UNIVERSITY OF TWENTE.

# IT Infrastructure Maturity Model (ITI-MM)

## A Roadmap to Agile IT Infrastructure

UNRESTRICTED

**Master Thesis**

**Ferry Haris**

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## IT Infrastructure Maturity Model (ITI-MM)
A Roadmap to Agile IT Infrastructure

**Unrestricted**

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Bonn, August 2010


## Author

*Ferry Haris*

| | |
|---|---|
| Program | Business Information Technology,<br>School of Management and Governance |
| Student number | 0206571 |
| E-mail | ferry.haris@gmail.com |

## Graduation Committee

*Pascal van Eck*

| | |
|---|---|
| Department | University of Twente, Computer Science |
| E-mail | p.vaneck@utwente.nl |

*Maria-Eugenia Iacob*

| | |
|---|---|
| Department | University of Twente, Information Systems and Change Management |
| E-mail | m.e.iacob@utwente.nl |

*Arnold Buddenberg*

| | |
|---|---|
| Department | Deutsche Telekom AG, IT Governance – Group Enterprise Architecture |
| E-mail | arnold.buddenberg@telekom.de |

UNIVERSITY OF TWENTE.

Drienerlolaan 5
7522 NB Enschede, The Netherlands

Friedrich-Ebert-Allee 140
53113 Bonn, Germany

# Management Summary

Nowadays, as more and more organizations rely on Information Technology (IT) to support their business, flexibility in IT infrastructure becomes increasingly important. A continously changing business environment, with various complex demands, force them to deliver their services by any means in order to preserve their competitiveness. The recent economic downturn also compels these organizations to operate in very cost effective ways.

While many experts already recommend certain initiatives, such as: upgrading hardware, following IT Service Management best practices, and even outsourcing IT to external parties, lots of organizations still do not possess an infrastructure that is more agile, service oriented, and easily managed.

There is a considerable body of literature discussing the importance of IT infrastructure flexibility. A mature IT infrastructure is considered desirable by many organizations in order to achieve the intended flexibility. Some authors have even attempted to define metrics in order to assess their accomplishment. However, the systematic processes they can follow to achieve this mature infrastructure are hardly studied. In response, this thesis introduces the ITI-MM, a maturity model designed to assess an organizations' IT infrastructure. Through its maturity levels, the ITI-MM provides an improvement roadmap to support organizations step-by-step in achieving a mature or agile IT infrastructure. By assessing their current situation against the ITI-MM, IT organizations can identify the gap they currently face and work on producing better improvement plans for projects that are really essential to them. Using an open discussion approach between IT and business stakeholders, ITI-MM guides its users to improve their infrastructure while ensuring its alignment with the business requirements.

This thesis presents the research stages followed in developing the ITI-MM. Based on the results of a literature study of IT infrastructure and maturity model concepts, the ITI-MM's components were designed and validated. Furthermore, the model was applied during a pilot assessment in DT, to determine its applicability in a real-life context.

### Main Conclusions of ITI-MM

- ITI-MM covers the scope of IT infrastructure as defined in theory: technology and human aspects.
- ITI-MM covers the different terms used by business and IT stakeholders.
- ITI-MM is free from any attachment to specific infrastructure products and vendors.
- The main concept of ITI-MM is already acknowledged and easily understood by several experts.
- ITI-MM is ready to be used in a real-life context because the pilot assessment and the perceptual evaluation conducted show the effectiveness of its approach in gaining a deeper understanding of the participants' current situation.
- ITI-MM contributes positively within the fields of IT Governance and Enterprise Architecture. It helps IT organizations prioritize their investments regarding the use and growth of IT infrastructure.

## Further Research

- Application in more assessments: The validity of ITI-MM would increase once applied in many more assessment sessions. Assessing additional, different industry sectors beyond DT, might increase its acceptance in the bigger communities.
- Scoring method: Given that the current ITI-MM employs an open discussion method, the possibility to include others might increase the model's ease of use.
- Sets of KPIs: Quantitative KPIs included in each maturity level description might help ITI-MM's users evaluate their infrastructure better.
- Assessments monitoring tools: Since an assessment session can only test a limited number of infrastructure components, tools that can monitor whole appraisal sessions and monitor their improvement progress would be helpful.
- Relations with other frameworks or standards: In the field of IT Governance, there are many frameworks and standards already defined. To increase its acceptance, it is necessary to investigate how ITI-MM could complement other frameworks or standards.
- Relations with Business-IT Alignment field: As the objective of ITI-MM is to improve an organization's IT infrastructure while preserving its alignment with the business requirements, the model's positioning in the field of Business-IT Alignment could also be interesting to study.

# Acknowledgements

This thesis marks two important things: (1) it completes my study in Master Business Information Technology program at the University of Twente (UT); (2) by that, it ends my journey as an international student in The Netherlands. For this reason, I convey my deep gratitude to the Ministry of Communication and Information Technology, Republic of Indonesia, for the scholarship given.

When I read its description for the first time back in November 2009, I immediately knew that the development of ITI-MM was the kind of project which would really suit me. And indeed, I made the right decision to do it. The project and the whole process which followed, help me grow both personally and professionally. It greatly expanded my view of the IT and business world. Of course, without the support and challenges I got from many people around me, I would not have been able to finish this thesis project as well as it is presented here.

Firstly, I would like to thank Pascal van Eck, my first supervisor from UT. Pascal has always given me straightforward feedback and helped me figure out some action I needed to take in order to come-up with the good solution. As the teacher and supervisor I worked with the longest during my study in the university, Pascal really knows me well. Secondly, I would also like to give thanks to Maria-Eugenia Iacob, my second supervisor from UT. Because I always wanted to improve my scientific skills on problem solving, Maria always honestly and directly challenged me in ways I have never imagined before. Maria's input ensured a balance in the content of this thesis towards both scientific and practical fields.

Thirdly, and foremost, I would like to thank Arnold Buddenberg, my supervisor from Deutsche Telekom AG. On many occasions, Arnold challenged me with his experience and knowledge about IT Infrastructure and IT Governance. The link between us goes beyond just a professional relationship, since he also acts as a good mentor for me. Together with his wife, Beth, we always had nice discussions about life in general and other kinds of topics which are also very interesting for me: information management, Internet, marketing, etc. Beth made a significant contribution as well to this thesis project.

Further, I would like to thank my parents, brother, and sister. Although we are separated in different continents, I always feel close to them.

Last but not least, I would like to give my sincere thanks to all my friends who were always ready to help and support me throughout the project: Camlon H. Asuncion, Iryna Gordeyeva, Oleksandr Varlamov, Arzu Yucekaya Bat, Tettri Nuraini, Aditya Kusumajati, and many other names which are impossible to mention here one by one.

Finally, I hope you will enjoy reading and that you gain much profit from the content of this thesis. One thing I would like to emphasize and share with you here is: "*IT is very complex and broad in nature, not just about technology. However, at the end it will be all about focusing efforts toward people, process, and organization.*"

For further questions or feedback regarding the content of this thesis, always feel free to contact me.

Ferry Haris
August 2010

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# List of Abbreviations

| | |
|---|---|
| AAA | Authentication, Authorization, and Accounting |
| ADC | Application Delivery Controllers |
| CMDB | Configuration Management Database |
| CMM | Capability Maturity Model |
| CMMI | Capability Maturity Model Integration |
| COBIT | Control Objectives for Information and related Technology |
| COO | Chief Operating Officer |
| CPU | Central Processing Unit |
| CRM | Customer Relationship Management |
| DRS | Distributed Resource Scheduler |
| DT | Deutsche Telekom AG |
| FGD | Focus Group Discussion |
| GIMM | Gartner Infrastructure Maturity Model |
| I/O | Input/Output |
| ICT | Information and Communication Technology |
| IPR | Intellectual Property Rights |
| IT | Information Technology |
| ISO | International Organization for Standardization |
| ITIL | Information Technology Infrastructure Library |
| ITI-MM | IT Infrastructure Maturity Model |
| KM | Knowledge Management |
| KMS | Knowledge Management System |
| KPI | Key Performance Indicator |
| MAPE-K | Monitor, Analyze, Plan, Execute, Knowledge |
| MCDM | Multiple Criteria Decision-Making |
| MEM | Method Evaluation Model |
| MM | Maturity Model |
| NHS | National Health Service |
| NIMM | NHS Infrastructure Maturity Model |
| OS | Operating System |
| OSG | Open Source Group |
| QMMG | Crosby Quality Management Maturity Grid |
| ROI | Return On Investment |
| RTI | Real-Time IT Infrastructure |
| SAN | Storage Area Network |
| TOGAF | The Open Group Architecture Framework |
| TRM | Technical Reference Model |
| TSE | Tokyo Stock Exchange |
| VDC | Virtual Data Center |
| VPN | Virtual Private Network |
| WAN | Wide Area Network |

# Part I

# Background

# 1 Introduction

This chapter provides an overview of the research published in this thesis. It presents the research motivation, background problem, research scope and its contribution to scientific and practical fields. This chapter ends with the thesis outline.

## 1.1 Research Motivation

The research presented in this thesis is motivated by a real case problem in one organization. Before describing the problem further, a look first at the organization's profile is needed in order to understand the appropriate context within which the research takes place.

### 1.1.1 Organization Background

#### 1.1.1.1 Deutsche Telekom AG

Deutsche Telekom AG (DT) is a global group of telecommunication and information technology service companies [2]. As an International Group, DT is represented in 50 countries. DT headquarters are located in Bonn, Germany. DT employs approximately 258,000 employees worldwide (as of December 2009). More than half of its net revenue is generated outside Germany.

DT aims to become the most highly regarded service company in the global industry. The company focuses on major technical and social trends and plays a key role in shaping them: the increasing digitization of many spheres of life, the personalization of products and services, growing mobilization and internationalization.

**Table 1: Facts and Figures of Deutsche Telekom AG [2]**

| Description | Facts |
|---|---|
| **Revenue:** | 64.6 billion Euros (2009 financial year) |
| **Employees:** | 258,000 employees worldwide (December 2009) |
| **Stock Markets:** | Germany (all stock exchanges) and Tokyo (TSE) |
| **Internationalization:** | DT is represented in 50 countries worldwide |

In 2009, DT was named "sector leader" in a ranking carried out by the renowned SAM agency (Sustainable Asset Management, Zurich) for its sustainability performance in the mobile communications sector. The Group meets its entire power requirements in Germany using renewable energy sources. DT's sustainability campaign "Big changes start small" was introduced in September 2009 and aims to encourage customers and the public to play their part by making small changes.

Under the "**T**" umbrella of the Group's company brand, DT delivers their products and services through three business units: **T-Home** (signifies "everything for the home"), **T-Mobile** (signifies "everything for people on the move"), and **T-Systems** (represents the Group's worldwide offerings for large companies).

However, since April 2010, DT provides customers in the domestic German market with product and service offerings tailored to their requirements from a single source. To achieve this, the company consolidated its previously independent business units for fixed-network (T-Home) and mobile (T-Mobile) communications.

**T-Systems**
T-Systems operates information and communication technology (ICT) systems for multinational corporations and public sector institutions. Trying to help them to concentrate on their core competencies, T-Systems acts as an enabler to resolve ICT challenges faced by customers and provides tailored solutions based on each unique requirement. T−Systems generated revenue of around 8.8 billion Euros in the 2009 financial year.

#### 1.1.1.2 DT Enterprise Architecture Group

At the start of this research, DT's Corporate IT Functions run under the leadership of the Group's Chief Operating Officer (COO). Its IT organization is divided into seven large departments: IT Governance, IT Service Management, IT Solutions/Enabler, Data and IT Security, IT Finance, Human Resources and GHS, IT Europe, and IT South and Eastern Europe (see Appendix A for the detail structure).

