ICT-Readiness in Industrialised Building System (IBS) Management Processes: Case Studies

Peniel Ang Soon Ern[1], Narimah Binti Kasim[2]

Department of Construction Management
Universiti Tun Hussein Onn Malaysia (UTHM)
Parit Raja, Baru Pahat, Malaysia
peniel.ang@gmail.com[1]
narimah@uthm.edu.my[2]

***Abstract*— Extensive use of modern Information and Communication Technology (ICT) tools supports the different Industrialised Building System (IBS) processes by enabling more accurate documents and hence good conditions for an effective production where errors are discovered early and problems in the manufacturing and assembly phases can be avoided. However, the acceptance of ICT at the organisational level is still in its infancy. Despite the potential benefit of ICT, convincing construction organisations to embrace its use and implementation has proved a difficult task. Hence, this paper aims to report on the findings from the case studies conducted on a few industry stakeholders. The case studies assessed the current industrial ICT acceptance for IBS management processes, identified the key barriers affecting the ICT-readiness and established the enablers for greater ICT uptake in the IBS management processes. The case studies were executed through semi-structured interviews conducted with a few main IBS manufacturers and government policy makers. Analysis was done with NVivo 8 software. Results indicated that current ICT acceptance in Malaysia is rather low. Thus, there is a great opportunity for the future development of more effective frameworks to encourage ICT-acceptance in the IBS construction field and thus for the increased ICT adoption for the overall construction industry.**

Keywords — ICT-readiness; ICT; IBS; Malaysia; construction management; precast

I. Introduction

Industrialised Building System (IBS) Roadmap 2003-2010 in Malaysia has defined IBS as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site works [1]. The endorsement of IBS Roadmap 2003-2010 in Malaysia expressed the importance and urgency of IBS implementation in Malaysia. Nevertheless, the government of Malaysia considers that the usage of IBS is low despite the potential advantages. IBS Mid Term Review in 2007 reported that approximately only 10% of the complete projects used IBS in the year 2006. Less than 35% of total construction projects (using at least one IBS product) in year 2006 had been reported in IBS Mid Term Review as compared to forecasting IBS project of 50 % in 2006 and 70% in year 2008 as projected by IBS Roadmap. Lack of R&D, low Information Technology (IT) adoption and limited technology availability are observed to have generally discouraged IBS take up in Malaysia [2].

In point of fact, extensive use of modern IT tools is able to support the different IBS processes by enabling more accurate documents and hence good conditions for an effective production where errors are discovered early and problems in the manufacturing and assembly phases can be avoided [3]. With the effectiveness of Information and Communication Technology (ICT) implementation, IBS uptake will too increase. However, the current practice of ICT implementation in the tracking of IBS components in Malaysia is rather rare. It appears that most innovative system and components are using innovative materials which are based on imported technologies which are obviously more expensive and difficult to purchase by local contractor [4].

Hence, there is a need to study on the ICT-readiness of Malaysian IBS construction players in the management of IBS processes and provide a possible way out to encourage ICT take-up in their projects. The terminology of "ICT-Readiness" is described as the readiness of its people to adapt to a new technology [5]. For the context of this research, ICT-Readiness is described as "the susceptibility of an organisation or individual in embracing, implementing and incorporating ICT into the processes of IBS components management".

This paper aims to present the findings of the case studies conducted among some prominent industry stakeholders in the construction industry in Malaysia. This study is significant in recognising the existing ICT implementation in the current IBS process management in Malaysia, identifying the resistant factors to ICT-readiness and to establish further potential to deal with the ICT-readiness issues.

II. ICT Uptake in Global vs. Malaysia's Perspective

Past research findings [3, 6, 7, 8] suggested the utilization of IT in IBS projects to support integration, provide accurate data, help customers in selection process, distribution and logistics and cost comparison. Below are some examples of the latest ICT aspects being incorporated into the prefabrication management processes today:

a) Radio Frequency Identification (RFID)

RFID is broadly applied in other industries, but it has not formally emerged as an effective management tool in the precast industry. The introduction of RFID for the application in the precast industry supply chain, whether it is directly or indirectly incorporated into the execution of the entire project, can profoundly enhance cost competitiveness [9].

b) Automated machineries

Today, the European prefabrication industry uses platform-based and system-based mass customisation – especially for the provision of wall and ceiling elements. An almost complete digital chain – using computer integrated manufacturing (CIM) from the very early planning stage through to manufacturing – is state of the art within the timber construction in Switzerland as well [10].

c) Building Information Modeling (BIM)

Findings showed that BIM, a 3D modelling software is able to resolve many technical difficulties in the precast construction processes. For instance, with the adoption of BIM in the precast concrete industry, engineering cost are reduced, cost of rework due to errors are tremendously reduced as well [11]. BIM will change the traditional planning process significantly, and perfectly enhances the mass customisation approach to manufacturing individual client solutions.

