A Study on Development of IT System Roadmap in Construction industry

Xue-Quan Lee[1], Moon-Seo Park[2], Hyun-Soo Lee[3]

[1] M.S. Student, Dept. of Architecture, Seoul National University, Korea
[2] Associate Prof., Dept. of Architecture, Seoul National University, Korea
[3] Prof., Dept. of Architecture, Seoul National University, Korea
Correspond to xq326@snu.ac.kr

ABSTRACT: These days, the extension and complication of construction project has attached greater significance to IT system for effective project management. Construction companies inside the country have established IT system, but the fact is that they are not up to the expectations of investment provision, and the absense of objective and strategy about project management information system makes its efficiency doubtful. The research, from the point view of construction company, makes an estimate of indefinite future, and presents the process of making out IT system roadmap as a long-term strategy in building IT system.

Keywords: PMIS(Project Management Information System): BIM(building information model): IT System: System portfolio:

1. INTRODUCTION

Today, in the industrial environment shown as limitless competition, construction enterprises are required to make various efforts for their continuous development, and application of information system occupies an important position. Information system becomes essential to construction industry in accordance with various purposes and intentions, for the improvement of business efficiency and effectiveness, for smooth communication of different construction participants, and for systematic management and application of massive data and information. However, information strategy and development of information system may not be performed for the fragmented purpose, but may be understood and established taking into consideration the future vision or development direction of the enterprises.

On the other hand, universal technical environment around construction information is now changing. The internationalization of construction project has been going on for long, and construction techniques tend to be standardized mainly by those of powerful construction countries in the world. Especially standardization of construction data or construction information relevant to information, is now going on rapidly along with BIM. Therefore, such data or trend of technical development connected with information standard may be reflected on construction enterprises' information strategy or development direction of information system.

With the development of construction techniques, information system is playing more and more important roles in the of construction project management. To cope with the situation, a wealth of research on PMIS and efforts applicable to business have been going on in construction industry. IT is occupying a position as an indispensable factor just like water and air which is of vital significance to our life. Information efficiency can be achieved based on the long-term information strategy, and needs a routine check through periodical evaluation.

At present construction companies inside the country have established their information management system, but they are not up to the expectations of investment provision, and the absence of objective and strategy about project management information system makes its efficiency doubtful.

Thereupon the purpose of this research was to make out IT system developing Road Map for construction project management, on the basis of analyzing construction field operation, schedule, cost, quality and procurement, and management support system.

IT system, which is now being used in D industry, was confined to four management work, schedule-cost-quality-procurement, and directions for improvement were suggested, and 18 old and new system development requisitions were made out. The developing or improving systems were reconstructed according to five-phase scenarios, focusing on core subjects as "work transfer to subcontractors" and "integrated formation and applicable system of construction information represented as BIM", and therefore IT System developing Roadmap was put forward by establishing system portfolio. Research structure is as follows in picture 1-1

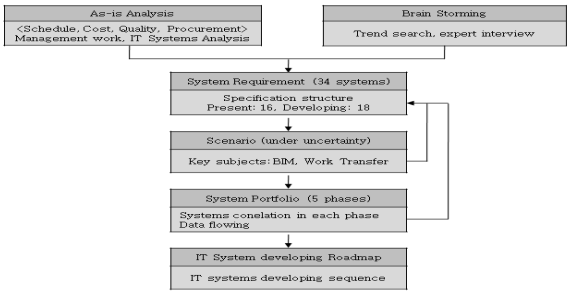


Figure 1-1. Research Structure

2. BACKGROUND OF CASE STUDIES

2.1 Trend of Construction Environment

2.1.1 Increase of Uncertainty

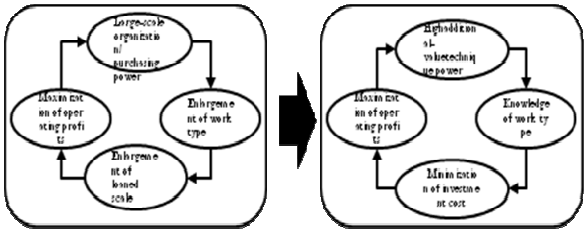
Rapid change of construction environment requires a new vision of the enterprises toward information techniques now. Constant efforts may be made to adapt to the changes and to create more developed environment. Especially, from the viewpoint of a whole organization, information system and direction may be established, and organized information system and a new developing strategy may be devised by constructing long-term effective systems, and the ability to estimate and analyze the future may be reinforced.