The research presented here is conducted within the DT IT Governance – Enterprise Architecture Group. As a governance organization, this group is responsible for developing tools and methods which can be applied in future architecture projects to support services or products development. This group also supports and/or participates in projects, giving advice or ensuring that solutions developed fit within the context of corporate architecture guidelines.

The Enterprise Architects are responsible for defining key architecture standards and coach the program team on their application to ensure that the program delivers the agreed enterprise benefits. Once the key standards and blueprints have been agreed, the Architects provide architecture consultation and guide the program to ensure the compliancy and transparency of implemented activities.

Some of the working results derived by this group influence other IT functions in corporate and business units' levels. They are for example: guidelines, principles, customer or product data models, application strategy, and blueprints wherein a high level view of future development is described. Blueprints they have produced are reusable documents that guide how IT should answer the demand, so that the agreed business benefits are achieved.

### 1.1.2 Background Problem

#### 1.1.2.1 Initial Problem Description

***-Confidential-***

#### 1.1.2.2 Problem Investigation

In order to gain a deeper understanding of the root cause of the problem, several interviews with DT's employees were held. At the time the interviews were conducted however, we did not yet have official access to some company resources. A list of questions was sent to the interviewees via e-mail. The questions were sent 9 February 2010. Three respondents participated in the interviews.

The complete list of questions and their respective answers can be found in Appendix B1 and B2.

The first respondent was asked about the position and role of the Enterprise Architecture Group within DT. He was also asked which of their products might influence other business units. The questions were meant to ascertain more about their position, especially related to the policy power, relative to other IT functions within DT. Furthermore, the interviewee was also asked about his view on the cause of the problem and prospective solutions, including identifying interested stakeholders who may potentially be impacted and interested in the solution produced in this research. Some of the interview result has already been presented earlier in Section 1.1.1.2 - DT Enterprise Architecture Group.

Responses from other respondents were received on 19 February 2010 and 1 March 2010. With them, an attempt was made to delve deeper into the root cause of the problem. They were asked about how they particularly see the problem, its root cause, and the possible solutions. They were also asked how they see their counterpart partner within their customer-provider relationship. The goal was to get a balanced view, not just only from one side, which might give a false signal of the problem's root cause. The analysis of their respective answers is described in Section 1.1.2.3.

#### 1.1.2.3 Problem Analysis

***-Confidential-***

## 1.2 Scope of the research

### 1.2.1 Research Objective

The objective of this research is **to develop a maturity model for IT infrastructure**. It is called "IT Infrastructure Maturity Model" (ITI-MM). Although the motivation is only based on a single company case, the same problem may also be present in other organizations, especially multi-business-unit companies; or companies in the telecommunication industry; or even in any kind of company which outsources their IT infrastructure to others. This research argues that a maturity model can be used to assess an organization's IT infrastructure, can enable an organization to define improvement plans and help them implement such plans better.

### 1.2.2 Research Questions

To guide the study, the following research questions have been defined:

- **RQ1: What is an IT infrastructure? What are the components that build it?**
  These questions should result in a concrete definition of IT infrastructure and its components. A theoretical definition of IT infrastructure is required in order to put the ITI-MM in the right context or scope.

- **RQ2: What IT infrastructure maturity models are available? What are the criteria to evaluate them?**
  The goal in this research is not "re-invent the wheel". The intent is to identify and possibly re-use available components for the ITI-MM as much as possible. In

order to get the best out of the available models, set(s) of criteria to compare and analyze them must be defined.

- **RQ3: What is the IT Infrastructure Maturity Model (ITI-MM)? What are the elements that compose the ITI-MM?**
  This question will be answered by describing the ITI-MM and its elements.

- **RQ4: How to prove the validity of ITI-MM?**
  This question will be answered by describing the validation process taken to test ITI-MM validity in terms of its usefulness in practice.

### 1.2.3 Research Approach

In trying to solve a practical problem faced by an organization, this research uses a problem solving approach proposed by Roel Wieringa, called Engineering Cycle [1]. In his publication, Wieringa argues that there are two types of problems commonly faced by researchers: *knowledge* and *practical* problems. A researcher faces a knowledge problem if there is a difference between his current and desired knowledge state. On the other hand, a researcher faces a practical problem if there is a stakeholder that sees a difference between the current and desired state of the world, which he wants to reduce.

Based on Wieringa's classification of practical problems [1], we conclude that the problem to be solved here is a selection problem. The problem will be solved not by inventing something new but by selecting the best out of a set of known ways of doing something. In the solution design phase, the available components for the ITI-MM are re-used as much as possible.

In Engineering Cycle [1], a research follows these iterative steps: Problem Investigation, Solution Design, Solution Validation and Solution Implementation. However, since we have limited time in doing this research, we only conduct the first three steps and leave the implementation phase back to the organization, whether they have the intention to use the solution. Figure 1 depicts our detail approach in this research.

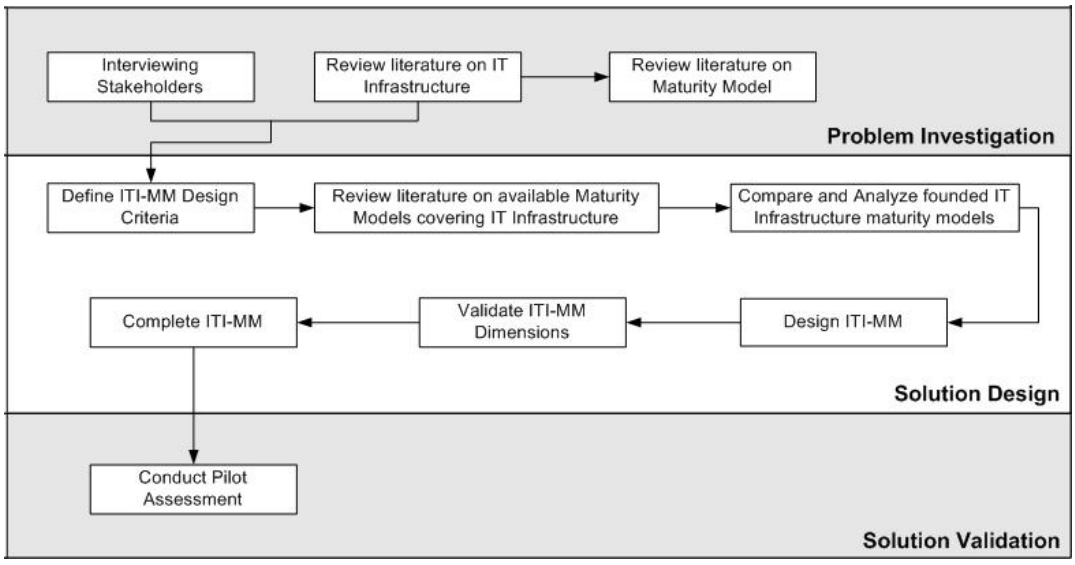


**Figure 1: Research Approach**

In the **Problem Analysis or Investigation** phase, semi-structured interviews[1] with several stakeholders were conducted and a literature review on IT infrastructure and maturity model concepts was undertaken. These interviews were conducted to provide a deeper understanding on the root cause of the problem (see Section 1.1.2.2). Together with the literature review the design criteria were identified. A semi-systematic literature review[2] was undertaken to identify, analyze and synthesize the relevant works for the research.

During the **Solution Design** phase, the available maturity models were compared in order to produce the best solution to solve the problem. First, a set of criteria was defined, to compare the available maturity models based on the theoretical foundation and problem analysis already done. Afterwards, several IT infrastructure maturity models were surveyed, again through a semi-systematic literature review. Using the resulting criteria, a comparison is done and a decision reached on which model(s) would be the best one(s) for our solution. The resulting comparison is used as the basis for designing the ITI-MM.

After the initial ITI-MM model is developed, several experts responsible for IT infrastructure validated its dimensions. This is to see whether the dimensions used in the ITI-MM fit the purpose of the MM itself [36]. A Focus Group Discussion (FGD) with several pre-determined questions is used. This method is used because of its capability to generate a rich understanding of a topic by involving a group of people in an active discussion [36]. The result of the FGD is used to update the ITI-MM's initial design.

In order to validate the final ITI-MM, a pilot assessment is undertaken to measure its usability in the real-life context. From its end results, several recommendations for the organization are derived. People's perceptions about ITI-MM's usefulness and their willingness to implement the model are also evaluated. During this perception evaluation the Method Evaluation Model (MEM) is used. It evaluates three constructs: Perceived Ease of Use, Perceived Usefulness, and Intention to Use [42].

Table 2 shows the research methods used in answering each research question.

**Table 2: Research methods**

| Research question | Research method |
|---|---|
| What is an IT infrastructure? What are the components that build it? | Semi-systematic literature review |
| What IT infrastructure maturity models are available? What are the criteria to evaluate them? | Semi-systematic literature review |
| What is the IT Infrastructure Maturity Model (ITI-MM)? What are the elements that compose the ITI-MM? | MM design, focus group discussion to validate its dimensions |
| How to prove the validity of ITI-MM? | Pilot assessment |

[1] Semi-structured interview was chosen since open-ended questions are prepared before. Afterwards the answers are analyzed qualitatively to explore the root cause of the problem (exploring the 'why' question of this research) [58].

[2] It is a semi-systematic literature review because we only followed partially the systematic one published by Brereton, et al. [41].

## 1.3 Impact and Relevance

Many researchers have taken note of the potential value of an organization's IT infrastructure and the importance of its flexibility in supporting continously changing business environment in the current and future knowledge economy world [6, 29, 51-54]. Weill and Vitale [3] even suggest that IT infrastructure flexibility must be able to handle increased customer demand without increased costs.

This research delivers a maturity model that can help organizations develop better improvement plans in order to achieve the highest level of flexibility, and applies it to DT's IT infrastructure. The highest level of maturity describes an IT infrastructure that is able to adapt quickly to change and accelerates business innovation.

### 1.3.1 Practical Impact

In one of their publications, Gartner, Inc. found that more than seventy percent of IT budgets, in many organizations, are spent on infrastructure [55]. Forrester Research, Inc. even found that "…. *the average IT organization spends 70% to 80% of its budget on maintaining the status quo versus only 20% to 30% on new initiatives. Best practice companies have taken this ratio to 60/40, and some are actually driving toward 50/50. Measuring and reporting this ratio can be a key indicator of both the efficiency of IT as well as IT value creation.*" [57]. With so much resource allocated to IT infrastructure, it is surprising that the potential impact of it is often not fully appreciated or even planned. If the context is set into the total IT budget being somewhere in the region of 3%-5% of revenue (depending on sector), it soon become clear that having a mature infrastructure can reduce costs, business risks, and act as the enabler for improving the way any organization does business [56]. However, since the improvement in IT infrastructure requires an active effort to evolve over time, organizations need to develop a long-term strategic plan for the infrastructure [55].

From the practical point of view, this research delivers a guideline or roadmap for organizations to develop this long-term strategic plan for infrastructure. By using the ITI-MM, they can assess their current infrastructure, determine what they should focus on next, and build a strategic plan for its evolution. Since it is also being tested in the DT organization, ITI-MM proves itself ready for use in real organizational work settings.

### 1.3.2 Theoretical Impact

From a theoretical perspective, this research contributes to the gap on 'how organizations can improve their IT flexibility'. Although many studies have been done about IT flexibility, most focus on its importance, develop the constructs and measurements [6], and discuss its connection with business performance, strategic alignment and investments [51-54]. Based on the literature study done during this research project, there is little literature found describing the managerial or administrative improvement effort of IT infrastructure. Most of the discussion in Computer Science or Information System fields is about technical improvement and this implementation might not be so interesting for business and IT managerial people. ITI-MM bridges this gap by providing a framework that can invite business and IT people together.