Despite the sophisticated tools mentioned above, by contrast, the Swiss precast concrete industry is making very little use of the ICT and automation possibilities that are available today [10]. One underlying reason could be due to that ICT has failed to bring about a competitive advantage to organisations in spite of the large investments over the past decade, and a large percentage of systems have failed to achieve their intended business objectives. Recent studies in the area of 'IT failure' have shown that 75% of IT investments did not meet their performance objectives [12].

Looking from Malaysia's perspective, the current practice of ICT implementation in the tracking of IBS components is rather rare. It appears that most innovative system and components are using innovative materials are based on imported technologies which are obviously more expensive and difficult to purchase by local contractor [4].

All in all, real-time materials tracking of IBS components have yet to reach an effective stage. The significant challenge currently facing the construction industry is that the tools and techniques of ICT currently used in the tracking of materials are still under development, and inevitably will result in costly delays to the progress of any construction project. Therefore, it is imperative to look deeper into the issues concerning the implementation of ICT in the IBS management processes and identify ways to create an "ICT-breakthrough" for the betterment of the industry.

III. Methodology

This paper focuses on the case studies undertaken to assess the current industrial practice of the ICT-readiness for IBS management processes and to establish the requirements for developing a framework to increase ICT-readiness in the IBS management in construction projects. Consequently, multiple-case studies approach has been used in order to investigate a contemporary phenomenon within the 10 cases which comprise of six IBS manufacturers and four IBS government representatives.

The study was focused on the production stage of the IBS management process, which starts from the planning to the IBS components transportation stages. In view of that, the respondents are scoped only to the IBS manufacturers, excluding the other IBS players. Apart from them, IBS government representatives are selected as respondents to provide more information on the policy setting in the IBS field in Malaysia. Due to the need to explore and gain deeper understanding of the research topics, this study opted to adopt face-to-face semi-structured interview. Data analysis software used in this research is NVivo8.

TABLE I. PROFILE OF RESPONDENTS

RESP.	TITLE	TYPE OF RESPONDENT	EXPERIENCE IN IBS
1	Technical Manager	IBS Manufacturer	7 years
2	Head, Technical Support	IBS Manufacturer and Contractor	32 years
3	Vice President of IBS Division	IBS Manufacturer	>20 years
4	Senior Design Engineer	IBS Manufacturer and Contractor	6 years
5	Project Manager	IBS Manufacturer	10 years
6	General Manager	IBS Manufacturer	13 years
7	Senior Manager	CREAM, CIDB	9 years
8	Senior Manager	CREAM, CIDB	12 years
9	Director	IBS Centre, CIDB	13 years
10	Division Head	Public Works Department	30 years

Table I shows the designation and years of experience in dealing with IBS substantiate the respondents having a sound knowledge of understanding with IBS. Respondents 1-6 comprise of the main IBS manufacturers in the Malaysia construction industry. They are the major players, which imply these companies have a higher involvement and ICT implementation in the IBS processes as compared to the smaller IBS manufacturers whom are constrained to opt for sophisticated methods in the IBS management processes. Meanwhile, respondents 7-10 are government organisation representatives who are associated with IBS policy making, IBS research and being the government's main technical agency.

IV. ICT-Acceptance in IBS Management Process: Case Study in Malaysia

The case studies are analysed according to the four units of analysis, which are "IBS components management problems", "Good practices to addressing problems", "ICT implementation" and "Requirements for ICT-Readiness framework". The results and discussions are as the followings.

A. IBS Components Management Problems

One of the frequent recurring issues of the management of IBS components in Malaysia is delivery problem. The reasons behind this problem are due to the bad planning when unloading was being done. This issue will normally be solved by ensuring a better supervision done. However, human are prone to errors and thus, better supervision being incorporated with ICT tools would definitely provide a better solution to this delivery problem. This is supported by [13], pointing IT as an enabling factor to the critical success factors of IBS implementation in Malaysia.

