CHAPTER 6

DEVELOPMENT OF THE INITIAL IT INFRASTRUCTURE FLEXIBILITY MATURITY MODEL

6.1   Introduction

The designing process of a maturity model was modified from Tapia (2007), Salleh (2007), and Pöppelbuß & Röglinger (2011).   This chapter discusses the maturity levels in the IT infrastructure flexibility model. Starting with an explanation of maturity model, this chapter discusses about the initial IT Infrastructure Flexibility (ITIF) Maturity Model that was constructed from fourteen critical success factors as improvement domains from the pervious chapter. Each of the level consists of technical dimension (file format standardization, integration interval, and system design), people dimension (teamwork, independence and pro-activeness, IT awareness, IT learning commitment, change willingness, hybrid skill, and awareness of critical success factors), and management dimension (connectivity, IT security management, data management, and IT project management). The initial ITIF Maturity Model is attached in Appendix C.

6.2   Purpose of the ITIF Maturity Model

The purpose of the ITIF Maturity Model is to assist construction organizations assessing their IT infrastructure performance in coping with the technological change by considering flexibility issue. The model provides a guideline for each maturity level for organizations to improve flexibility status and progress through the maturity levels. The model will help organizations in determining improvement routes for the ITIF success factors. The basic building blocks in the model are called "process areas"; it describes *what* those using an effective process do (practices), and *why* do those things (goals) (Moore & Williams, 2012; Ply, Moore, Williams, & Thatcher, 2012).

## 6.3   Designing ITIF Maturity Model

6.3.1   Scope

The scope of the model involves technical, people and management dimensions that include technical dimension, people technical and management skills, and management issue. The factors implied were from the thorough factors selection as a result from the construction industry surveys.

6.3.2   Representation

There are two types of maturity model representations, staged and continuous, which can be thought of as two different views of the same data (Tapia, Daneva, & Eck, 2007). The *continuous representation* model allows the user to focus at the specific

processes that are considered important for the organizations' immediate business objectives (Constantinescu, 2007). It focuses on capability levels, which applies to organization's process improvement achievement in individual process areas (Dadhich & Chauhan, 2012). All the factors in the same level must be the same, only then can be considered have achieved the maturity level; for example, to satisfy level 2 for technical dimension, the organization must satisfy the specific goals and level 2 for people dimension as well. In practice, Shrum (1999) found that the model has always consisted six levels, numbered 0 through 5, indicates '*not performed*' through '*optimizing*'. The Systems Engineering Capability Model (SECM) introduced by the Electronic Industries Association's Interim Standard 731 is a model with a continuous representation.