## 1.4 Outline of the thesis

The remainder of this thesis is organized in four parts. Part I presents the introductory chapters. Chapter 2 provides the theoretical concepts of IT infrastructure and Maturity Model, which are essential for this research. Chapter 3 describes the available maturity models on IT infrastructure together with the comparison criteria used in the selection process.

Part II presents the ITI-MM. It starts with Chapter 4 describing ITI-MM design process. Chapter 5 describes the initial structure of the *domains* and *capabilities* together with the validation process taken using a focus group discussion with experts from DT. Chapter 6 presents the ITI-MM model, its level descriptions and guidelines on how organizations may employ ITI-MM to assessing their IT infrastructure.

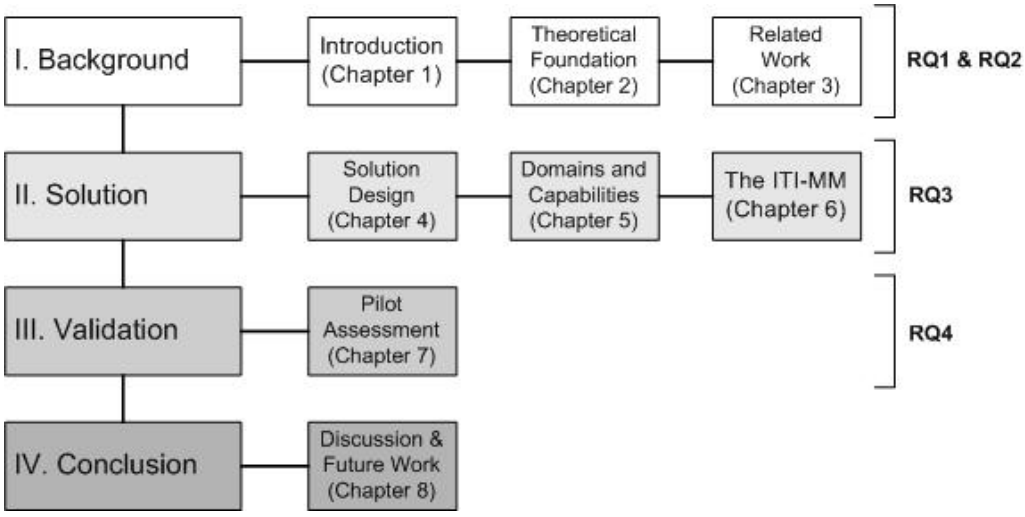


**Figure 2: Outline of the thesis**

Part III of this thesis presents the pilot assessment (Chapter 7), which has been conducted to validate the ITI-MM as a whole. People's perception on its usefulness in the real-work settings is also analyzed. Finally, Part IV (Chapter 8) discusses the main contribution of this thesis, its limitation, and recommendations for future works.

# 2 Theoretical Foundations

In this chapter several important definitions and ideas adopted in this thesis are presented. The notions of an IT Infrastructure and a Maturity Model are the key concepts discussed here. Even though IT infrastructure is often only associated with technical aspects, both the technology and human aspects of infrastructure are addressed in this thesis. To clarify this and other concepts, the discussion on IT infrastructure is presented in Section 2.1, followed by the discussion on Maturity Models in Section 2.2.
A semi-systematic literature review has been used to compile these concepts. The data has been gathered using several indexing engines, such as Web of Science, ACM Digital Library, and Google Scholar.

## 2.1 IT Infrastructure

### 2.1.1 Definition of IT Infrastructure

Broadbent, et al. [4] define IT infrastucture as "the base foundation of budgeted-for IT capability, shared throughout the firm in the form of reliable services, and centrally coordinated". They also state that IT capability itself is conceived of two different aspects: technical and human.

Based on that definition and combining it with the IT skills described by Henderson and Venkatraman [5], it can be concluded that IT infrastructure is a multifaceted concept that seems to include two related but distinct components: (1) a technical IT infrastructure, and (2) a human IT infrastructure [6]. The technical IT infrastructure consists of applications, data, and technology configurations. While the human IT infrastructure deals with the knowledge and capabilities required to effectively manage IT resources in an organization.

As summarized in Byrd and Turner's publication [6], some researchers consider technical IT infrastructure as the enabling foundation of shared IT capabilities upon which entire businesses depend. Sharing that same perception, Nancy B. Duncan (cited in [6] as well) describes technical IT infrastructure as a set of shared, tangible IT resources forming a foundation for business applications. She also states that platform technology (hardware and operating systems), network and telecommunication technologies, data, and core software applications compose the tangible IT resources of the IT infrastructure.

On the other hand, Henderson and Venkatraman [5] state that human IT infrastructure includes the experience, competencies, commitments, values and norms of the IT personnel delivering IT products and services. Human IT infrastructure is an important factor as well in the practice of IT operations, since fault tolerance of the whole IT infrastructure depends on IT personnel's technical skills in managing those technologies being used.

Based on those facts, although IT researchers and practitioners often allude to IT infrastructure only as technical IT infrastructure, in this research the definition synthesized by Byrd and Turner [6], which covers the importance of both technical and human aspects of IT infrastructure, is used. They define it as follows:

> "*IT infrastructure is the shared IT resources consisting of* ***a technical physical*** *base of hardware, software, communications technologies, data, and core applications and* ***a human component*** *of skills, expertise, competencies, commitments, values, norms, and knowledge*

*that combine to create IT services that are typically unique to an organization. These IT services provide a* ***foundation for communications*** *interchange across the entire organization and for the development and implementation of present and future business applications."*

### 2.1.2 IT Infrastructure Components

In the previous section, IT infrastructure is defined as consisting of both technical and human aspects. Weill and Vitale [3] state that IT infrastructure is usually composed of four components: IT Components, Human IT Infrastucture, Shared IT Services, and Shared and Standard Applications. Figure 3 illustrates the IT infrastructure building blocks according to their definition.

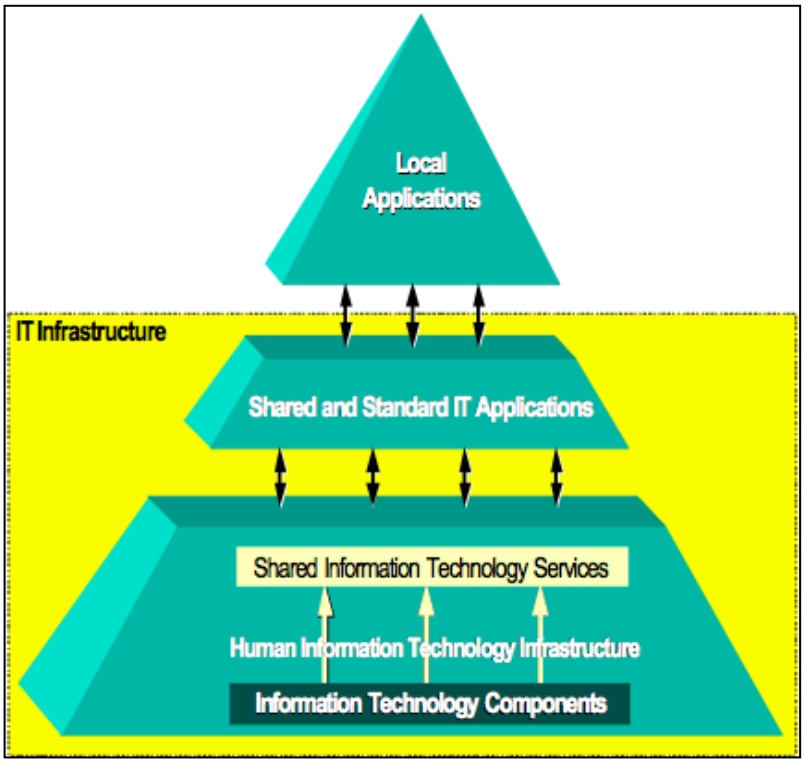


**Figure 3: IT infrastructure building blocks [3]**

- **IT Components**
  As the base of IT infrastructure, IT Components are the technology commodities that are readily available in the market such as: computers, routers, printers, data base software packages, operating systems, etc.

- **Human IT Infrastructure**
  Commonly IT components need to be translated in terms of business and the people needed, including those who run and manage the components. This Human IT Infrastructure layer consists of knowledge, skills, standards, and experience.

- **Shared IT Services**
  This layer views the infrastructure as a set of services that users can understand, draw upon, and share in order to support conducting businesses. For example: to manage data, we can use data management services; to handle security, we can draw upon the security and risk services; etc.

- **Shared and Standard Applications**
  The top piece of IT infrastructure consists of stable applications such as human resource management, accounting, budgeting systems, etc. In the past few years there has been a significant trend to consolidate common business processes and the associated IT applications.

If we only focus on the technical components of IT infrastructure, The Open Group Architecture Framework (TOGAF), in the Technical Reference Model (TRM) section, defines the same components as those defined by Weill and Vitale [8]. In TOGAF-TRM, IT Components are covered in Communication Infrastructure and Application Platform; Shared IT Services are covered in Application Platform; and Shared and Standard Applications are covered in Infrastructure Applications. Figure 4 depicts the model of TOGAF-TRM.

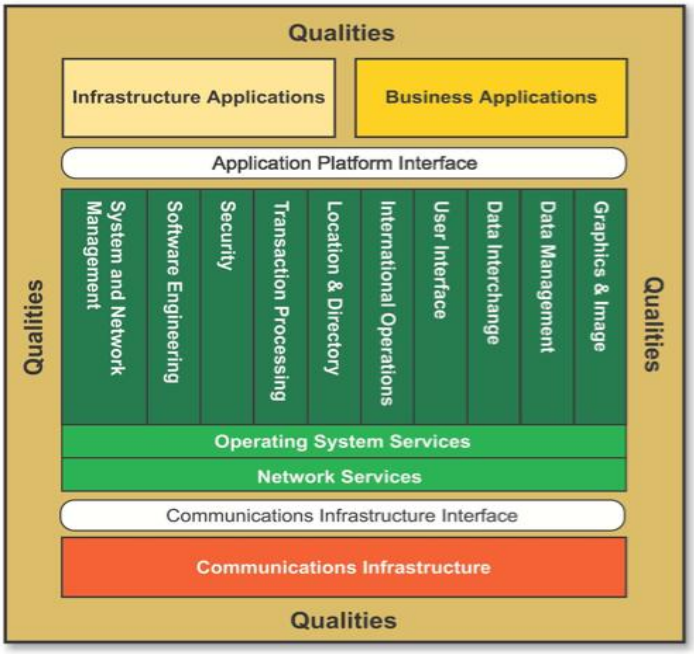


**Figure 4: Detailed TOGAF Technical Reference Model [8]**

In practice, TOGAF is considered the *ad-hoc* Enterprise Architecture Framework standard. Since TOGAF-TRM defines the same technical components as defined by Weill and Vitale, which recognize the definition of IT infrastructure as covering both technical and human aspects, their [3] IT infrastructure building blocks depicted in Figure 3 is used as the covering scope of this research.

### 2.1.3 Future IT Infrastructure

When discussing IT infrastructure, one cannot be ignorant of the business context in which it exists, because, what is essential about IT infrastructure is how it can support businesses in achieving their goals.

In the current dynamic economic world, more and more organizations see IT infrastructure as an integrated asset for business [3]. It is no longer seen as a layer that only costs money but it provides a strategic and unique capability that brings added value. To support continously changing business environment, organizations need a flexible IT infrastructure that can easily adapt to current and future changes [29, 51-54]. When it is seen as an integrated asset, business case for the new business requirements is sooner meet, due to lower costs of the IT infrastructure layer compared to the legacy solutions.