Besides that, logistics appeared to be an issue in the IBS components management problems too. The transportation of the precast components will face difficulties especially when the sizes were too huge, there were problems accessing certain routes or any adhoc changes were issued. Alternative routes will then be searched to solve the transportation problem. However, adhoc changes would likely able to be tackled when proper information are computerised and could be adjusted accordingly.

In addition, design was another highlighted issue that will appear common to other IBS manufacturers. Slight design errors would cause a dominos effect to other subsequent precast processes. Design modularity, procrastination culture, lack of communication and human problems were said to be the main reasons to this design issue. It was commented that IBS processes need to be integrated from the start of the design process so that the whole design and construction process can be aligned [14]. Integrated approach in design and construction will be able to minimise the fragmentation gaps [13].

Another critical issue that was emphasised was the issue of coordination. The construction industry in Malaysia is generally less consistent with certain schedule and planning. The unhealthy culture tends to affect the overall project coordination. When it comes to the precast technique, it will even affect the overall planning because many advanced planning has to be done much earlier before the IBS components are casted. The common resorted solution would be sending an officer to the site to do the necessary amendments to the coordination problem. However, if there were proper monitoring throughout the processes from all players through an integrated system, a better coordinated project would be assured. Still, genuine collaboration is rare due to the issue of trust [15].

B. Good Practices to Overcome Problems

Some of the prominent good practices taken to overcome IBS components management problems were the implementation of Just in Time (JIT) concept, effective planning and the adoption of some ICT tools such as MS Excel and MS Project. Other good practices mentioned that was in relation to human were cultivation of good teamwork, post mortem meetings and close relationship with client. It is established that the good practices cited above were not much of any relation with sophisticated ICT tools. The good practices mentioned were more of technical menial and human solutions. Hence, an issue to be addressed here is to identify the awareness of IBS manufacturers towards the benefit of ICT and the possible barriers that exist, preventing them from adopting the tools.

Unfortunately, there seems to be a hint of pessimism as most of the IBS manufacturers did not see the full effectiveness of the moves by the government. In the research of [16], lack of incentive and promotion from the government are the barriers to the adoption of IBS in Malaysia. The remarks from the manufacturers highlighted the need to derive a constructive and practical ICT-readiness framework or IBS guide for the betterment of IBS players as a whole to readily adopt and increasingly develop the potential of ICT tools in the IBS components management processes in Malaysia.

C. ICT implementation in IBS Components Management Processes

Table II reports on the types of ICT aspects implemented in the IBS components management processes.

TABLE II. EXISTING ICT TOOLS IMPLEMENTED IN IBS COMPONENTS MANAGEMENT PROCESSES

Existing ICT tools	R 1	R 2	R 3	R 4	R 5	R 6
MS Project, Excel	/	/	/	/	/	/
Primavera				/		
ACCPAC					/	
AutoCAD	/	/	/	/	/	/
REVIT						/
TEKLA				/	/	/
STAAD. PRO					/	/
RYAN						/
PRECAST INTERNAL SYSTEM (PIS)					/	
Computer controlled batching plant	/		/			/
Form vibrators			/			/
Hollow core plants			/			
Stencilling manufacturing			/			
Technology operated mould				/	/	/
Elematic machine					/	

The common ICT tools implemented are Microsoft Excel, Microsoft Project and Primavera for project management; and AutoCAD for design stage. The sophisticated tools such as TEKLA, REVIT, RyanIT and STAAD.Pro for design purpose; ACCPAC for procurement and Precast Internal System (PIS) for in-house software were adopted by these prominent IBS manufactures. As for

the tools employed in the IBS manufacturing yard, there were higher technologies machineries such as the computer controlled batching plants, mould vibrators, technology operated moulds, hollow core elematic machine and semi-automated hollow core extruder. Most of the said tools were predominantly used in the design, planning and production stage. However, the usage of the in-house software, Precast Internal System (PIS) was utilised throughout the whole IBS components management processes. Nevertheless, the tools were said to not have been implemented effectively in the overall processes.

With that, further advancement of ICT adoption is fundamental to increase profit and productivity and even improve the management of the IBS components. Some initiatives that were suggested by the respondents were the development of database for product registration; barcode and chip for concrete strength; bar-nesting software for storage of excess components; centralised system for sharing of information; automation of machineries, self compacting concrete machine for casting procedures and the move towards mechanisation (Refer Table III). Through the suggested ICT advancements, it is proven that there is a higher optimism for an increased ICT adoption in the IBS components management processes.

