

# Progression in IT adoption and stage of IT maturity in the construction sector of Singapore

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**ABSTRACT:** The IT maturity model, based on Nolan's Stages of Growth Model, is applied to analyse the characteristics of IT users, IT facilitators and IT providers in relation to their respective degrees of awareness, degrees of application and degrees of integration. The objective is to assess and draw useful conclusions about the progression in IT adoption by the construction sector in Singapore. At the same time, it can help to determine the stage of IT development for this sector. The data used for the analysis includes information obtained from an industry-wide questionnaire survey followed by informal discussions with industry players, as well as a review of the relevant publications. Evidence shows that there is an increasing trend of companies improving their efficiency and productivity through using IT. There is also an increasing trend of education institutions promoting IT usage through providing training. And, catering to this, there is an emergence of software development by IT vendors. Going beyond, it is clear that stakeholders need to focus their attention on achieving integration of technology, process and people as the next stage of development. It is recommended that appropriate strategies be put in place.

## 1 INTRODUCTION

### 1.1 *The Intelligent Nation 2015 (iN2015)*

The Intelligent Nation 2015 (iN2015) is a 10-year master plan that will transform Singapore by enhancing competitiveness of the key economic sectors and build a well-connected society through the use of infocomm technologies (ICTs). As described by the Infocomm Development Authority of Singapore (IDA), the broad intent of the master plan is "to grow the infocomm sector, and chart the use of technology for work, life and leisure". And, in order to achieve this aim, the plan will have to involve identifying new possibilities for Singapore's industries, economy and society through the innovative use of infocomm technologies.

### 1.2 *The Construction and Real Estate Network (CORENET)*

Building an intelligent construction industry complements the aim of iN2015. Since the setting up of the study group known as CORENET in July 1993, it has come a long way to becoming a major IT initiative that is led by the Ministry of National Development and driven by the Building and Construction Authority (BCA) in collaboration with other public and private organisations. The goal of CORENET is

to "re-engineer the business processes of the construction industry to achieve a quantum leap in turn-around time, productivity and quality." In order to achieve this, the CORENET revolves around developing IT systems and key infrastructure to integrate the four major processes of a building project life cycle. Currently, the effort is focused on developing a set of infrastructure and industry projects in order to:

- i) provide Information Services to allow businesses to speed up business planning and decision making processes;
- ii) provide Government to Business infrastructure to facilitate electronic building plans submission, checking and approval processes;
- iii) provide Business to Business enablers to facilitate building project collaborations and business transactions;
- iv) provide a set of standards to improve business communications; and
- v) provide a series of promotional, training and incentive programmes to create awareness and encourage adoption.

Strategically, the Construction Industry IT Standards Technical Committee (CITC) has been formed in 1998 with the primary role of establishing an in-

dustry-wide framework for the development and promotion of IT standards in the construction area. As part of the CORENET, it has further demonstrated a joint government and industry effort to prepare the construction sector for the IT age of the 21<sup>st</sup> century.

## 2 AIM AND OBJECTIVES

### 2.1 *Aim of the study*

The study aims to apply the IT maturity model, based on Nolan's stages of growth model, to analyse the characteristics of IT users, IT facilitators and IT providers in relation to their respective degrees of awareness, degrees of application and degrees of integration.

### 2.2 *Objectives of the study*

Based on this aim, the objectives are set out as follows:

- i) to assess and draw useful conclusions about the progression in IT adoption in the construction sector of Singapore;
- ii) to determine the current stage of IT development for this sector; and
- iii) to make policy recommendations to enable further progress to be achieved.

## 3 METHODOLOGY

### 3.1 *Mailed questionnaire survey*

In 2003, a questionnaire was mailed to a total of 754 companies operating in the construction industry in the areas of (i) Architecture; (ii) Engineering; (iii) Quantity Surveying; (iv) Property Development; (v) Construction; and (vi) Product Manufacturing and Supplies. The questionnaire comprises a total of 39 questions. They are grouped under 6 distinct headings; Section A: General Information; Section B: Computers and Software; Section C: Use of IT Systems; Section D: Data and Telecommunications; Section E: The Part Played by IT in the Company; and Section F: Standardisation and CORENET. A total of 84 companies (i.e. 11.1 per cent) responded to the survey. Responses from the survey were analysed using the SPSS software and the results and findings had been published (Goh, 2004; 2006; 2007).