As quoted by Byrd and Turner [6], Davenport and Linder state that a flexible IT infrastructure should be viewed as an organizational core competency, suggesting that a "good" infrastructure is quantified by its flexibility and robustness to enable change. IT infrastructure flexibility must be able to handle increased customer demands without increased costs [3]. Other researchers, Allen and Boynton, even noted that efficiency and flexibility are the two most critical factors in selecting any IT application or system, with flexibility the more important of the two [6].

Meanwhile, Banerjee, et al. [29] identify a trend in big organizations to move into a more globally distributed environment. To support this trend, they suggest an Agile IT Infrastructure as the solution. Its direction is more towards a standardized IT platform, modular architecture, and the presence of an application infrastructure supporting communication and collaboration. In agreement with this idea, Camarinha-Matos, et al. [30] even predict that in the year 2015 more organizations will embrace the concept of Virtual Organizations. This concept concerns the way organizations do business and connect to each other in a distributed environment, using advanced information and communication technology, such as the Internet [37]. Camarinha-Matos, et al. [30] argue IT infrastructure that can support Virtual Organization will have the following characteristics:

- Technology-independent reference architecture for the horizontal infrastructure
- Provide support for federated information and resources management
- Flexible control mechanisms supporting the implementation of a large variety of behaviors
- Plug-and-play concept extended to inter-organizational services
- Full e-transaction security and privacy is guaranteed
- Having user “programmable” infrastructure

In his work, Umar [31] describes a broader concept for the future business organizations. He uses the term Next Generation Enterprises (NGEs), which represents organizations who utilize innovative new business models and fully exploit and integrate the next generation technologies. This concept includes the notion of virtual organizations, virtual enterprises, networked enterprises, real-time corporations, digital enterprises, mobile corps, etc. Umar also describes several dimensions that every organization needs to focus on while developing their IT infrastructure supporting this concept: automation, real-time operations, mobility, agility, self-service, and widely distributed operations.

## 2.2 Maturity Model

The Oxford English Dictionary defines the word ‘maturity’ as the state, fact, or period of being mature [20]. Fraser et al. [21] define the literal meaning as ‘ripeness’, which conveys the notion of development from some initial state to some more advanced state.

In his dissertation, Santana Tapia [36] says that maturity models (MMs) describe the evolution of a specific entity over time, where the entity can be an organizational area or function. Furthermore, he argues that MMs are descriptive and normative, not prescriptive. MMs are descriptive in the sense that they describe the essential characteristics or processes in which each organization will be distinguished at each specific maturity level. They are also normative because they provide a minimum set of attributes that need to be adopted for improvement. However, MMs are not prescriptive because they do not describe the ways on how organizations should do the improvements. MMs focus on ’what’ not ’how’. Essentially, MMs help organizations easily establish goals for process improvement and identify opportunities for optimizing business benefits.

Maturity approaches have their roots in the field of quality management, where one of the earliest works was Crosby Quality Management Maturity Grid (QMMG) [21]. That model describes the typical behavior exhibited by a firm in five levels of maturity: (1) Uncertainty; (2) Awakening; (3) Enlightenment; (4) Wisdom and (5) Certainty. In the IT field, perhaps the first best-known derivative model from this line of work is the Capability Maturity Model (CMM) for the software development process. Even though the model has been already superseded by the Capability Maturity Model Integration (CMMI) [36], it provides a description of the basic principles and concepts on which today's maturity models are based [22].

MMs share in common that they define a number of dimensions or process areas at several discrete stages or levels of maturity. The various components that may or may not be present in each maturity model are [22]:

- A number of levels (typically three to six)
- A descriptor for each level
- A generic description or summary of the characteristics of each level as a whole
- A number of dimensions or process areas
- A number of elements or activities for each process area
- A description of each activity as it might be performed at each maturity level

According to Forrester, Inc. [28], to be a good assessment framework, a maturity model should also include:

- A questionnaire with clear questions
- A list of the dimensions the assessment addresses
- A simple scoring scale/methodology that improves transparency
- An explanation of how the framework communicates results
- A list of potential interviewees for outside-in assessments

## 2.3 Summary

In this chapter, a definition of an IT infrastructure was given. In its full definition, IT infrastructure is represented as the combination of both technical and human aspects. It is built by four connected components: IT Components, Shared IT Services, Shared and Standard Applications, and Human IT Infrastructure.

Furthermore, in order to gain a better understanding of what kind of IT infrastructure should be facilitated and endorsed in the ITI-MM, an overview of the characteristics every IT infrastructure needs to have in the future was described. Concepts such as Next Generation Enterprises (NGEs) or Virtual Organizations can only be reached if businesses can embrace an Agile IT Infrastructure.

Finally, the nature of a maturity model (MM) was presented. Several general characteristics of a good MM were also described to guide the ITI-MM design.

# 3 Related work

As already stated in Chapter 1, this research does not intend to "re-invent the wheel". This chapter discusses several assessment approaches (MMs) for IT infrastructure that are already available in the scientific and practical fields. Using a set of selection criteria, different MMs are analyzed in order to determine which model(s) is the best. The outcome of the comparison forms the ITI-MM design foundation. The MMs were identified via several different indexing engines, such as ACM Digital Library, Google Scholar, Google, and Web of Science.

Section 3.1 presents all the MMs found and Section 3.2 follows with the comparison and analysis.

## 3.1 IT Infrastructure Assessment Approaches

In this section, MMs already available to assess IT infrastructure are presented. They range from the MMs that assess only specific components to those that assess entire aspects of IT infrastructure. Table 3 summarizes the MM's names, owners or authors, and number of levels and domains that they have.

**Table 3: Highlights of IT infrastructure maturity models**

| Maturity Models | Model Owners | Levels and Domains |
|---|---|---|
| Autonomic Adoption Model | IBM (2006) [11] | 5 levels, 5 control scopes, and 3 dimensions |
| Autonomic Maturity Levels | Daniel Worden (2004) [14] | 5 levels |
| Gartner Infrastructure Maturity Model | Gartner, Inc. (2006) [15] | 7 levels and 6 domains |
| Green Maturity Model for Virtualization | Francis and Richardson (2009) [16] | 4 levels and 4 domains |
| VDC Maturity Model | F5 Networks, Inc. (2008) [17] | 5 levels |
| Forrester Infrastructure Virtualization Maturity | Forrester Research, Inc. (2009) [18] | 4 levels |
| Capacity Management Maturity Model | Solution Labs, Inc. (2009) [19] | 5 levels |
| NHS Infrastructure Maturity Model | Department of Health Informatics Directorate, United Kingdom (2009) [32] | 5 levels and 6 domains |

### 3.1.1 Autonomic Adoption Model

IBM introduced the Autonomic Computing (AC) concept in 2001 and developed an adoption model as well. They argue that incorporating self-managing capabilities into IT environment is an evolutionary process. No organization can incorporate AC over a short period [11].

This model is usually used together with the reference model for autonomic control loop suggested by IBM, called MAPE-K (Monitor, Analyze, Plan, Execute, and Knowledge) [12].

Developed as a three-dimensional model, it is intended to calibrate the degree of autonomic capability that current organization has and to develop action plans in order to increase the autonomic potential. Figure 5 depicts the model's dimensions.

The 'functionality' dimension, as drawn along the x-axis, characterizes the extent of automation in information technology and business processes. The five levels presented are defined as follows:

- At the *manual* level, IT personnel perform all IT management functions. There is no automated system being used to help the routines.
- At the *instrument and monitor* level, there are already several systems management technologies used to collect details from every managed-endpoint, helping to reduce the time it takes for IT personnel to collect and synthesize information as the IT environment becomes more complex.
- At the *analysis* level, new technologies are introduced to provide correlation among several managed-endpoints. The management functions begin to recognize patterns, predict the optimal configuration and offer advice about what course of action IT personnel should take. As these technologies improve and IT personnel become more comfortable with the advice and prediction given by them, the technologies can progress to the next level.
- At the *closed loop* level, the IT environment can automatically take action based on the available knowledge about what is happening in the environment.
- At the *closed loop with business processes* level, business policies and objectives govern the operations of IT infrastructure. Users interact with the autonomic tools to monitor business processes, alter the objectives or both.

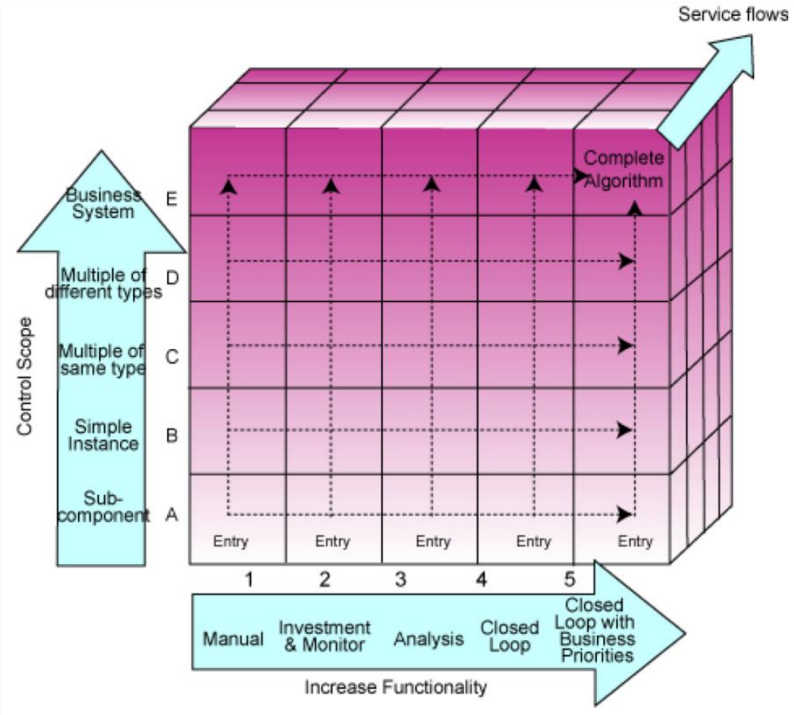


**Figure 5: Autonomic Adoption Model [11]**

The 'control scope' dimension, as drawn along the y-axis, characterizes what is being managed. This dimension also consists of five levels of resource management:

- At the *subcomponent* level, only portions of resources are managed, such as an operating system on a server or certain applications within an application server.
- At the *single instance* level, an entire standalone resource is managed, such as a server or a complete application server environment.

- At the *multiple instances of the same type* level, homogeneous resources are managed, typically as a collection, such as a server pool or cluster of application servers.
- At the *multiple instances of different types* level, heterogeneous resources are managed as a subsystem, such as a collection of servers, storage units and routers or a collection of application servers, databases and queues.
- At the *business system* level, a complete set of hardware and software resources that perform business processes is managed from the business process perspective, such as a CRM system or an IT Change Management system.

The 'service flow' dimension, as drawn along the z-axis, captures the combination of IT management process activities that are being performed. The flows incorporate Information Technology Infrastructure Library (ITIL) processes such as change management, incident management, problem management, and so on. Various business and IT processes might demonstrate different maturity levels (in terms of automation and control scope) at the same time, as various tasks and activities within particular service flows are automated.

This adoption model supports autonomic computing evolution by enabling incremental adoption of additional autonomic capabilities. It also supports organizations in producing an incremental action plan to take advantages of the autonomic capabilities.

This model allows both IT vendors and customers to approach the introduction of autonomic computing capabilities in a flexible way. For example, one could evaluate the value of introducing a high level of autonomic behavior to a small scope of IT resources within the context of a specific IT process. In another case, one could consider a less aggressive level of self-managing behavior with respect to a broader set of components or processes [13].