The ***staged representation*** provides a sequence of improvements, advancing through a predefined and proven path of successive levels, where each level serves as a basis for the next maturity level, and it serves as a basis for comparing the maturity of different projects and organizations (Soydan & Kokar, 2012). It offers a roadmap to efficiently focus on improving process with milestones for bringing the entire organization in a coherent and uniform way from the initial level to the optimizing level. This representation provides a higher-level view of the entire organization, and a simple, straightforward, easily understandable label, with more direct business implications (Constantinescu, 2007). The staged representation maturity model commonly has five maturity levels, numbered 1 through 5, which indicates the lowest performance through optimizing (Gulbert, 2008). To achieve the required level in one area, it does not necessary to achieve in another area. The Software Engineering Institute's Capability Maturity Model for Software is a model with a staged representation (Shrum, 1999).
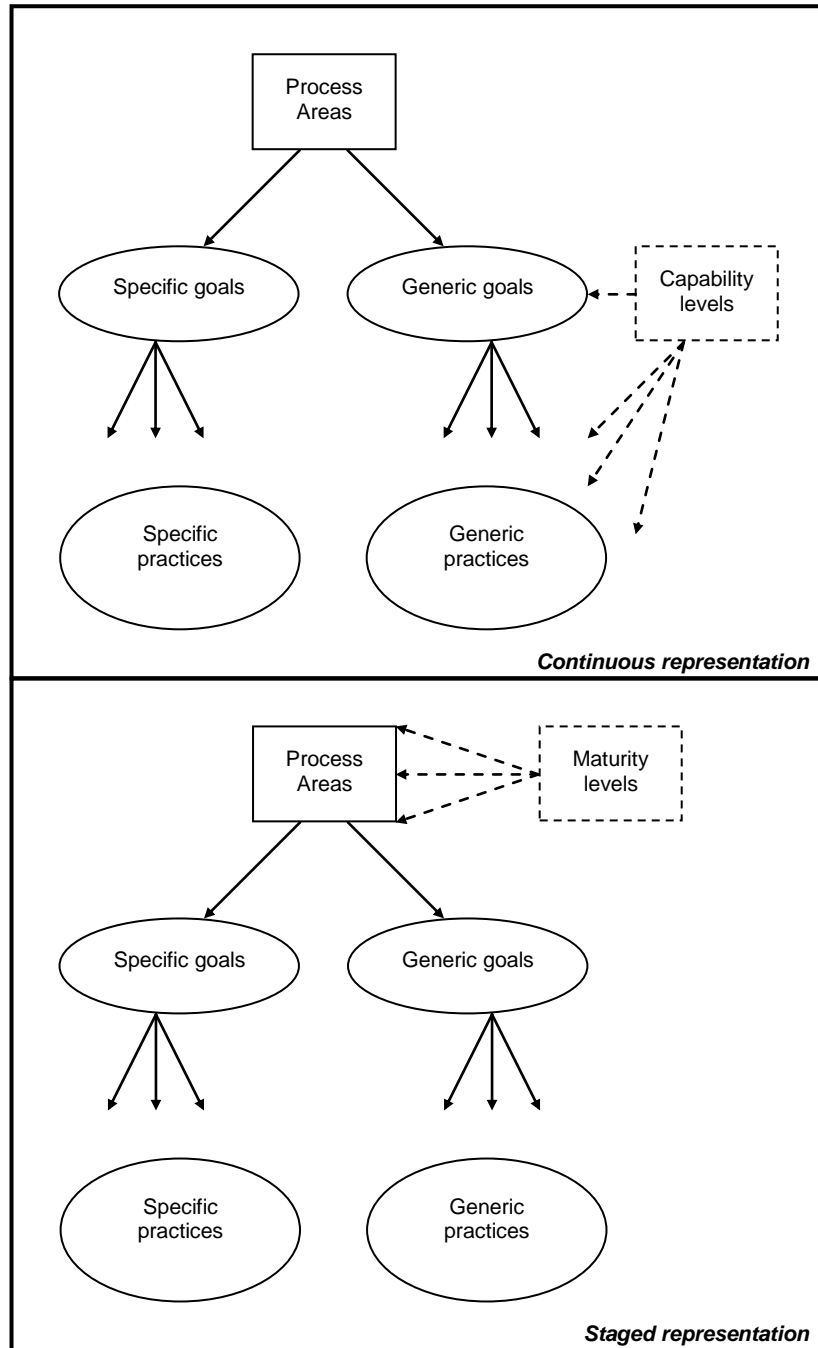
Figure 6.1: Comparison between continuous and staged representation of a maturity model (Gulbert, 2008)

The ITIF Maturity Model uses the staged maturity model as it assesses the maturity of the IT development processes, aiming to reach a stage that allows improvements for the next stage. It evaluates progress using the same baseline as any other organizations. Organizations can purse process improvement at any pace it wishes, though, the basis for evaluating progress will be exactly the same. Each maturity level forms a necessary foundation on which to build the next level. Construction organization can have different levels of maturity in each of the units included in the model. This gives flexibility to the organization to focus on the units with a low level of maturity, and those units with higher maturity can be continued with later improvement efforts. Figure 6.2 shows example of ITIF Maturity Model appraisal.
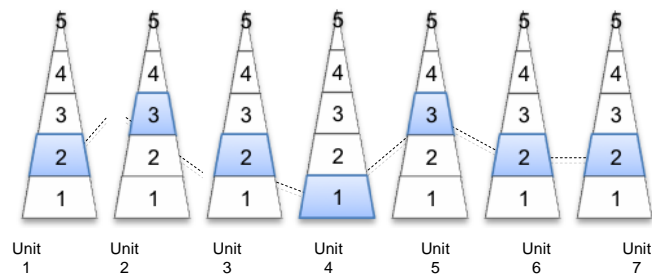

Figure 6.2: The pyramid structure of the model (Tapia, et al., 2007)

6.3.3   Structure

The maturity model defines a number of dimensions at several discrete level of maturity.   Generally, a few common characteristics have been found in a maturity model.   There are as follow:

    i.   Level - A number of levels.

    ii.   Element - A descriptor of each level; a short explanation to indicate the goal.

    iii.   Summary - A summary of the characteristics of each level as a whole.

    iv.   Dimension - Dimensions or process areas

    v.   Factors - Elements or activities for each dimension areas.

    vi.   Description – Description of each activity as it might be performed at each maturity level; a major requirement and measure of the stage, especially aspects that are new to the stage and not included as elements of lower stages.