TABLE III. Future ICT tools implemented in IBS components management processes

RESP	Future ICT Tools
R 1	IBS components database
R 2	Bar-code, Bar-nesting software
R 3	Centralised system
R 4	Self-compacting machine
R 5	Centralised system
R 6	Mechanisation, Improve software
R 7	Design integration and knowledge management
R 8	BIM
R 9	-
R 10	BIM

D. Requirements for an ICT-Readiness Framework

In order to develop an ICT-readiness framework to improve the management of IBS components processes, there is a need to ascertain the requirements for developing it. Thus, we need to first identify the main barriers to the low adoption of ICT in the IBS components management. The few main barriers that were identified, as shown in Table IV were the mindset factor which is to stick to conventional ways rather than the more sophisticated pre-cast technique; lack of ICT awareness; high cost due to the low Return of Investment (ROI) and the challenge in having standardised design software due to the existence of too many local authorities in Malaysia.

TABLE IV. Barriers to ICT implementation in IBS components management processes

ICT Barriers	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10
Mindset		/	/	/		/	/	/	/	/
Lack of awareness	/			/						
Preference to conventional method	/					/				
High cost							/			/
Existence of too many standards in Local Authorities									/	/
Lack of "push factor" e.g. incentives		/								

The respondents suggested that to overcome the mindset barriers, competition and value should be created to improve on human capital. Besides that, more training and workshops are able to create higher awareness to ICT adoption in IBS management processes. As mindset barrier is closely related to people factor, it is vital to create change, to adopt and adapt. People can be considered as core drivers of a business. As a collective force, they can add value to organisational IBS readiness [13].

Apart from that, the government plays a crucial role by creating the demand to implement ICT. Because of the small profit margin, the change from conventional to IBS was not feasible unless more attractive incentive systems and benefits, which can lure the conventionalist to IBS, are in place [13]. This can be realised by giving more tax rebate which will definitely motivate all IBS players to implement ICT in a greater scale whilst incentives should be given in any form such as software discount. Making it a requirement to upgrade ICT skills will be a move to encourage more practitioners to upgrade their ICT level in their respective operations. In addition, the government's role to monitor payment from the IBS contractors to the manufacturers would indirectly ensure good paybacks and hence more effective IT investment would be possible. The policy and regulatory issues is core to the use of IBS. Thus, policy was one of the barriers consistently being pointed out by majority of the Respondents. The industry perceives that the government should play an extensive role in establishing training programs through continuous professional development (CPD) and conducting a continuing awareness program [13]. Thus, there is a need to involve more participation and contribution from the government as they will be the main party that will be able to enforce and set the standard for ICT implementation.

The focus on technology is a major factor behind raising organisational IBS readiness; specifically, managing, operating, standardizing, maintaining, forecasting, and investing technology is therefore seen as a core function [17]. The management ICT is therefore critical to ensure that new technologies and emergent economies are successfully leveraged. Findings from case studies stated that business process re-engineering is vital to ensure all processes are managed and improvised. There is a need for the centralisation of IBS information amongst projects and amongst IBS players. Besides that, integration of ICT tools is vital to transform the IBS management processes to full mechanisation.

All in all, the requirements to develop the ICT-readiness framework should create an impact factor for full maximisation of ICT tools. Consequently, the ICT-readiness framework should provide a platform to move towards the direction of increased ICT-readiness and eventually automation would be the preferred choice to replace any conservative construction methods.

v. Conclusion

The management of the IBS components processes is definitely essential because the profit and success of the whole project will be determined by how well the components are being managed. From the findings above, a few conclusions can be derived. There is only an average level of acceptance towards the transformation of ICT implementation in the construction materials management. It is proven that most of the problems or issues faced throughout the IBS components management were normally solved with human solution or by technical menial solution. ICT tools were not regarded as the best practices in overcoming the IBS components management problems. The main barriers comprise of people factor; government policies; ineffectiveness of existing technology and processes and high cost factor. There is a lack of a technology push created for the IBS players to have a greater awareness of ICT benefits. Thus, there is a need to develop an ICT-readiness framework that will be the driving factor for the manufacturers to further implement ICT in their IBS components management processes. The framework can be developed in regards to the people mindset, government policy and technology.

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