### 3.1.2 Autonomic Maturity Levels

Daniel Worden [14] has developed a roadmap for autonomic computing architecture. Like other researchers who developed the Autonomic Adoption Model, he believes that developing an autonomic computing architecture is an evolutionary process. There is no instantaneous approach to make systems incorporate autonomic characteristics, namely: self-optimizing, self-protecting, self-configuring and self-healing.

This model consists of five levels:

- **Basic**: The product and environment expertise resides in human minds, requiring consultation on even mundane procedures.
- **Managed**: Scripting and logging tools automate routine execution and reporting. Individual specialists review information gathered by the tools to make plans and decisions.
- **Predictive**: Early warning flags are raised as preset thresholds are tripped. The knowledge base recommends appropriate actions. The proposed resolution of events is leveraged by a centralized storage of common occurrences and experience.
- **Adaptive**: Building on the predictive capabilities, the adaptive system takes action itself based on the situation.
- **Autonomic**: Policy drives system activities such as allocation of resources within a prioritization framework.

At the basic and managed levels, applications are not aware of the state of their environment. Problem prevention doesn't exist yet. It needs to define and rollout sensors in order to allow the systems' components to predict when they are on the verge of violating a threshold. Arriving at the adaptive level, there is an automatic process that monitor resources, defines a systematic reaction to a set of indicators, and the automation of procedures that alleviate the underlying problem. For example, RAID disk drives can be configured to automatically mirror a failed drive to the spare one. The automatic characteristic of the last process defines the difference between predictive and adaptive.

Adaptive and autonomic levels require an IT infrastructure that is widely available and integrated, to allow the smart components to recognize what is happening in their environment and take action accordingly.

### 3.1.3 Gartner Infrastructure Maturity Model

Gartner, Inc. believes that the future of IT infrastructure is the Real-Time IT Infrastructure (RTI) [15]. According to their definition, RTI is:

- an IT infrastructure that is shared across customers, business units, and applications;
- dynamically driven by business policies and service-level requirements; and
- can automatically configure and optimize itself (or the so called "tera-architecture")

They also believe that RTI can be achieved through Virtualization and Automation concepts.

In order to help organizations self-evaluate and create a strategic plan to reduce infrastructure costs, increase agility, improve service-level management and staffing development, they built the Gartner Infrastructure Maturity Model (GIMM), which mainly acts as a blueprint for the strategic evolution of IT infrastructure. The model consists of seven stages with six domains that focus on consolidation, virtualization and Real-Time Infrastructure. Figure 6 illustrates the details of the model.

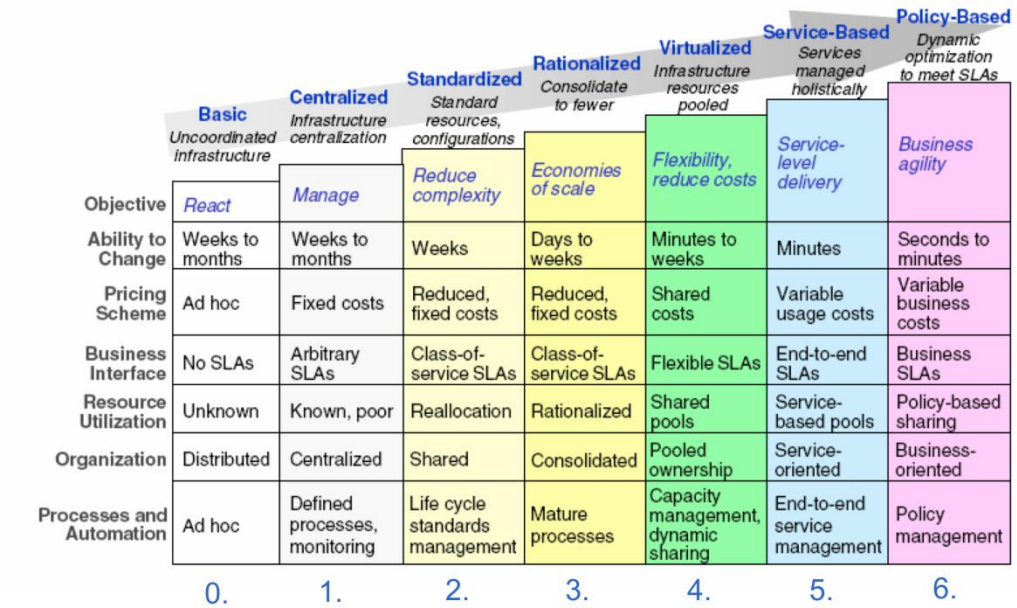


**Figure 6: Gartner Infrastructure Maturity Model [15]**

Gartner also defined three attributes of RTI from the business point of view: Agility (where infrastructure is dynamic); High Quality of Service (where management is based on policies); and Low Cost (where costs are charged based on usage). Characteristics of each attribute are described in Table 4.

**Table 4: Characteristics of Real-Time IT Infrastructure attributes**

| | |
|---|---|
| Agility | • Reusable components<br>• Standard processes<br>• Maintainability/serviceability<br>• Rapid extendibility/integrability<br>• Degree of automation |
| High Quality of Service | • Quality is built-in and automated<br>• Resilient architecture<br>• Scalable architecture<br>• Manageability |
| Low Cost | • Flexible sourcing/procurement<br>• Standard technologies and processes (economies of scale)<br>• Interchangeable components<br>• Process integration and automation<br>• Just-in-time capacity<br>• Resources pooled and virtualized |

Figure 7 illustrates the GIMM in terms of economic and other RTI attribute values.

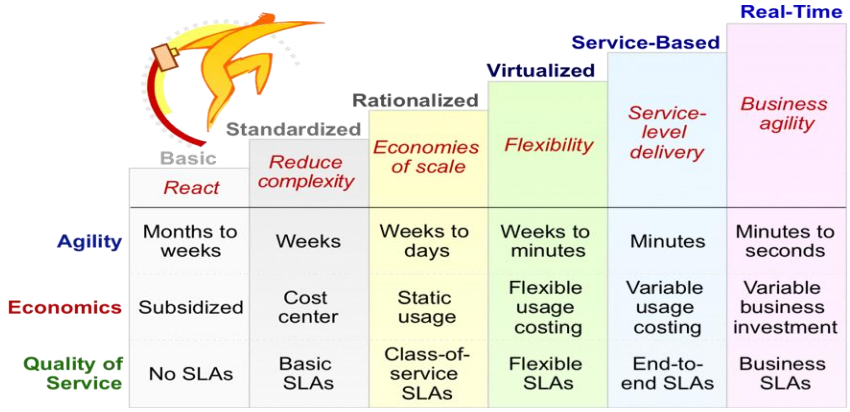


**Figure 7: Simplified version of Gartner Infrastructure Maturity Model [15]**

### 3.1.4 Green Maturity Model for Virtualization

The biggest environmental challenge faced today is global warming, caused by carbon emissions. Many organizations today speak about their desire to operate in a 'green' manner. Based on these phenomena, Kevin Francis and Peter Richardson have developed a maturity model, which focuses on energy consumption over the full IT infrastructure components' life cycle [16]. They believe it could be the prime motivator for more 'green' application design. They also argue that improving energy efficiency would reduce economic costs.

The model, as depicted in Table 5, was built upon the concept of virtualization. It consists of four maturity levels with four assessed domains.

**Table 5: Green Maturity Model for Virtualization [16]**

| Virtualization Maturity | Name | Applications | Infrastructure | Location | Ownership |
|---|---|---|---|---|---|
| Level 0 | Local | Dedicated | Fixed | Distributed | Internal |
| Level 1 | Logical | Shared | Fixed | Centralized | Internal |
| Level 2 | Data Center | Shared | Virtual | Centralized | Internal |
| Level 3 | Cloud | Software as a Service | Virtual | Virtual | Virtual |

- *Level 0* means no virtualization at all. All applications reside on individual PCs, with no sharing of data or server resources.
- *Level 1* introduces the idea of a shared application. For example the use of client-server technology or the N-tier structures.
- *Level 2* is concerned with the virtualization of the hardware and software infrastructure. This level is most often associated with the term Virtualization. The difference with Level 1 is that the hardware and software infrastructure, upon which applications run, is itself shared (virtualized). For example: in server infrastructure platforms, Microsoft Virtual Server or VMware are used; for the storage solution, Storage Area Network (SAN) related technologies are used; and for networking, the concept of a Virtual Private Network (VPN) describes the level appropriately. No dedicated resources are kept.
- *Level 3* is virtualizing not only resources but also the location and ownership of the infrastructure. Nowadays it is referred to as Cloud Computing. At this level, IT infrastructure is no longer tied to a physical location and can potentially be moved or reconfigured to any location.

Table 6 describes the technology aspects that relate to each virtualization maturity level.

**Table 6: Technology aspects for virtualization [16]**

| Virtualization Maturity | Name | Server | Storage | Network |
|---|---|---|---|---|
| Level 0 | Local | Standalone PC | Local disks | None |
| Level 1 | Logical | Client/Server, N-tier | File server, DB server | LAN, Shared service |
| Level 2 | Data Center | Server virtualization | SAN | WAN/VPN |
| Level 3 | Cloud | Cloud platform | Cloud storage | Internet |

### 3.1.5 VDC Maturity Model

In the field of Virtualization, F5 Networks, Inc. believe that no solution can consider the data center as a single entity. Instead, they are scattered into eight virtualization technologies: Network Virtualization, Application Server Virtualization, Operating System Virtualization, Management Virtualization, Storage Virtualization, Application Virtualization, Hardware Virtualization, and Service Virtualization [17]. Using a simple concept, they define the Virtual Data Center (VDC) as a data center that is made up of eight-virtualization technologies, with all the virtualized components working together to deliver applications.

The VDC Maturity Model was developed to create a baseline self-evaluation tool and progression meter in order to guide the data center's growth from one level to the next. As can be seen in Figure 8, the model consists of five levels of maturity.

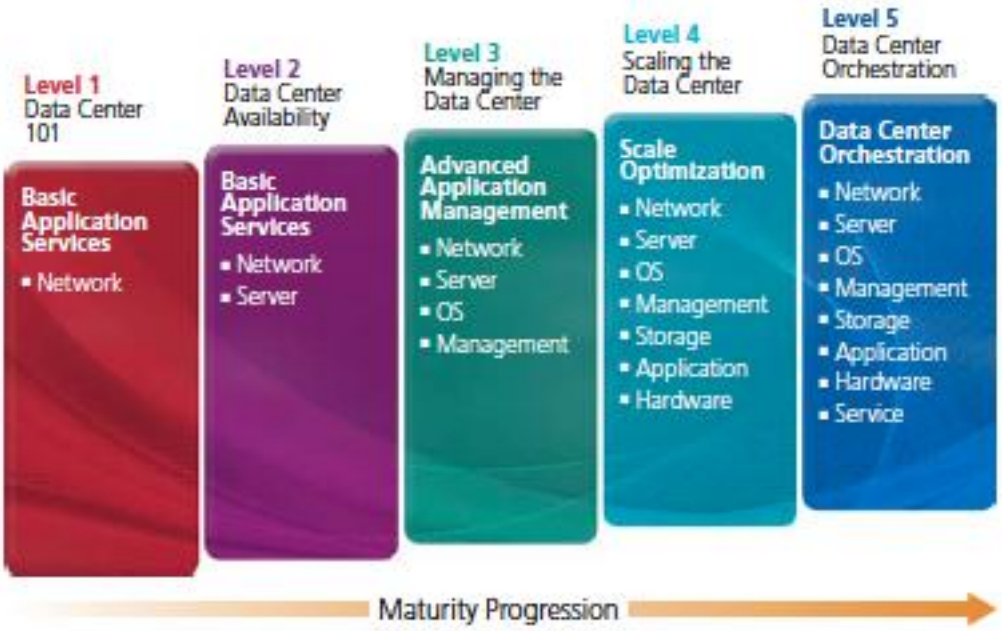


**Figure 8: VDC Maturity Model [17]**

- *Level 1* is where all data centers begin. All Level 1 data centers have basic physical requirements and there is typically very little, if any, virtualization here. Virtualization at this level is limited to the basic network. This is a 'hands-on' data center that requires constant attention and full-time servicing.
- *Level 2* introduces the idea of basic application availability, using more complicated Application Delivery Controllers (ADC) to provide web and application server virtualization. However, usually the ADC is used only to provide basic load balancing functionality. There is still no future planning or intelligent management of the data center components.
- *Level 3* looks at the data center from the applications point of view. More advanced application management, availability, optimization, and security is introduced. Basic user management is also introduced at this level, factoring in how and where users are accessing applications in the data center and applying Authentication, Authorization, and Accounting (AAA) of user transactions. Planning also becomes more part of data center management.
- *Level 4* addresses the need to scale the data center to support business needs. This is where larger concepts such as disaster recovery and application security begin to appear. More sophisticated technologies become part of the data center fabric, such as virtually segmented hardware for switching and routing, software switching, virtual OS image management, etc. Data center and automated system management tools become a necessity here.
- *Level 5* data centers are a complete VDC. The data center has exchanged the individual components for a fully orchestrated 'service' that uses each virtual category together. As workload demands increase, a fully configured management sub-system allocates the necessary resources to support business needs. Resource and workload management includes all forms of virtualization, from operating system to network to storage, culminating in service virtualization.