Figure 6.3 shows the basic design of a maturity model proposed for this study.   This design was used after the description of each factors were defined.

	Dimension
	Element
Level *n* – level name	*Summary* Factor(s): *Description*
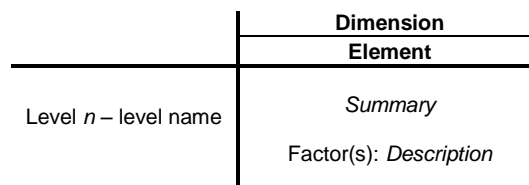
Figure 6.3: Basic features of a maturity model

Table 6.1 lists the various maturity models and authors used for the development of the initial ITIF Maturity Model, specifically in factor's definition and adoption, model structure, and guideline of use. The concepts and models of each factor were extracted, adopted, combined, and modified from the listed models and authors. This includes wording/re-wording, leveling/re-leveling, rephrase, and redefine from previous models. These findings were modified and tested on IT implementation for construction organization's to conform to the real situation in case studies, which will be discussed in Chapter 7.

Table 6.1: The resources used for factors and concept adoption

Concepts/Factors	Sources
Model concept ▪ 5-levels of maturity ▪ Summary of each level	▪ Used by majority of published maturity models (as discussed in Chapter 3). ▪ Pugsley (2008), Wadhwa & Rao (2002)
Model elements ▪ For dimensions of technical, people, and management.	▪ Duncan (1995), Byrd & Turner (2001), Fink (2009)
Technical elements ▪ Compatibility ▪ Modularity	▪ Gray (2009), Chagoya (2007) ▪ Fink (2009)
People elements ▪ IT leadership skills ▪ Business functional skills ▪ Interpersonal skills	▪ Kwak & Ibbs (2002), NASCIO (2003), Gray (2009), Agile Maturity Model (Ambler, 2010), Curtis, Hefley, & Miller (1995) ▪ Agile Maturity Model (Ambler, 2010) ▪ Rainer & Hall (2002), Hamel (2009), Curtis, Hefley, & Miller (1995), Grigg & Mann (2008)
Management elements ▪ Technical-oriented ▪ Management-oriented	▪ Warillow (2009), Francis & Richardson (2009), IT Architecture Capability Maturity Model (US Department of Commerce, 2003), IBM (2006), Robertson (2012) ▪ Sowden (2006), Gray (2009), IBM (2006), Adaptive Infrastructure Maturity Model (Hewlett-Packard Company, 2007),

6.3.4   Maturity levels

Maturity levels imply the number of discrete levels of maturity for the model, along with their qualifiers and definitions. A staged representation maturity model relies upon a 5-layer model, ranging from 1 to 5 where level 1 represents "initial' or minimal maturity, and level 5 represents "optimized", or fully matured (Dadhich & Chauhan, 2012; Gulbert, 2008; Shrum, 1999), for examples, the Project Management Maturity Model (Crawford, 2006) and the Standardized Process Improvement for Construction Enterprises (SPICE) (Sarshar, et al., 1999).   Therefore, in this research, the 5-level was chosen as a suitable number as it allows a sufficient level of granularity to permit differentiation between hierarchies of maturity.   The proposed 5-level can be characterized as following Table 6.2. The definition for each level was adopted from definitions of infrastructure flexibility made by Pugsley (2008) and Wadhwa & Rao (2002).

Table 6.2: Characteristics of levels.

Level	Level Name	Level description
1	Initial	A state where the IT systems implementation happens on a project-by-project basis.
2	Rigid	A state of the organizations implement IT for one specific purpose of IT system, without an ability to be reconfigured.
3	Restricted	A state where IT implementation is driven by a single business objective, where the IT system has limited adaptability to accept broad changes.
4	Extensive	A state where IT implementation is happening in an integrated way across IT systems that covers a larger ability to adapt changes.
5	Flexible	A state of IT system is being able to pursue change and adapt quickly to changes continuously, automated, and synchronized between IT systems and business units.