In addition, construction market is getting large, complicated and specialized, and customers are having more various demands due to the high standard of life. The whole environment is now undergoing a great change because of introduction of new system. To respond spontaneously to the changing construction environment, there is necessity for change of construction industry, that is, the corresponding improvement. It is necessary to strengthen the ability of understanding between inside and outside to cope with larger and more complicated construction environment.

2.1.2 Existing Limitations of Work Model

Up to now, large-scale construction companies, on the foundation of large-scale organization and purchasing power, by participating in large-scale contract construction and developing work, have maximized selling scale and formed the basis of profit models which pursue improvement of operating profits. But these value-creating models are sensitive to the change of market's given condition which is likely to take a task of keeping large-scale organizations themselves. For instance, under such circumstances as not selling land a lot in a large way, or confronted with the difficulties in the smooth flowing of mobility, the existing models which pursue economy of scale are severely hit and make it difficult to keep and manage large-scale organizations.

However, by enlarging knowledge industry which is based on techniques with high additional-value and minimizing investing cost and maximizing operating profits to pursue profit models, most risk on maintaining large-scale organizations can be avoided. It is to say that simple construction work with low additional-value may gradually be transferred to specialized construction enterprises, and by combining high engineering work with financing work, and business management work which are based on highly-accumulated and organically-connected data as well as information, investment cost may be minimized and additional value may be maximized. Picture 2-1 shows the change of work models.



Picture 2-1 shows the change of work models

The pursuit of such development can be attained via two phases. First, of the present work, simple and repeated work is gradually transferred to specialized construction enterprises so that D industry reinforces their business ability, focusing on work management. Second, from a long-term viewpoint, the ability to plan construction products which can ensure competitive power of D industry and engineering ability may be cultivated.

The research was concentrated on the first phase which needs fulfilling the necessary conditions to achieve appropriate development goals.

1) To transfer a multitude of work, and likewise minimize the risk following it, appropriate work is simplified at its maximum to make repeated fulfillment possible.

2) Simplified and repeated work is information-systematized to minimize the possibility of making mistakes, and such kind of information system is offered to specialized construction enterprises to use.

3) In order that D industry conducts management work which is based on data and information, integration DB of work management may be established, and information system which can make full use of it may be established.

4) Such integrated DB and information system concerning work management may be connected with the information system that will be used by specialized construction enterprises.

2.1.3 Consistent Production and Application of Construction Information over the Construction Life Cycle

Construction is a complicated project with diverse techniques and resources invested, and the information to deal with is very complicated. Owing to diverse project participants and various functions that are fulfilled at the same time even in an organization, it is easily faced with confusion without proper information circulation.

Various research has been done by a great may research workers and practitioners, which of it is mostly done on the integrated system of information to solve the problem. BIM, which is being used actively all over the country at present, is brought up as a conclusive method. BIM, information system to more effectively manage the process in which many projects are going on at the same time, can bring on many changes and affect work process

that is necessary to be taken into deep consideration. The research regarded BIM as an important factor which may greatly influence the information system of D industry.

Definition of BIM (Building Information Modeling):

In existing construction field, information is represented by semiotic and two-dimensioned drawing information system. But BIM, transformed into three-dimensioned information system which possesses real shape of the building and related information, is capable of keeping all the information included in project, just like in Picture 1 within the database of computer, and is changing according to the needs into various forms to offer various information.

BIM can be called a technique which produces and manages all the information appropriate to various fields over life cycle from early concept plan to keeping management. In addition, with BIM technique applicable to the construction field, diverse information can be used more efficiently, and many advantages are detailed. It is the case that approaches are being found out to make full use of BIM.