The goal of data center virtualization is to help organizations achieve their business goals, whether they are consolidation, cost containment, disaster recovery, or even 'going green'. However, before those goals can be achieved, the current state of any data center needs to be assessed using the VDC Maturity Model. Organizations don't need to follow or aim for level five; they may adjust the level based on the goals they want to achieve.

### 3.1.6 Forrester Infrastructure Virtualization Maturity

Through many interviews with their clients, Forrester Research, Inc. found that most organizations only attain a small portion of the potential benefits server virtualization promised. Furthermore, they have determined that the use of virtualization follows a pattern of experience that breaks down into four stages of maturity [18]. Organizations must pass through each stage of maturity to prepare for the next stage. This process helps the organization prepare for the next level of automation, implementation, and evolution. Figure 9 gives a general overview of the model.

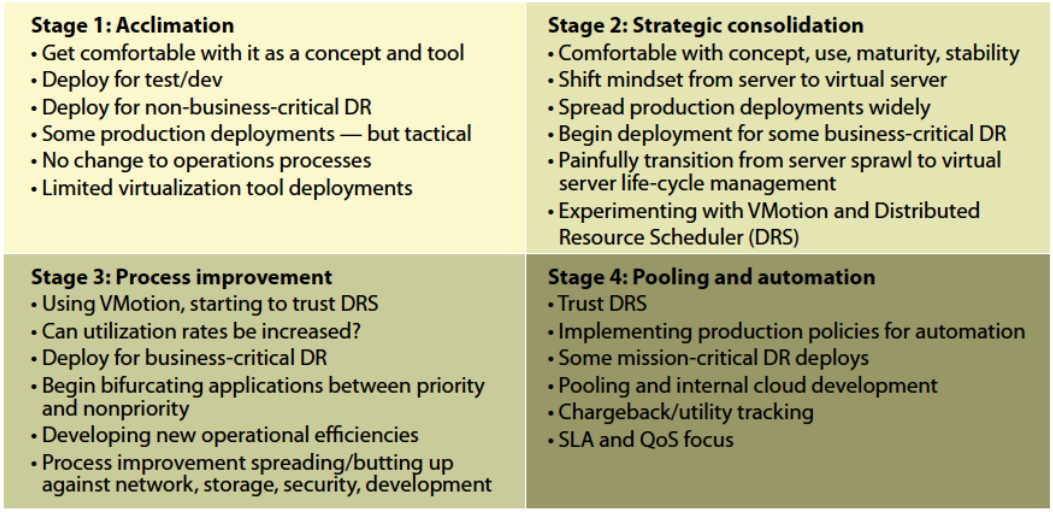


**Figure 9: Forrester Infrastructure Virtualization Maturity [18]**

- **Stage 1: Acclimation**. In this phase, most organizations start by learning about the technology and how it works, testing it against simple applications and determining where it can be safely applied. It is here that disaster recovery capabilities are first tested on less critical applications. Typically they virtualize applications that are considered easy targets, because they have a low business impact, few users and minimal performance requirements.
- **Stage 2: Strategic consolidation**. In this stage, organizations grow more comfortable with the concept, maturity, and stability of their chosen server virtualization technology and begin to shift to a more strategic implementation. It is easy to identify when an organization shifts its default deployment mindset from server to virtual server.
- **Stage 3: Process improvement**. Here, organizations start leveraging the unique benefits of the virtualization infrastructure features, such as live migration, backup services, resource scheduling, etc. The growing use of these technologies leads to improvements in key processes such as change management, incident management, and deployment.
- **Stage 4: Pooling and automation**. Here, using policy-based automation that drives up client self-service, organizations reduce the manual labor. As virtualization proliferates and automation moves to higher and higher level tasks,

the organization begins to manage its virtual environment as a pool, allowing it to treat this pool as an internal 'cloud computing' service.

To help organizations see where they currently stand, Forrester also prepared a list of questions and a scoring system to function as the assessment tool of their model. Organizations need to score their implementation and processes. In the end, the combination of both scores times two will define the total maturity score: Stage 1 = 1-25 points; Stage 2 = 26-50 points; Stage 3 = 51-75 points; Stage 4 = 76-100 points.

### 3.1.7 Capacity Management Maturity Model

Lately, some researchers and practitioners consider Capacity Management more critical to business than ever. Current economic crisis challenges justify it [19]. Before optimizing their Capacity Management, organizations need to know where they currently stand in the maturity of processes and deliverables.

For Solution Labs, Inc., Capacity Management is all about the fine balance between the quantity and type of IT resources that are required to sustain acceptable business service throughput and responsiveness – and the costs associated with acquiring, deploying, and managing them. They also define a new concept called Service Capacity Risk, which is the exposure of having insufficient hardware resource capacity (CPU, I/O, Memory, etc.) to sustain the required service levels (response time, transaction throughput, batch processing, etc.) or to meet regulatory and/or compliance mandates and guidelines. New technologies such as dynamic and automated resource provisioning and reconfigurations are considered to be the way to significantly reduce Service Capacity Risk.

Trying to balance the business and technology aspects of virtualization, Solution Labs developed a five-level maturity model [19], described as follows:

- **Level 1. Simple Metrics, Manual Reporting – Low ROI in Capacity Management**
  Here, processes and technologies are in place to provide relatively simplistic tracking and manual reporting of 'raw performance metrics' at a server level. E.g. CPU is X% over time, Y% over time. Based on such 'raw' metrics, weekly or monthly reports are generated.
  **Advantages**:
  - No capital investment in capacity management tools
  - Technologically and organizationally simple
  - Manual generation of reports is easiest with this approach

  **Disadvantages**:
  - Time consuming and labor intensive
  - Inefficient and error prone
  - Minimal sets of metrics. It requires additional manual works.
  - High ongoing cost of "ownership" due to custom nature of implementations (if any have been done programmatically)
  - Difficult (usually staff cost prohibitive) to cover all the infrastructure, especially in larger environments
  - Highest levels of Service Risk lead to very low resource capacity efficiency

- **Level 2. Simple Metrics, Automated Reporting – Low/Mid ROI in Capacity Management**
  At this level, processes and technologies are in place to provide comprehensive tracking and fully automated reporting of 'raw performance metrics' at the server

or virtual partition level. Automated generation of daily, weekly, and monthly reports based on metrics is done across most, or better all, of the infrastructure.

**Advantages**:

- Simple
- Eliminates human error
- Automated reporting frees staff time for more advanced (higher ROI) capacity management activities
- Automation makes it possible to cover all resources, which reduce Service Capacity Risks

**Disadvantages**:

- Capital investment cost of Capacity Management tools
- Minimal sets of metrics. It requires additional manual works.

- **Level 3. Application/Service Oriented Metrics, Manual Reporting and Analysis – Mid ROI in Capacity Management**
  At this level, processes and technologies are in place for tracking, analyzing and reporting on metrics that align to key, server-oriented aspects of business services. Weekly and monthly-based reports are generated manually.

  **Advantages**:

  - Better understanding of Business Service requirements for resources over time (for that portion of the infrastructure under management)
  - 30% higher average levels of average resource utilization than Level 2

  **Disadvantages**:

  - Capital investment cost of Capacity Management tools
  - Complex, time-consuming and labor intensive
  - Error-prone
  - Impossible to achieve overall, or even much coverage of the infrastructure
  - Limited foresight "distance" due to time required to generate manual reports and analysis

- **Level 4. Application/Service Oriented Metrics, Automated Reporting and Analysis – Mid/High ROI in Capacity Management**
  Here, processes and technologies are in place to fully automate tracking, analysis, and reporting on metrics that closely aligns to business services. In addition to workload data, performance and capacity metrics are factored in (e.g. configuration, costing, response times, transaction rates, etc.). Automated, exception-oriented analyses and reports are generated on daily, weekly and monthly basis.

  **Advantages**:

  - 300% - 400% better total ROI and value than Level 1
  - Elimination of human error
  - Better understanding of Business Service requirements for resources over time
  - Automation allows extension across most/all infrastructure
  - Reduced staffing requirements
  - Time saved via automation may be applied to increased Predictive Modeling efforts

  **Disadvantages**:

  - Requires commitment to Capacity Management as a key discipline within broader organizational change-management processes and controls.

- **Level 5. Application/Service Oriented Metrics, Automated Reporting and Analysis, Predictive Modeling – Highest ROI in Capacity Management**
  At this level, in addition to that being done in Level 4, predictive analytics are used on appropriate and key elements of the infrastructure to completely understand the relationship between the response time and throughput of business services and their underlying requirements for physical resource.

  **Advantages**:
  - Elimination of human error
  - Best possible understanding of Business Service requirements for resources over time (for that infrastructure being modeled on a regular basis)
  - Lowest possible Service Capacity Risk for targeted Services

  **Disadvantages**:
  - Potential to be staff intensive and/or expensive
  - Cannot cover all the infrastructure with modeling
  - Requires commitment to Capacity Management as a key discipline within broader organizational change-management processes and controls.