Source: Pugsley (2008), Wadhwa & Rao (2002)

6.4   ITIF Maturity Model Elements

The framework was developed from the integration of three distinct-but-related areas of ITIF research literature: technical, people, and management dimension. Each of the three domains will be explored in detail in the sections below. The proposed ITIF Maturity Model consists of fourteen ITIF success factors that fall under the seven elements of three domains, as shown in Table 6.3 below:

Table 6.3: The elements' characteristics

Dimension	Elements	Element Characteristics	ITIF Success Factor	Term used in the model
Technical	Compatibility	Ability of IT infrastructure to share any type of information across any IT components.	Standardization of file formats	*File format standardization*
			Quick integration of new system	*Integration interval*
	Modularity	IT components of databases and applications reusability.	Design to be reconfigurable	*System design*
People	IT management skill	The leadership skills acquired by the IT personnel.	Teamwork in multidisciplinary environment	*Teamwork*
			Self-directed and pro-active	*Independence & pro-activeness*
	Business functional skill	Attitude and ability of IT personnel towards intellection of latest IT.	Commitment to learn	*IT learning commitment*
			Be updated	*IT awareness*
			Willing to change	*Willingness of Change*
			Able to interpret management and technical needs	*Hybrid skills*
	Interpersonal management	IT personnel's understanding about the nature of construction industry environment.	Awareness of CSF	*Awareness of CSF*
Management	Technical oriented	Range of technical-oriented support from the management.	Connectivity	*Connectivity*
			IT security & management	*IT security management*
			Data management	*Data management*
	Management oriented	Extension of management-oriented support for IT development.	IT project management	*IT project management*

6.5   What are being evaluated?

6.5.1   Technical dimension

Technical dimension consists of compatibility and modularity as the critical factors indicated as analyzed in previous chapters.

(i)   Compatibility

Compatibility measures an ability of the IT infrastructure to share the information within or/and across IT systems. Two factors assessed as important indicators under this element are (1) standardization of file format, and (2) integration interval from current system to a newer system.

The file format standardization is a particular way that digital information is encoded for storage in a computer file (Alwall, et al., 2007). In most computer operating systems, including Windows and Mac OS, the format of a file is separated from the base filename by a dot. This portion of the filename is known as the filename extension (Karresand & Shahmehri, 2006). For example, Word documents are identified by names that end with "*.doc*", and JPEG images by "*.jpg*". For the construction industry, it is a challenge to standardize the file formats because there are different kinds of formats for different kinds of information. For instance in the tendering process, client may receive several different file formats such as drawings in *.jpg*, the bill of quantities in *.xml,* and the form of contract in *.pdf.* Therefore, it is significance to measure how construction organizations ensure the system's compatibility

through the standardization of file formats. Table 6.4 shows some examples of standardized file format templates.

Table 6.4: Some examples of standardized file format templates.

Standard Formats	Acronym	Description
Really Simple Syndication	RSS	• Web feed formats • Used to publish frequent updated works in a standardized format *Source: Nottingham (2005).*
Portable Document Format	PDF	• Open standard for document exchange • Represent documents in a manner independent of application software, hardware, and operating system *Source: Adobe (2006)*
Industry Foundation Classes	IFC	• Intended to describe building and construction industry data • Cross-discipline coordination of building information • Enable data sharing via ifcXML and aecXML *Source: Bentley (2007)*
Extensible Markup Language	XML	• A markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. • Examples of XML-based languages are RSS, XHTML, and Atom. *Source: Walsh (1998)*
Open Document Format	ODF	• XML-based file format for spreadsheets, chars, presentations and word processing documents. • The standardization process involves the developers of many office suites or related document systems. *Source: Lee (2011)*
HyperText Markup Language	HTML	• Main markup language for the web pages. • Used to get the standardized contains of any web pages. *Source: Shannon (2010)*

A flexible IT system should be compatible with a wide range of types of applications, to ensure it properly loads and displays data in all major operating systems. Thus, integration is measured according to how quickly the system is able to integrate between platforms and applications (Cone, 2008). This includes protecting, tracking, and retrieving data. Faster integration speed indicates a more compatible system (Xu & Liu, 2011). The following discussion explains the five maturity levels under the element of compatibility.

- *Maturity Level 1*

  Organizations have no dedicated and project-based IT infrastructure, and the available systems do not support different file formats. The integration between current and newer IT system is slow which takes up to (more than) three-month time due to many integration procedures involved.