### 3.2 *Discussions with industry players*

A post-verification of the results of the questionnaire survey was conducted through the CITC in 2004. As explained, this industry-wide committee was set up by the Standards, Productivity and Innovation Board (SPRING Singapore) in collaboration with the Infocomm Authority of Singapore (IDA) in 1998. Views and comments were solicited from members of the Committee on the key findings of the survey.

### 3.3 *Review of recent publications*

In view of the survey and discussions having been carried out in 2003 and 2004, respectively, it is likely that the results and findings might not reflect the most current state of development. Hence, in order to bring them up to date, recent publications that are related to the topic, especially those published after 2004, have been reviewed for this purpose.

## 4 SCOPE OF ANALYSIS

### 4.1 *Nolan's stages of growth model*

The Stages of Growth Model is a theoretical model that can be applied to study the growth of IT in a business organisation. It was developed by Richard L. Nolan during the 1970s (Nolan, 1973; 1979). The original model had proposed four stages but subsequently two more stages had been added to comprise the current six stages of evolution of IT in organisations. In Stage I – Initiation, it is characterised by a limited use of IT owing to lack of awareness or indifferent attitude of users, and an emphasis by the organisation to spend on functional applications that can reduce costs. In Stage II – Contagion, it is characterised by a managerial need to explain the potential of computer applications to alienated users and this leads to the rapid growth of adoption of computers in a range of functional areas. In Stage III – Control, it reacts to excessive and uncontrolled expenditures of time, effort and money on computer systems, and the major problem for the management is the organisation of tasks for the control of computer operating costs. In Stage IV – Integration, it features the adoption of new technology to integrate systems that are previously separate or standalone with an increased focus on data processing. Stage V – Data administration and Stage VI – Maturity had been added to the model to further describe the proliferation of IT in an organisation. These two stages feature a new emphasis on managing corporate data rather than IT and, therefore, mark the development and maturity of the new concept of data administration. In summary, the six stages of growth are given as follows:

- i) Stage I – Initiation;

- ii) Stage II – Contagion;
- iii) Stage III – Control;
- iv) Stage IV – Integration;
- v) Stage V – Data administration; and
- vi) Stage VI – Maturity.

#### 4.2 A simplified three-stage IT maturity model

Based on Nolan's model, a simplified IT maturity model, comprising only three stages, is adapted for assessing the progression of IT adoption in Singapore's construction sector. The rationale behind using a simplified model is that the assessment of progression would be made at the industry level rather than at the organisational level as in the Nolan's model and, therefore, three distinct stages of growth are considered applicable at a macro-level. In essence, the three stages of growth to be applied to the study are given as follows:

- i) Stage I – Initiation;
- ii) Stage II – Growth; and
- iii) Stage III – Maturity via integration.

In Stage I – Initiation, the same definition in the Nolan's model applies which is marked by low awareness and indifferent attitude of users. In Stage II – Growth, it is characterised by the rapid growth of adoption of computers in a range of functional areas and, therefore, an increased functional application of IT is key. In Stage III – Maturity via integration, it features user and systems integration through the development of networks and database.

#### 4.3 Characteristics of IT users, facilitators and providers

The characteristics of three distinct categories of industry players are to be clearly defined for each of the three stages of growth. It is to provide a set of objective criteria for the assessment of progression of IT adoption at the industry level. The distinct categories of players are given as follows:

- i) IT users (such as government, public and private organisations, R&D institutions, etc.);
- ii) IT facilitators (such as regulatory agencies, telecommunication companies, education and training institutions, R&D institutions, etc.); and
- iii) IT providers (such as hardware and software manufacturers or developers and suppliers, R&D institutions, etc.).