### 3.1.8 NHS Infrastructure Maturity Model (NIMM™)

NIMM™ is an IT infrastructure maturity model that was developed by the NHS Technology Office together with a number of different NHS IT Organizations in the United Kingdom [32]. During its development, the NHS team worked closely with Atos Healthcare, a consultant company, helping to define and develop the NIMM™. It also supported initiatives to raise awareness across the NHS IT leadership community and NHS infrastructure partners. Currently, the governance and ownership of NIMM™ reside with the NHS Infrastructure Directorate, which is part of the United Kingdom Department of Health's Informatics Directorate. Although the nature of NIMM™ has been developed with the NHS in mind, its concepts and approaches can be applied to any large IT infrastructure

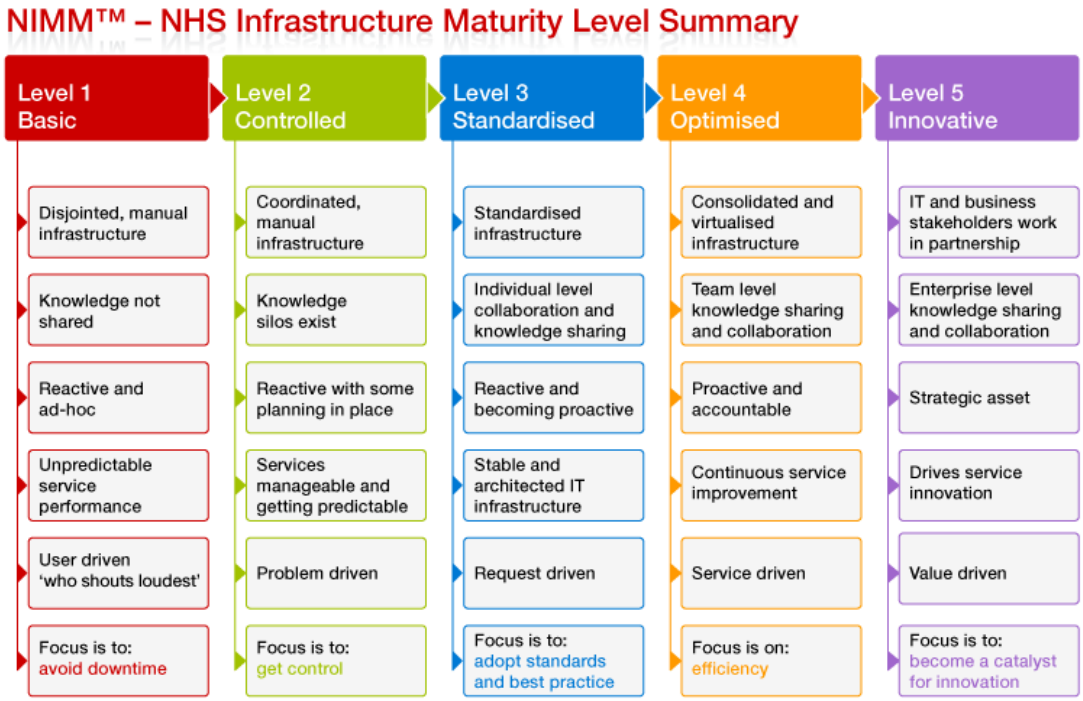


**Figure 10: NHS Infrastructure Maturity Model (NIMM™) [32]**

environment regardless of sector. Figure 10 depicts the NIMM™ maturity levels and its improvement objectives.

Several high-level design goals were used during its development. The NIMM™ should [33]:

- be simple and intuitive to use, written in "plain English"
- be calibrated to be most relevant for the NHS
- be technology and vendor independent
- consider both technical and management aspects of IT infrastructure provision
- take into account any significant dependencies between infrastructure capabilities in order to highlight what the primary & secondary effects of change may be
- be modular in the use of maturity levels, recognizing that an organizations' IT infrastructure capabilities will be at different levels of maturity
- be easily customizable to allow deployment groups to use the model to create profiles of capabilities needed for different services to be deployed
- usable in a descriptive and prescriptive mode to accelerate adoption
- recognize that it will constantly evolve, that business needs change and technology evolves

Based on its creator note, the NIMM™ model as depicted in Figure 10 only describes the characteristics of what the IT organization 'should look like' at each level. To elaborate a deeper view of IT infrastructure maturity, and help its users assess their IT infrastructure, the NIMM™ development team defined seventy-six key capabilities they think every IT infrastructure should cover. These key capabilities are then tested using five perspectives or views they believe can give a holistic overview of an IT infrastructure. To improve the support of business value delivery, it is important to have full coverage and understanding of one's IT infrastructure [34]. Figure 11 depicts the five perspectives used to assess IT infrastructure in the NIMM™.

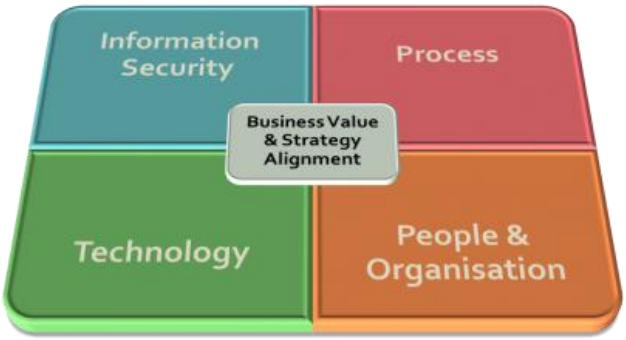


**Figure 11: The five assessment perspectives of NIMM™ [34]**

## 3.2 Comparative analysis of the models

### 3.2.1 Comparison criteria

Before comparing the MMs, a set of criteria is first defined, which describes what an IT infrastructure maturity model should include and what an IT infrastructure covered by the MM should look like at the highest level of maturity. This is achieved using the theoretical concepts described in Chapter 2, combined with the background problem

described in Chapter 1. With this combination, a good solution for the problem, which also can be generalized to other contexts, is designed. Table 7 lists the criteria used to compare and analyze the MMs.

**Table 7: The MMs comparison criteria**

| Criteria | Sources | Description |
|---|---|---|
| **(1) Knowledge Management** | Problem investigation; [39] | Knowledge management refers to a systematic and organizationally specified process for acquiring, organizing and communicating both tacit and explicit knowledge of employees so that other employees may make use of it in order to be more effective and productive in their work.<br>The IT infrastructure MM should cover knowledge management in its model. |
| **(2) Pricing Scheme** | Problem investigation | Pricing scheme defines structures and details on services' pricing and billing, which are provided by an IT Service Provider [38].<br>The IT infrastructure MM should cover pricing scheme in its model. |
| **(3) Technical and Human IT Infrastructure** | IT infrastructure definition | IT infrastructure definition covers both technical/technological and human aspects. Both are important, not just technology, since humans (known as IT Personnel) are responsible for running and maintaining the usage, development, and innovation of IT-based business support.<br>The IT infrastructure MM should cover both technical and human aspects in its model. |
| **(4) Technology-independent** | Camarinha-Matos, et al. [30] | The vision of an IT infrastructure in a Virtual Organization environment is as a 'horizontal platform' supporting networked organizations. Technology-independence ensures interoperability, enterprise applications' integration, and mediation over formats, protocols and models. It supports flexible IT Infrastructure in terms of *connectivity*, *compatibility* and *modularity*.<br>The IT infrastructure MM should be technology-independent in the sense that it does not require the use of a specific vendor's products or services to justify the maturity level. |
| **(5) Real-time Operations** | | Real-time operations describe how organizations display the real-time status of business activities critical to the company's day-to-day operations and how they act immediately upon that information.<br>The IT infrastructure MM should support an organization's utilization of these real-time operations. |
| **(6) Agility** | | Agility expresses the *quickness* or how quick an organization can adapt to constantly mutating business requirements through the provisioning of new infrastructure development or configuration changes. This can be achieved with flexible and robust IT infrastructure. |

| | | |
|---|---|---|
| | | The IT infrastructure MM should help organizations achieve a high agility level. |

The first and second criteria, Knowledge Management and Pricing Scheme, were taken from the problem analysis described in Section 1.1.2.3. An IT infrastructure MM should cover both issues because improvement in both subjects can help every organization to operate in more clear and transparent ways. They also improve the ways service customers and providers communicate.

An IT infrastructure MM should definitely cover both human and technical aspects of IT infrastructure. Human aspect is important in order to run and align the technical infrastructure used with the business requirements. Furthermore, because the major goal is to help organizations establish an IT infrastructure that can really support their businesses now and in the future, it includes three criteria from Camarinha-Matos, et al. [30] concerning the characteristics every future IT infrastructure should have.

Although there are also several other criteria that describe the future IT infrastructure environment, such as widely distributed operations, mobility supports, and self-service supports, they require the fulfillment of other criteria such as automation and agility. Therefore they have not been included into this set.

### 3.2.2 IT infrastructure maturity models comparison

Table 8 summarizes our comparison of the MMs.

**Table 8: MMs comparison matrix**

| Maturity Model | Comparison Criteria | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Autonomic Adoption Model | ⊗ | ⊗ | ⊗ | √ | √ | ⊗ |
| Autonomic Maturity Levels | ⊗ | ⊗ | ⊗ | √ | √ | ⊗ |
| Gartner Infrastructure Maturity Model (GIMM) | ⊗ | √ | ⊗ | √ | √ | √ |
| Green Maturity Model for Virtualization | ⊗ | ⊗ | ⊗ | √ | ⊗ | ⊗ |
| VDC Maturity Model | ⊗ | ⊗ | ⊗ | √ | ⊗ | ⊗ |
| Forrester Infrastructure Virtualization Maturity | ⊗ | ⊗ | ⊗ | √ | ⊗ | ⊗ |
| Capacity Management Maturity Model | ⊗ | ⊗ | ⊗ | √ | ⊗ | ⊗ |
| NHS Infrastructure Maturity Model (NIMM™) | √ | ⊗ | √ | √ | √ | ⊗ |

Legend: √ The model considers the criterion
⊗ The model does not consider the criterion

Of all the MMs studied here, only the NIMM™ covers knowledge management in its model. It also explicitly includes human IT infrastructure needs along with technology. On the other hand, GIMM is the only model that includes the pricing scheme. However, although it covers almost all the technical aspects of IT infrastructure, it does not explicitly consider the human factor in its model. Therefore, GIMM does not fulfill the requirement of the third criterion.

All the MMs are considered to be technology-independent, although the Green Maturity Model for Virtualization was developed for a specific vendor's infrastructure environment.

As can be seen in the matrix, unlike GIMM and NIMM™, the rest of the MMs mostly do not consider the criteria defined in this research. This may be because most of them restrict their discussion to very limited aspects or components of IT infrastructure. Furthermore, the criteria used here mostly refer to a higher-level context compared with these MMs.

Based on the analysis, the conclusion reached is that according to the comparison criteria defined in Section 3.2.1, GIMM and NIMM™ are the best applicable models of the six.

## 3.3 Summary

In this chapter, a review of MMs for assessing IT infrastructure already available in scientific and practical fields was presented. Furthermore, it also described the set of criteria used to compare those MMs in order to analyze which of them offers the best solution to be used in this research. The comparison demonstrates that GIMM and NIMM™ offer the best possible solutions for designing the ITI-MM.

# Part II

# Solution

# 4 Solution Design

In this chapter the process followed in designing the ITI-MM is presented. Although designing an MM is not a widely discussed topic in either scientific or practical literature, it was possible to adopt an MM development process devised by Santana Tapia [36]. In this research, the Gartner Infrastructure Maturity Model (GIMM) and the NHS Infrastructure Maturity Model (NIMM™) are combined. This combination puts the ITI-MM into a unique position compared to others, since both business and IT people can use it together.

Section 4.1 describes the generic MM design process followed by Section 4.2 where the background process and arguments used in designing ITI-MM are presented. Section 4.3 compares the ITI-MM design process with the generic one.

## 4.1 Generic MM Design Process

Developing MMs systematically is not a topic widely covered in either scientific or practical literature. Instead, most MM literature limits itself to the resulting models and does not discuss their development process. However, in his PhD dissertation on MM for business-IT alignment in networked organizations, Santana Tapia [36] deliberately provides the development process he followed. It is described in Figure 12.

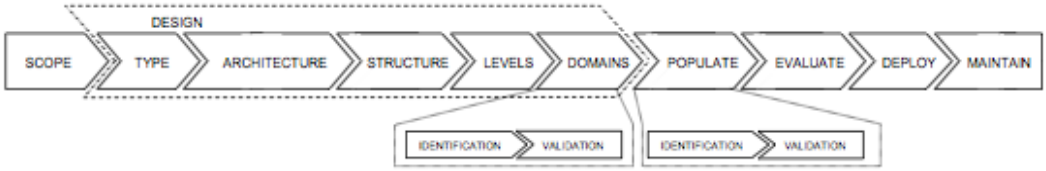


**Figure 12: Generic MM development process [36]**

Based on Tapia's design process, the first step in developing an MM is to determine the **SCOPE** of the model, by which he means to set the boundaries of its usage and to define the purpose of the model. This is done in order to differentiate the model from existing ones.