- *Maturity Level 2*

  Standard file format is start to exist but is utilized in certain modules (module is a unit that is used to construct the whole IT system) of IT system. The integration speed is quicker because less integration procedure involved due to the existence of formatting standardization. The system is able to integrate with new IT system in weeks.

- *Maturity Level 3*

  An organization established a standard format for all IT modules to develop an IT system, and this makes the new infrastructure able to integrate in weeks to days.

- *Maturity Level 4*

  A centralized system is used to standardize file formats. The change control and updates are managed uniformly; therefore, it quickens the integration in days to hours.

- *Maturity Level 5*

  Organizations establish integrated automated and centralized system to standardize file formats for all IT systems within an organization. The new

templates for file formats are implemented uniformly to meet new strategic needs. The integration speed takes hours to seconds for full assimilation between later and newer IT systems.

(ii) Modularity

Modularity involves creating most efficient modular IT architecture to support existing and new IT products, which measures the ability of IT infrastructure to be easily configured and reconfigured. The critical factor of this element is during the design stage prior to its development. The purpose of system design is to create a technical solution that satisfies the functional requirements for the system, with considering long-term adaptability system (Pataki, Dillon, & McCormack, 2003). Some evidences to verify system designs are listed in Table 6.5.

Table 6.5: System design requirements

System designs	Description	Techniques
Functional specification	▪ Written primarily in business terminology ▪ Contains a complete description of the operational needs of the various entities that will use the IT system	▪ Interviews ▪ Observations
Technical architecture	▪ Foundation and structure of the system are indentified in terms of system hardware & software, supporting tools, and the strategy for distribution of the system components across the architecture.	▪ Interviews ▪ Document and authorization analysis
System standards	▪ Common processes, techniques, tools and convention used throughout the projects. ▪ Used to maximize efficiencies and introduce uniformity.	▪ Interviews ▪ Brainstorming ▪ Policy and standards reviews
Physical database	▪ Actual database used by the system. ▪ Ensure the completeness, accuracy, and reliability of the data.	▪ Data administration
System requirement analysis	▪ System components are distributed across the physical architecture ▪ Prototype is designed	▪ Presentations ▪ Report development tools
Technical specification	▪ Enable building and testing the system	▪ Operational requirement analysis ▪ System load analysis ▪ Business impact analysis ▪ Potential problem analysis ▪ Training needs decomposition

Source: Pataki, et al. (2003)

The following discussion describes the maturity of system design to ensure the modularity of the IT system.

- *Maturity Level 1*

  There is no IT documentation or standards due to lack of involvement of the construction organization in implementing IT.

- *Maturity Level 2*

  The IT system is designed for a specific purpose only, without the intention to make the IT system adaptive. The IT documentation and standards are established by a variety of ad hoc means, and are localized or informal.

- *Maturity Level 3*

  Design standards exist and organizations have started to establish technical reference mode and standards profile framework. The design focused at one specific need.

- *Maturity Level 4*

  The organization focuses at designing IT system to be adaptable, to more than one specific need. The technical reference model and standard profile are updated on a regular cycle to reflect the updated IT design.

- *Maturity Level 5*

  The focus of organizations is towards continuous improvement in adaptive design for IT system. A computerized system is used to test the design

usability and design analysis to support system design for continuous improvements.

6.5.2 *People dimension*

The people dimension measurement is divided into three perspectives, which are IT management skill, business functional skill, and interpersonal management. These three elements have different indicators:.

(i)   IT leadership skill

IT management skill measures skills acquired to manage IT projects. This element has two critical factors that are (1) teamwork and (2) self-directedness and pro-activeness.

Teamwork is defined by Palit & Stein (2009) as a 'collaboration skill' which the IT personnel have to develop abilities to work in groups with persons of different background, to think critically in solving problems, and to communicate effectively, both orally and in writing. Palit & Stein (2009) also explained that good teamwork is important in facing challenges that occurred during the development of IT infrastructure – teams carry out many critical functions, including information collection and dissemination, decision making, and implementation, where these elements contribute to a successful IT project (Davison & Ward, 1999). Many approaches can be done to develop and nurture a good teamwork in an organization. Table 6.6 gathered some common modes that are used in an organization to guide team working.