2.2 Domestic and Overseas Researches

2.2.1 Domestic Researches

For the evaluation and improvement of the research, literature investigations on the recent studies have been made, and the main contents are as follows.

Areas	Author	Main Issue	Suggestions
Schedule	Myung Houn, Jang. And 51 others	Difficulty to deal with risk in the process of construction work Inconsistency of plan and progress rate of actual-results Nonstandardization of evaluating criteria during prearranged process	Decision-making right in construction field DB accumulation of schedule Search for connection between main progress schedule and detailed progress schedule
Cost	Sang Won, Han And 34 others	Establishment of cost estimate model by collecting data with examples Approximate estimate based on analysis of changes in amount of construction	Cost estimate relevant to other systems DB accumulation of Cost
Quality	Seung Ha, Shin And 29 others	Construction of system to analyze quality expenses Low level of quality in construction industry compared with other industry Insufficiency of the importance	Transformation of quality management work into subcontractors Introduction of integrated management system, “quality+safety+environment”
Procurement	Seok Heon, Yun And 41 others	Lack of systematic management about materials Increase of field efficiency using real-time monitoring for the management of materials, hoisting machinery, etc Ordering and producing in lead time according to materials, Analyzing inspected periods to connect with the scheduled plan	Diversified collecting methods of procurement data Making full use of monitoring system Search for connection with the system relevant to the schedule

2.2.2 Overseas Researches

FIATECH(Fully Integrated Automated Technology) published ‘Capital Project Technology Roadmap’. In this publication, they established a consensus vision for the capital projects industry and a unifying initiative to achieve the vision. Following this roadmap, they found out hereafter projects, and suggested projects guideline and methodology.

VTT, Technical Research Centre of, published ‘Strategic Roadmaps and Implementation Actions for ICT in Construction’. They offered a vision for ICT (Information and Communication Technology) in construction in addition to a set of roadmaps across 12thematic areas.

By surveying the trend of construction industry and studies inside and outside the country, a necessity is put forward that in addition to traditional PMIS which may contribute its function to course of system improvement or development, that is, the improvement of business efficiency and effectiveness, more functions to reinforce such abilities may be added or complemented.

1) Reinforcement of the ability to estimate and analyze future

It is analyzed that the ability to spontaneously cope with rapidly changing construction environment and increase of its potential risk may be reinforced, and therefore the system function to support and complement the ability is essential.

2) Reinforcement of ability to understand and communicate

It is analyzed that the ability of communication which can cope with diversification of participants followed by business complexity, and different courses of communication followed by participants’ active participation may be reinforced, and that especially, visible communicating tools are necessary to be added, and therefore the system function to support and complement the ability is essential.

3) Reinforce the ability to cope with changes

It is analyzed that the ability to perform work management which can cope with smartly the changes from contents of drawing to those of business may be reinforced, and therefore the system function to support and complement the ability is essential.

3. Analysis of Present Situation and Improvement Direction

The research, through brainstorming with D company, has analyzed schedule, cost, quality, procurement process, and system, suggested improvement direction to them, and brought up IT system which is necessary for the work.

In the field of schedule management: Various effect of estimated risk events on the other schedule or the whole schedule is simulated to extract or designate the schedule which is affected by the risk. By contrasting with the planned schedule, responsiveness to the risk influence which is applicable to the preliminary countermeasure, and responsiveness to the risk influence which is applicable to the subsequent countermeasure are analyzed to establish the system which is possible to support quantitative decision-making.

Besides, master plan, monthly progress schedule, weekly progress schedule, daily report, and other

schedule information may be connected to establish a module that can increase work efficiency concerning schedule. A system may be established in which the construction progress in the field may be visible to produce the most suitable proposal and grasp easily the alterable matters, which is only used to manage the specific schedule just as civil engineering work, framework and file work which needs absolute time for excavation, cure and so on.