In Stage I – Initiation, the industry is typically characterised by low user awareness, limited use of

IT owing to no or little planned expenditure on IT hardware and software. During this stage, IT facilitators have no or little governmental support owing to a lower priority accorded to develop them. In view of the low demand for IT products and services, there are few local software developers and the industry generally depends on overseas IT vendors for its supplies.

In Stage II – Growth, the industry is typically characterised by the increasing user interest to improve efficiency and productivity through the adoption of IT for functional applications. During this stage, there is a coordinated effort by the IT facilitators to promote usage, set standards, provide education and training among others. Correspondingly, there is an emergence of software development by the IT providers, as well as software and hardware integration, as a means to customise their products and services to cater to the needs and requirements of local users.

In Stage III – Maturity via integration, the industry is typically characterised by the increasing availability of user-friendly technologies as a result of an expanding IT user base. Correspondingly, the roles of the IT facilitators have primarily become market-driven. During this stage, the IT providers mainly direct their products and services towards enabling user and systems integration through the development of networks and database.

## 5 RESULTS OF ANALYSIS

Using the simplified three-stage IT maturity model, it is hypothesized that Singapore's construction sector is at Stage II – Growth in regard to its progression in IT adoption at the industry level. For the purpose of validating this hypothesis, the information obtained from the questionnaire survey, follow-up discussions and literature review has been analysed by applying the set of characteristics of the three categories of industry players, namely, the IT users, IT facilitators and IT providers as the criteria of assessment or validation. The results are provided in the following sections.

### 5.1 Validation through IT users

The survey found a very high percentage (97.6%) of respondents had indicated that their staff use the personal computer or terminal at work, and a very high percentage (94.6%) of them had also indicated that their staff have their own personal computer. From this, it was evident the statistics showed a very high level of IT awareness and use among the companies surveyed. The survey also found that these companies had focused their attention on computerising administrative functions such as book-keeping and

invoicing. The respondents had generally noted a reduction in mistakes in documents as the positive outcome of using IT, and they had highlighted the top three advantages as “Work Done More Quickly”, “Better Quality” and “Faster Access to Information”. These aspects of derived improvement clearly relate to efficiency and productivity.

### 5.2 *Validation through IT facilitators*

The survey found that the respondents had generally used national IT standards relating to CAD and construction costs. They are, namely, SS CP80: 1999 – Classification of Construction Cost Information Standard and SS CP83: 2000; 2004 – Computer-aided design (CAD) Standards. A high percentage (80.3%) had responded that they benefited from information standardisation which was an ongoing project of the CORENET. A moderately high percentage (64.9%) had also responded that they would like to have more activities of promotion and training for the various projects under the CORENET. This could be seen as a positive response from existing and prospective users. It could also signal that the roles of the IT facilitators need to be enlarged.

### 5.3 *Validation through IT providers*

The survey found that a moderately high percentage (77.1%) of respondents had indicated they benefited from the One-Stop Submission Centre (OSSC) project of the CORENET. The project was set up to build a network infrastructure that supports electronic submission of building project documents to regulatory agencies for processing and approval through a secure environment. From this finding, it could be implied that newly customised software that comply with the national standard (i.e. SS CP83) would have emerged to enable the wider application of CAD in the industry to meet the requirements of electronic submission of building designs for obtaining planning approval. Hence, when there is a demand, there will be creation and supply.

## 6 DISCUSSION OF NEXT STAGE OF GROWTH

Beyond Stage II, the next stage of growth will be targeted at achieving integration. In Stage III, Singapore’s construction sector will have to display characteristics of an expanding IT user base, roles of the IT facilitators to be largely driven by the market, and IT products and services to be directed towards enabling user and systems integration through the development of networks and database. In essence,

achieving integration of technology, process and people will be key.

As part of the CORENET, a few major projects have been developed with the aim to provide a Government to Business infrastructure to facilitate electronic building plans submission, and checking and approval processes. As the next stage emphasizes integration, the new platform has to be model-based. Clearly from now, the industry has to fully migrate from the traditional 2D design drafting platform to one that is 3D model-based.