Table 6.6: Teamwork's guides

Approach	Purpose
Performance appraisal	To reward behavior attending individual task attainment (Scott & Einstein, 2001).
Organizational chart	To outline job description and responsibilities that suggests the development of the operations within an organization (Clayton & Fisher, 2006).
Staff management plan	To acquire and manage human resources on the project (Hints, 2009).
Core competencies analysis	To identify the critical success behaviors of individual (G. Hamel & Prahalad, 1994)
Team building activities	To improve team performance including self development, positive communication, leadership skills, and the ability to work closely together as a team for problem solving (Klein, et al., 2009)
Mentoring in teamwork	To keep the team players motivated to work in a team and in a better way (Fruchter & Lewis, 2003).

Self-directed skill is an aptitude to work without the usual managerial supervision toward a common purpose or goal (Fisher, 2000). In another words, an individual who has this skill is able to work effectively independently. Thinking and acting ahead in anticipation of future problems, needs, or changes – these are the qualities brought by IT personnel of being pro-active (Larsen, 2010). To work as a good team player, self-directed skill and being pro-active are essential to lifelong learning (Camargo, et al., 2011). The maturity for element of IT management skill is discussed as follows:

▪ *Maturity Level 1*

Several independent groups or individuals form on ad-hoc basis to solve a single issue or an individual IT project. A project-driven team is set but result in conflicts. The organization typically provide performance appraisals, but offers little guidance or training in conducting the activities supported by these forms. Each team member tends to wait and follow the leader's instruction without any self-starting initiatives.

- *Maturity Level 2*

  A team typically formed to solve a single issue or a single IT project. The organization has an organizational chart with employee management plan. The organization is starting to establish policies to develop employee skills specifically for IT development. The IT personnel develop repeatable methods that have been set up to perform IT development activities.

- *Maturity Level 3*

  An organization is starting to define a program and career planning development strategies for each individual, and systematically developing IT personnel core competencies. IT personnel mostly depend on the leadership and perseverance of a few individuals.

- *Maturity Level 4*

  There is an improvement in both individual skills and team capabilities, and these qualities are integrated to perform IT project effectively. Each role of team player is well understood. The organization establishes a project-oriented team and leaders use their experience to provide personal support, guidance, and some skills development. The organization performs team-building activities. The individual becomes self-reliant and independent; can work under own initiative to perform activities for the alignment of team and organization's goals.

- *Maturity Level 5*

  Each role is well understood, and the team is autonomous. The organization supports individuals toward continuous developmental of personal

competencies by providing training or funding. Leaders further support further development of personal or team competencies. Individual strive to improve themselves, their team, and their team's knowledge, skill, and motivation, which is now embedded as organizational culture. The team gains trust from the top management.

(ii)   Business functional skill

The critical factors for business functional skills are (1) be updated, (2) commitment in learning new IT process, (3) willingness to change, and (4) technical and management interpretation skill.

The first factor under this element is 'be updated' means that the IT personnel awareness about the updates and latest happenings in the field of IT along with technical reviews and news (Rong & Grover, 2009). Web pages and blogs offer the fastest way to get up-to-date information from reliable sources. Through them, individuals could to subscribe to RSS feeds, join online forums, technology magazines or journals. On top of that, conference and seminar are also a medium to get reviews on the latest technology. Besides the IT awareness, personnel commitment is assessed in a context of a dedication of IT personnel learning about latest IT, which include about the tools, applications, systems, and processes involved.

Willingness to change is a behavior that has become one of the core competencies of adaptive IT personnel (Stefanovic, Prokic, & Vukosavljevic, 2011). This enables the IT personnel to easily adapt to work effectively within a various situations with other individuals and/or groups. They understand and

appreciated diverse and opposing perspectives on an issue, adapting one's approach to the changes at hand, and easily accepting and making such changes, whether in one's own duties or in the organization strategic direction (Napshin & DeCarolis, 2011). The indicator to measure change capability is subjective but some organizations were found to do performance appraisal and provide a reward for individuals who has that positive aptitude (Don, 2008).

The skill of interpreting technical and management needs is important for IT personnel understand the business objectives (Willcocks, Venters, & Whitley, 2012). By both set of skills, it helps IT personnel to appreciate the management requirements, before proposing a technical solution for any particular project (McAlearney, 2008). Evidences that show the organizations require multi-disciplinary IT personnel, by providing business management training, hiring IT consultant to coach them understanding needs and limitations, and implementing requirement analysis, functional specification analysis, and technical manuals.

The four factors under business functional skills elements is as followed are maturing as followed:

- *Maturity Level 1*

  The IT personnel is not aware and not interested to know about latest IT. They follow the traditional IT project management approaches and is comfortable with it. They just accept the instructions - inability to interpret the business needs correctly.