In the field of cost management: A system may be established which is used to estimate the cost when alterable matters happens in the operating budget of the field-breakdown or alteration of refusal, and compare with the very beginning to simulate cost itself seperated from the air, and estimate the cost before the drawing is decided, and estimate the cost before amount of water is worked out.

In the field of quality management: A system may be established which can search for in real-time various documents' DB establishment and classification system, and which can make papers relevant to quality automatically come into being from daily report and work instruction to draw up quality exam and scheduled plan, and which can manage the results and create list of prearranged items that is checked daily.

Besides, a system may be established which provides different generations with options to the consumers' taste, and which can make the consumers experience suitable options, and which can make field and head office hold the same design information by standardizing and systematizing design materials, and which can identify design alteration and hold the information in common.

A system may be established by constructing DB on work quality and safety checklist, and by constructing DB on defect type and its solution of work operating functions, accident type and its solution, which can estimate possibility and influence of defect and accidents to prevent them from happening again.

In the field of procurement management: A system may be established which makes full use of RFID to monitor actively manpower movement and management of workers' personal history, payment and safety, and which is possible to systematically manage the workers with various background and experience on construction site and prevent the workers from the disaster in dangerous sites by estimating the places.

Besides, a system may be established which can monitor the materials in stock from open-air storage to safekeeping, which can grasp ordering of amount of water, and estimate possible amount of water in stock, and location of materials in stock and amount of water by mastering management of open-air storage, necessary amount of water, data on size of open-air storage and safekeeping, which can be integrated to manage all the work relevant to materials by using material information system. A system may be established which can draw up hoisting plan relevant to schedule plan that is based on the hoisting equipment to manage and estimate the cost of hoisting equipment, and estimate necessary amounts and most suitable locations of hoisting equipment.

Standard estimating system, which can collect and manage price information automatically may be established, and the system can monitor the progress of material-production, transportation process and work assignment on the construction site, and can produce itemized statements automatically among subcontractors by connecting with the system of performing estimation management, and can produce various forms of items.

The present business is centered on staff, but simple and repeated business with low additional-value may be transferred to enterprises. Staff may perform Master plan, and the work with risk and high-value, and then a new system appropriate to the such work may be established.

There are 17 required systems, 7 IT systems for schedule management, 2 IT systems for cost management, 4 IT systems for quality management, 4 IT systems for procurement management. Table 4-1 is an example of required system specification.

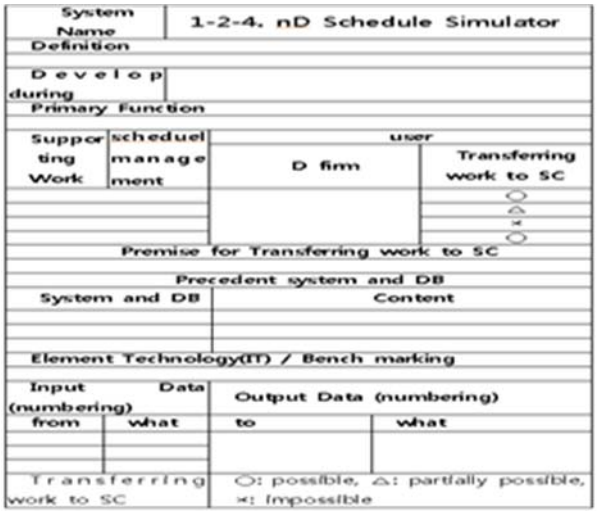


Table 3-1 Example of System Definition

4. IT Systems Developing Roadmap

4.1 Establishment of Scenario

The research establishes the scenario in the following way.

First, a great many changeable factors are assumed in the situation of the future. Here various factors inside and outside are sorted out.

Second, among a number of changeable factors, subjects which may have a big impact on the future of company are sorted out.

Third, phases are classified according to subjects.

Fourth, the phases of various subjects are enumerated according to the time. These phases become a scenario phase respectively and may be a milestone that can represent the future of company.

The research has divided the phases according to the most important subjects, "Introduction of BIM" and "Work Transferring to Subcontractors".

4.2 BIM Applicable Phase

"Introduction of BIM" is divided into three phases.