Since 2005, the use of Building Information Modelling (BIM) to prepare the design has been advocated on CORENET’s e-Plan Check project (Cheng and Teo, 2006). It is an artificial intelligence checking system that automatically checks electronic plans for compliance with regulatory requirements over the Internet. Designs that are prepared using BIM tools are uploaded onto the e-Plan Check system for automatic on-line or batch processing. The system will generate a report to highlight areas of non-compliance when the automatic checking process is complete. For BIM implementation in Singapore, the Industry Foundation Classes (IFC) has been adopted as the standard. In view of this adoption, the BCA has been working closely with the International Alliance for Interoperability Singapore Chapter (IAI (S)) to steer the industry towards the wider use of the IFC-based BIM. A few commercial design BIM tools that have been certified as complying with the e-Plan Check requirements for the architectural view include Autodesk’s ADT, Autodesk’s Revit and Graphisoft’s ArchiCAD.

## 7 POLICY RECOMMENDATIONS

Promoting use is the first recommendation. As the construction sector is typically fragmented as it is made up of numerous small players (i.e. in Singapore, about 68.6% of companies in the sector employ less than 10 persons), promoting IT use to the small businesses can develop a growing, sophisticated user base. This can be the best resource for the IT providers such as software and services companies.

Providing financial support to the IT providers is the second recommendation. Software and services companies often fail to survive even when they have good people and technology simply because they are starved of capital. Encouraging partnerships between local companies and multinational corporations can be the best way for local IT providers to get established. The longer aim would be to develop an industry that can cater to domestic needs, as well as compete for business in international markets.

Developing national capabilities is the third recommendation. As the IT facilitators, regulatory agencies, education and training institutions, as well

as R&D institutions should receive support from the highest levels of government. The strategies and programmes should be market-driven, that is, developed in close consultation with the private sector, including both local and multinational companies, and with domestic and foreign experts from academia and industry, to be practical and effective.

## 8 ADDRESSING ASPECTS OF LIMITATION

The study recognises two aspects of data limitation: (i) small dataset (i.e. only 84 responses received); and (ii) time relevance of data (i.e. survey held in 2003). In view of the limitation, the methodology has been designed to allow for other methods of data collection to be applied, such as, informal discussions and literature reviews. To explain further, the first aspect of limitation has been addressed by the carrying out of a post-survey verification of the results. As described in Section 3.2, a number of discussions with key industry players have been made mainly to “authenticate” the results of the analysis of survey responses. The second aspect has been addressed through conducting a search of publications relating to new developments in the use of IT in Singapore’s construction sector. As mentioned in Section 3.3, the gathered information would be used to map the progression since the time of the survey. As such, the next stage of growth could be projected and this has been discussed in Section 6.

## 9 CONCLUSION

A simplified version of the Stages of Growth Model developed by Nolan has been applied to assess the progression in IT adoption in Singapore’s construction sector. Based on the analysis of information obtained for the characteristics of the IT users, IT facilitators and IT providers, the results have validated the hypothesis that Singapore’s construction sector is at the second stage of the growth model. During this stage, it has been explained there tends to be an increasing interest of users to improve efficiency and productivity through the adoption of IT for functional applications, while there is a coordinated effort by the IT facilitators to promote usage, set standards, provide education and training, and there is an emergence of software development by the IT providers to customise their products and services for local use. Beyond this stage, it has been discussed that the essence of growth is in the achieving of integration of technology, process and people, and in that direction the CORENET has since in 2005 placed on its agenda the need to promote a model-based approach through a few of its major projects. Policy recommendations that relate to growing the user base, developing an industry for software and service providers, and building national capabilities

have been made to enable the formulation of targeted strategies and action plan for implementation in the next phase.

## 10 ACKNOWLEDGEMENT

The IT Barometer Survey of Singapore 2003 was wholly funded by the National University of Singapore under a completed research project.

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