- *Maturity Level 2*

  The IT personnel are starting to be aware of new IT used by rival organizations within the construction industry. With own initiative, they start to learn about new processes without formal documentation. However, they still resist change from the way they work due to the lack of information about the new IT process. The personnel have started to interpret the business needs by self-mentoring.

- *Maturity Level 3*

  Awareness about new IT is increasing among IT personnel and top management level. The commitment to learn about latest IT has also increased by attending events, demonstrations and conferences. The process is documented but for the project unit only. Some new approaches are adapted within the department. The leader has capability to understand business needs and put forward a technical solution, but the understanding among IT personnel is varies.

- *Maturity Level 4*

  Knowledge sharing activities exists within an organization. Emerging IT process is documented and is shared among IT staff. The entire organization accepted and adapted new IT systems. Entire IT unit acknowledge business needs, but with limited understanding with the management team.

- *Maturity Level 5*

  An internal knowledge-sharing portal (Internal Knowledge Portal) is established to share IT knowledge and do trend analysis. The IT personnel

are flexible and ready to change according to best practices. Business and technical department have good understanding about each other needs and limitations. There are close working relationships between the IT and Management teams, and new organizational policies are written in conjunction with both departments.

(iii)   Project management skill

The identification of IT project's CSF is important for a project to achieve its mission, therefore, IT personnel need to poses an IT project management skill, especially their ability to determine CSF of IT projects (Kandelousi, Ooi, & Abdollahi, 2011). By understanding CSF, it allow IT personnel to predict risk, hence save cost and shorten project timeframe (Dobbis, 2001). It is also allow members of the team working towards similar goals, and to assess and adjust the organization's direction in response to a changing environment (Gates, 2010). The following describes the maturity of this element:

- *Maturity Level 1*

  IT personnel have little awareness about IT project CSF due to deficiency of understanding about the importance of CSF and lack of effort taken to measure CSF by the organization.

- *Maturity Level 2*

  The organization has now started to realize the importance of CSF. The CSF is identified by the management, therefore IT personnel have started to aware about IT project CSF and stick to the list that have been identified, with limited ability to predict the changing CSF.

- *Maturity Level 3*

  IT personnel have an active role in identifying CSF, where the organization identifies the CSF through best practice in the industry by involving external industry experts, but have limited ability to provide strategy to successfully manage the CSF.

- *Maturity Level 4*

  Understanding about IT project CSF among IT personnel is increased, where the IT personnel are able to provide strategic solutions to successfully manage CSF.

- *Maturity Level 5*

  IT personnel have improved its ability predict future IT success trends; with established mechanism or platform provided by the organization in order to facilitate IT personnel to react to external drivers quickly in determining CSF.

6.5.3   Management dimension

Management dimension is divided into two categories, which are (1) technical-oriented, where support is given by the organization in providing infrastructure to sustain the development of IT projects, and (2) management-oriented that covers the administration of IT projects.

(i)   Technical-oriented

Three important success factors that fall under this element are connectivity, IT security management, and data management. Connectivity is a capacity for the interoperability of platforms, systems and applications (Jimeno, Christensen, & Nordman, 2008). The resources of connectivity can be assessed through various discrete networks such as presented in Table 6.7.

Table 6.7: Examples of network connection types

Types	Description
Internet	A global system of interconnected computer networks that use the standard Internet protocol suite to serve billions of users worldwide.
Local area network (LAN)	A computer network that interconnects computers in a limited area.
Wide area network (WAN)	A telecommunication area that covers a broad area.
Virtual private network (VPN)	A public telecommunication infrastructure to provide remote offices to a central organizational network.
Client-server	A computing model that works as a distributed application. It involves client (a service requester) and a provider of a resource/service (a server).
N-tier	A client-server architecture in which the presentation, the application processing, and the data management are logically separate processes. Developers only have to modify or add a specific layer, rather than have to rewrite the entire application over.
Server virtualization	Partitioning of a physical server into a smaller virtual servers.
Cloud computing	A remotely hosted server that can be assessed through the Internet, which require a greater speed and very dependable internet connection.