B0: present situation

B1: partial application
B2: full application

4.3 Work Transferring to Sub Contractors

"Work Transferring to Subcontractors" is divided into three phases.
S0: present situation
S1: sub-con input data
S2: CM at Rist, sub-con as OEM

4.4 5 Scenario phases in case project

Figure 4-1 explains there are 5-divided phases. It also shows that 'S2-B1-S2-B2' is the optimized order of stages for D company. The main contents according to phases are as follows.

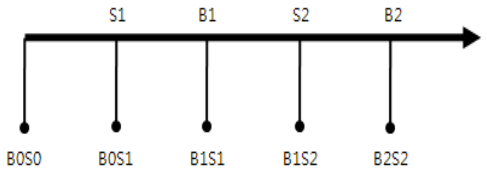


Figure 4-1. 2 Key subjects application in Dcase project

Phase1(B0S0): B0S0 is D company's present PIMS construction situation. Information systematization of schedule and cost management has been developed to a certain extent, but Information systematization in other fields of management is not sufficient, and the whole system organization which is most suitable to apartment house project can not support diverse and complicated projects.

Phase 2(B0S1): B0S1 is finishing point of S1. If the existing schedule information has existed around master plan, schedule information in this phase may be formed and managed according to grade of ranks, including the management of work daily report of subcontractors. It is the phase where the management of detailed schedule is possible, and subcontractors have information of schedule management as well, and therefore systematization of quality control work may begin. Especially, simple work as drawing up documents related to quality may be performed by subcontractors who can carry out the counting of previous schedule.

Schedule and cost management work form DB which, taking into consideration Flight Simulator as later developing program, can raise applicable rate of database if the present project is completed.

Phase 3(B1S1): B1S1 is finishing point of B1 where "3D CAD" begins to be used fundamentally. 3D CAD is a commonly and widely used program which has three-dimensional drawing information. In this phase, apartment house work, key industry of D industry, is focused on to apply data as 3D modeling of "unit family plan" to the existing systems. And 3D may be used to cost work and service to residents.

In addition, Flight Simulator may be developed from the schedule and cost work which is based on schedule and cost DB in phase B0S1.

Phase 4(B1S2): B1S2 is finishing point of S2. If in phase B1S1, 3D modeling information about "unit family plan" of apartment houses is connected with system, in this phase nD Simulator may be developed to apply 3D, 4D modeling data in all projects to it. These data may be connected with cost work, schedule and procurement management to come into action.

Especially, in this phase, monitoring to labor and materials in procurement management may be enlarged, and systematized foundation gets ready where such procurement information may be connected with schedule information to manage integrated information.

Phase 5(B2S2): B2S2 is finishing point of B2.

4.5 System Portfolios

System Portfolios show synthetically the present developing situation of individual system, and mutual relations, and later developing direction, through which future of PMIS may be grasped. In addition, according to the factors of enterprise management as strategy, management, operation which are classified by phases, the position of each system is identified in the whole system, and therefore work related to project is connected with the system which is used by the board of directors in higher rank.

From identified 5 scenarios, there are 5 system portfolios for D company. The following Figure is system portfolio in phase B2S2.

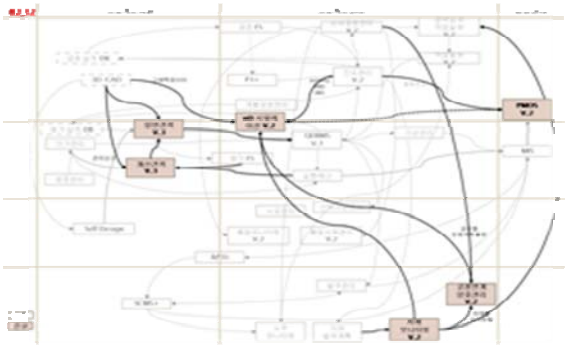


Figure 4-2 B2S2 system portfolio

4.6 Converting System Portfolio to Roadmap

Based on System portfolio from scenario mentioned above and developing systems, PMIS developing Roadmap may be eventually drawn. The vertical axis of roadmap is made up of four detailed management work such as schedule, cost, quality and procurement, and horizontal axis is the time axis represented as scenario milestone. The result may help to grasp D industry's PMIS developing continuity and sequence, and makes it easy to set up strategy of companies relevant to IT system.

