MS Project • Artemis • RAMPS

6. Conclusion and Suggestions

This research presents a systematic approach to defining construction activities, processes, procedures, methods, and tools. The task map can be used to develop a functional framework for identifying project teams, contractual responsibility, and construction information flow. The Task map can help not only system integrators but also project owners and managers to improve construction management activities. Thus, CMS development becomes more consistent and easier.

The task map complies with work breakdown structures in the construction industry. Thus, this framework can be easily implemented if a work breakdown structure is presented prior to commencement a project. However, it is required to prepare construction management procedure manuals in accordance with the work breakdown structure.

The task map provides a collection of management activities from the beginning to the end of a project. This framework can lead to the restructuring of construction management tasks and information for a project for future use. Especially, cost information items such as budget, finance, procurement, and contract, may also be easily reorganized.

The task map can be used to develop new project management systems and integrate existing project management systems. Using the task map, system integrators can easily produce process models, data models, and event models, even if system integrators do not have enough construction knowledge and experience.

7. References

Ahmed, S.M.; Ahmad, I, Azhar, S.; and Arunkumar, S.(2003) "*Current State and Trends of E-commerce in the Construction Industry: Analysis of a Questionnaire Survey* (in Spanish)," Submitted to Revista Ingeniera De Construction, Chili.

Berning, P. W. (2000). "*E-Commerce and the Construction Industry: The Revolution Is Here,"* <www.constructionweblinks.com> (Dec. 27. 2003).

Berning, P. W. (2003). "*E-Commerce and the Construction Industry: User Viewpoints, New Concerns, Legal Updates on Project Web Sites, Online Bidding and Web-Based Purchasing*," w.constructionweblinks.com> (Dec. 27. 2003).

CMAA (2002). "*2002 CMAA Construction Management Standards of Practice*," Construction Management Association of America.

MOCT (2001). "*Executive Ordinance on Construction Management Practice*," Ministry of Construction and Transportation.

Na, K.T. and Ryoo, B.Y. (2001). "*A Proposal to Compile a Practice Guide by Construction Phases for CM Service Projects*," Architectural Institute of Korea, 17(3), 67-74.

Na, K.T., Ryoo, B.Y., and Kang, B. H (2002A). "*A Study on Proposal to Improve Domestic Construction Management Service Guide*," Korean Institute of Architectural Construction, 2(3), 147-154.

Na, K.T., Ryoo, B.Y., and Kang, B. H (2002B). "*A Study on Work Scope of Construction Management in Turnkey Projects*," Architectural Institute of Korea, 18(3), 115-123.

SDS (1997). "*Innovator V 1.0*," Samsung SDS, 3-8.

Villeneuve, C. E., and Fayek, A. R. (2003). "*Construction Project Websites: Design and Implementation*," Cost Engineering, 45 (Jan. 2003).