Source: Windows (2005)

IT security management refers to confidentiality, integrity, and availability of the information – the accuracy and completeness of information is safeguarded and it is accessible only to authorized users when required (Jaferian, et al., 2008). This is important to protect valuable information from threats inside and outside the organization. Some indications of designing an IT security management in the organization are such as the establishment of security policies, risk assessments, security analysis, and comprehensive usage of third party system security such as firewalls, antivirus, and anti-spyware (Bosworth, Kabay, & Whyne, 2009).

Data management is the process of managing data as a valuable resource to an organization; it involves data architectures, practices, and procedures related with data and then executing these aspects on a regular basis (Gray, et al., 2005). Some of the activities of data management are listed in Table 6.8.

Table 6.8: Some activities of data management

Activity	Purpose
Data administration	Tasks done by the authorized person to administer data recoverability, integrity, security, availability, performance, and development & testing support (Gray, et al., 2005)
Data mining	A process in which large amounts of data are sifted through to show trends, relationships, and patterns (Han & Kamber, 2006).
Data warehousing	Storing data for easy access and efficient use (Han & Kamber, 2006; Khalil, Acharya, & Alam, 2012).
Storage area network	Transferring of data between computer system and storage elements (Tate, Lucchese, & Moore, 2006).
Cloud storage	A model of networked online storage where data is stored on multiple virtual servers, generally hosted by third party (Abadi, 2009).

The following describes the technical-oriented maturity from level 1 to level 5.

- *Maturity Level 1*

  The management provides basic network with no IT security considerations and data is managed manually using local disk storage.

- *Maturity Level 2*

  Some common tools and techniques are applied as basic management steps. The organization provides basic needs for network and IT security considerations; data administration is defined in a project-by-project basis.

- *Maturity Level 3*

  Consistent use of tools and techniques are provided by the organization. The management supplies an extensive network such as the Internet and virtual private network, client-server, and N-tier. Statistical data security is

performed to control access to the system and data management tools are utilized to manage the increasingly complex and their interrelationships.

- *Maturity Level 4*

The focus of the organization is to provide an integrated and automated technical support. Networks can be connected wirelessly and automatically regardless of geographical location. Data encryption is established along with IT risk and security analysis. An in-house data management is developed to suit with the organization.

- *Maturity Level 5*

The management utilizes open systems framework in promoting full IT components with interoperability and portability. An automatic or readily adaptable IT security tool is established, such as by utilizing artificial intelligence into their development of IT system security tools. Data management is cross-referenced and search ability is enabled across multiple data types and platforms, and includes auto-reporting and analyzing data.

(ii)   Management-oriented

IT project management is significantly important to ensure IT projects are ran efficiently and successfully delivered according to clients' expectations in an agreed timeframe and cost (Lacerda, Ensslin, & Ensslin, 2011). IT project management involves planning, executing, monitoring, and controlling process. Throughout the procedures, there are much documentation involved such as the project scope, project plan, resources and staffing plan, acquisitions plan, risk plan, training plan, quality assurance, and performance reports (Sauer & Reich,

2009). The IT project management plan is matured from an ad hoc to an integrated and inter-departmental plan. The maturity descriptions are as follows:

- *Maturity Level 1*

  The approach to IT projects is conducted on an ad hoc basis. Only portions of basic resources are managed.

- *Maturity Level 2*

  There is no consistency or standard procedures to manage IT projects across the organization. An entire standalone resource is managed, for example a complete application server environment.

- *Maturity Level 3*

  Consistent management procedures are used in all IT projects. The management is focused to provide a consistent and comprehensive approach of IT project execution. Homogenous resources are managed, typically as a collection such as a server pool or cluster or application servers.

- *Maturity Level 4*

  Project management is institutionalized with service centric and integrated processes. Process efficiency is monitored for improvement by taking into account changing business needs and external factors. Heterogeneous resources are managed as a subsystem, for instance, a collection of servers, storage units and routers, or a collection of application servers, databases, and queues.

- *Maturity Level 5*

  The IT project management plan is to established and is aiming for continuous improvement. At this level, the organization has the ability to anticipate future capacity demands, as well as, the capability requirements. IT change management plan is recognized.

6.6　Conclusion

Withdrawing from a conclusion in Chapter 3, existing infrastructure maturity models do not adequately address flexibility issues. Thus, this chapter highlights the characteristics of the initial framework for the proposed ITIF Maturity Model, starting with the description about maturity model. The initial model was developed through the collaboration of various models and the works of many authors and organizations by the data extraction process that include wording and re-wording, re-phrasing, re-leveling, and etc. to suit it with the construction industry setting.

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