There are some systems to be developed in system portfolios, and in it, we can recognize their relationship. The relationship has two types, FS and FF. FS means one system could be start to develop when preceding system is complete, FF means two systems are complete in same time. Figure 4-3 shows 33 systems correlationship in D case, through this, roadmapping, include system developing sequence schematization, comes to be possible.

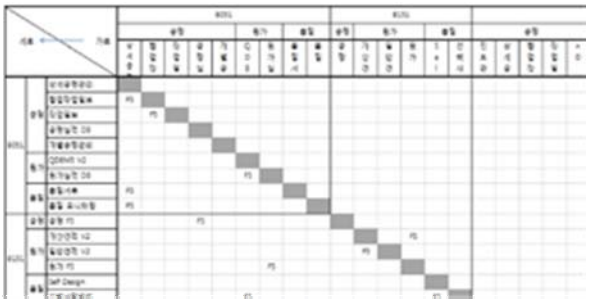


Figure 4-3 System Dependency Matrix

4.7 IT Systems development Roadmap

Figure 4-4 is final outcome. Vertical axis of this roadmap is classification of D company's standard management work process. Those 4 categories are Schedule, Cost, Quality, Procurement management. Each management scope is composition of detail work modules. Final outcome shows systems developing sequence and it helps D company to set a strategy with IT systems.

Figure 4-4 IT System Developing Roadmap

5. CONCLUSIONS

Lately, with the scope of construction project getting larger and more complicated, greater significance of IY system is attached to for efficient project management. Construction companies inside the country have established IT system, but the fact is that they are not up to the expectation of investment provision, and the absence of objective and strategy about project management information system makes its efficiency doubtful. The research, from the point view of construction companies, makes an estimate of indefinite future, and presents the process of making out IT system roadmap as a long-term strategy in building IT system.

The process for drawing up roadmap is as follows.

1) Requesting items for IT system are collected and arranged.

2) Scenario is made out to estimate future situation, and the phases of scenario are set up from relevant subjects to anticipate what is to come.

3) IT system portfolio is created according to each scenario phase, to estimate and analyze the system portfolio in each phase.

4) IT system roadmap is set up based on system portfolio. Case study has been made, for the application of suggested process, based on the investigation into D industry's present situation, study on construction information system inside and outside the country, and technique trends. The research takes IT system as a scope, "schedule-cost-quality-procurement" in management work, and puts forward improving directions, and sets up 18 system developing requisitions. Such developing or improving systems are recreated according to scenarios in five phases, based on the key subjects, "work transfer to subcontractors" and "integrated production and applicable system of construction information that is represented as BIM". Information strategy or information system development may not be carried out for fragmentary purpose or pursuit, but may be understood and set up for the enterprise's future vision or development direction.

REFERENCES

[1] Christensen, C.M. "The Innovator's Dilemma-When New Technologies Cause Great Firms to Fail", *Harvard Business School Press, Boston, MA.* 1997.

[2] Garcia, M.L. and Bray, O.H. "Fundamentals of Technology Roadmapping", *Strategic Business Development Department Sandia National Laboratories*.1997.

[3] IMTR. "Information systems for the manufacturing enterprise" *Integrated manufacturing technology roadmapping project.* 1997.

[4] Macintosh, A. Filby, I. Tate, A. "Knowledge asset roadmaps", *proceedings of the 2nd international conference on practical aspects of knowledge management, Basil*, pp.29-30. 1998.

[5] Kostoff and Schaller. "Science and technology roadmaps", *IEEE Transactions on Engineering Management*. 2001.

[6] Phaal, R. Farrukh, C. and Probert, D.,"Technology Roadmapping: linking technology resources to business objectives", *Centre for Technology Management, University of Cambridge*. 2001.