After defining the model's scope, **DESIGN**ing the model is the next step. In this phase, there are several MM concepts that an MM designer must include:

- **Model's Type**
  There are two types of MMs based on the key purpose that the models serve: *assessment* MMs and *development* MMs. The first one consists of models that serve as assessment tools, usually target certification, and help create or improve their users' image as reliable partners. The second type includes models that serve as development tools. Most organizations utilize them not to receive certification, but because they need guidance and focus for implementing best practices and key process areas, which lead to improvements and better results.

- **Model's Architecture**
  According to the Capability Maturity Model Integration (CMMI) standard, there are two types of architecture that an MM may have: *staged* and *continuous*.

- **Structure**
  The structure of an MM presents the organization of the model's components. It defines whether the MM includes domains, key process areas and goals, and how they are decomposed and used to reach maturity levels.

- **Maturity Levels**
  This implies defining the number of discrete levels of maturity for the model (typically five or six), along with their qualifiers and definitions.

- **Model's Domains**
  The last step related to designing an MM is the identification of the domains to which the levels apply. A domain is a relevant aspect within the scope of the MM. Once the domains have been identified, they need to be validated in order to ensure that they correspond to the purpose of the model.

Once the model is completely designed, it must be **POPULATEd,** by defining process areas for each domain. A process area is a group of practices in a domain, which when implemented collectively, satisfy goals considered important for making an improvement in that domain [36].

In order to **EVALUATE** its general applicability, the model needs to go through a validation process. The objective is to validate the entire MM to determine its relevance and rigor. Afterwards, the MM is **DEPLOYed** to see whether the model can be used in practice. To provide its acceptance and improve its standardization, the MM must be applied in organizations that differ from the ones that were involved in its design and population. Identifying which organizations may use the model and the application of the model to multiple organizations are the final steps towards its disssemination and acceptance. Finally, tracking the model's evolution is also important, in order to **MAINTAIN** the MM over time and keep it up-to-date.

In this research, Tapia's MM development process has been adopted in the design of the ITI-MM.

## 4.2 ITI-MM Design Background

The MM comparison presented in Chapter 3, determined that GIMM and NIMM™ are the two prominent maturity models for managing the development and growth of IT infrastructure. Both scored the same points, although neither of them fully covers the selection criteria.

When looking at the MMs comparison matrix presented in Table 8 – Section 3.2.2, it is evident that by combining GIMM and NIMM™ together, all the criteria are covered. GIMM covers pricing scheme and agility that are not covered by NIMM™. And NIMM™ covers knowledge management and the rest of the aspects of IT infrastructure not fully covered by GIMM. The combination of the two models looks like a favourable approach.

On Andy Savvides' personal website (one of the NIMM™'s creators), he argues that while they were building the NIMM™, the problem was not the lack of 'bottom-up' technical guidance in organizations (such as ITIL, COBIT, ISO standards, GIMM, etc.). What was needed was the incorporation of a 'top-down' approach, so that a common infrastructure management language could be created that business, IT and vendors could speak [40]. This opinion helped NIMM™'s development team create a model that can be intuitively used as 'Management Tool' to help IT Leaders manage performance.

In another publication, Savvides provides a mapping from each level of NIMM™ into the corresponding one in GIMM [35]. As previously seen in Section 3.1.3, GIMM has seven levels, while NIMM™ is a five-level maturity model (see Section 3.1.8). Figure 13 presents the mapping and demonstrates how NIMM™ and GIMM fit nicely together.

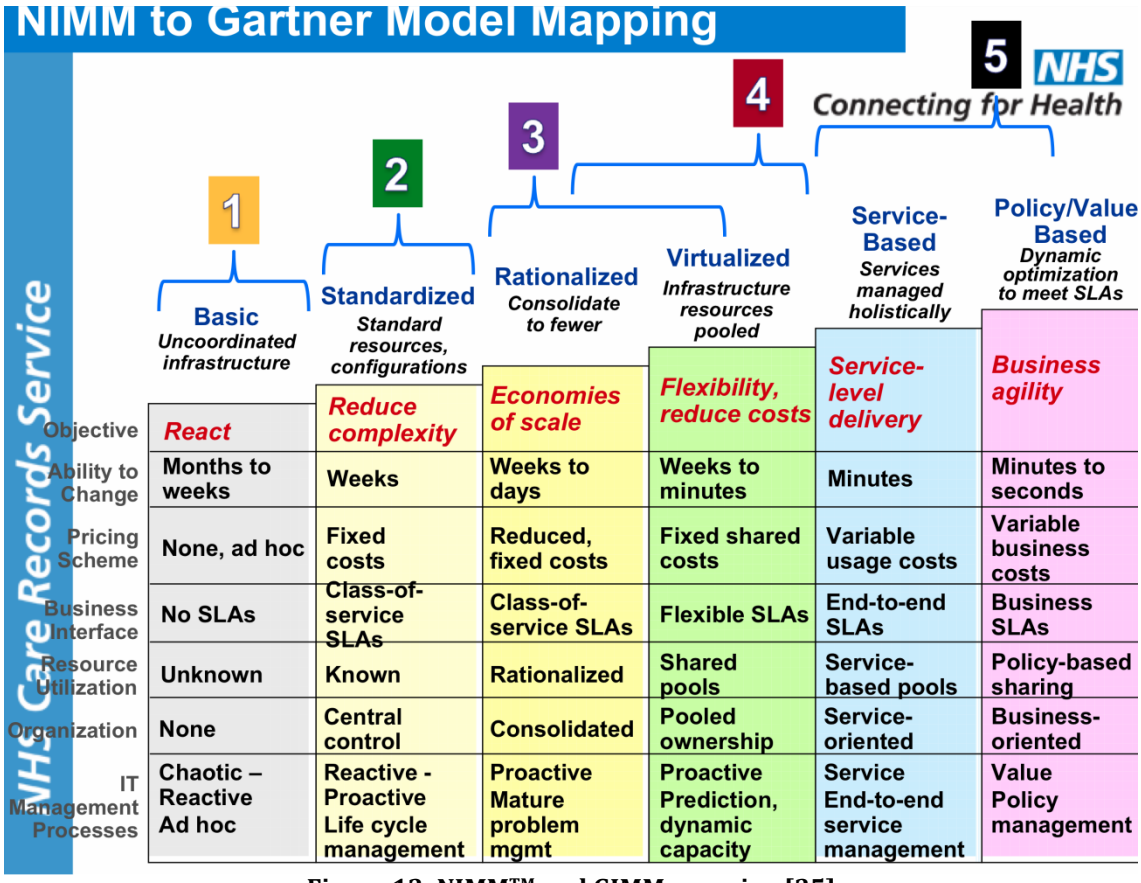


**Figure 13: NIMM™ and GIMM mapping [35]**

Given these findings, this research concludes that it is advantageous to combine NIMM™ and GIMM, using the mapping as presented in Figure 13, into a single model, the ITI-MM. It can also be argued that this special combination ensures the model covers both the 'top-down' and 'bottom-up' approaches in managing IT infrastructure. It also increases its possible usefulness because it can be communicated and used by business, IT, and vendors respectively. This combination helps business and IT communicate better, because the different terminology usually employed by the two groups, can now be bridged by the ITI-MM (see Section 1.1.2.1 on how communication between service customers and providers is obstructed by the different terms they use).

## 4.3 ITI-MM Design Process

Comparing the MM development process with that in Section 4.1, a combined GIMM and NIMM™ model results in the ITI-MM with the following characteristics:

### 4.3.1 Model's Scope

ITI-MM is a maturity model developed to help organizations assess their IT infrastructure. The model's scope includes several criteria, namely: knowledge management, pricing scheme, technical and human IT infrastructure, technological independence and guidance for organizations on how to realize real-time operations and attain a high level of agility.

### 4.3.2 Model's Type

The NIMM™ is designed as a self-assessment model [32]. Given that the available GIMM documentation does not fully cover its assessment model and processes, NIMM™ has been used as the main reference.

Borrowing the self-assessment concept from NIMM™, ITI-MM users will carry out the assessment process themselves in order to determine in which maturity level they currently reside. Using the results, they will define the improvement process they need to implement, in order to achieve the intended maturity level. ITI-MM's usage is not intended to achieve certification.

In this sense, the ITI-MM can be considered a development MM.

### 4.3.3 Model's Architecture

Because ITI-MM is based on NIMM™ and GIMM, it is a staged maturity model. However, in ITI-MM's setting, users may yield different maturity scores for each component being assessed.

### 4.3.4 Model's Structure

Keeping NIMM™ in mind as our main design source, ITI-MM possesses four building blocks: *levels*, *domains*, *capabilities*, and *perspectives*. *Levels* and *domains* describe what an IT infrastructure should look like at each maturity level, while *capabilities* and *perspectives* are used to help ITI-MM users assess their infrastructure. *Capabilities* are a set of infrastructure technical components and processes that an IT organization is responsible for in its daily operations. *Perspectives* are sets of questions used during the assessment discussion, to help participants shape their ways of thinking.

Unlike other maturity models that might assess a component or process against each domain, in ITI-MM *domains* are only used to help describe *what* an IT infrastructure organization and environment should look like at each maturity level.

### 4.3.5 Model's Levels

ITI-MM consists of five levels, whose name implies the main objectives each of them try to achieve: *Basic* (Level 1), *Controlled* (Level 2), *Standardized* (Level 3), *Optimized* (Level 4), and *Innovative* (Level 5).

### 4.3.6 Model's Domains

Based on the combined NIMM™ and GIMM, the ITI-MM possesses twelve domains. These domains are further validated to assure their accordance with the model's purpose and scope. Details on their validation can be found in Chapter 5.

### 4.3.7 Model's Population

Neither NIMM™ nor GIMM describe the process areas their users might need to focus on in order to become more mature. Based on NIMM™ solely, users define their own improvement areas according the consensus reached during the assessment discussion. The ITI-MM will also employ consensus discussions to realize a move from one maturity level to another.

### 4.3.8 Model's Evaluation

In order to validate the entire ITI-MM's relevance and rigor, the model will be evaluated by verifying its *domains* and *capabilities*. This validation is done together with experts from DT to determine its relevancy within the organization's context. Further, a pilot assessment is undertaken to evaluate whether the model is applicable within DT business units. Details on *domains* and *capabilities* verification can be found in Chapter 5, and the pilot assessment is presented in Chapter 7.

### 4.3.9 Model's Deployment and Maintenance

These two last phases are beyond the scope of this thesis. However, the importance of maintaining the ITI-MM's evolution, especially in the case of different IT infrastructure organizations and environments in the future is acknowledged. This includes increasing growth of an infrastructure's *capabilities*. Its general applicability of the ITI-MM in different kinds of organizations might also be interesting as followup research.

## 4.4 Summary

In order to design the MM solution intended by this thesis, the MM development process as defined by Santana Tapia [36] has been adopted. Using the MMs comparison result presented in Chapter 3, the ITI-MM has been designed by combining two maturity models: NIMM™ and GIMM. This combination provides the ITI-MM with several important building blocks, such as: *levels*, *perspectives* and *capabilities* from NIMM™ and *domains* from both models.

Chapters 5, 6, and 7 go on to describe what the resulting ITI-MM includes (as a result of combining the NIMM™ and GIMM) and how it improves through validation within the context of DT organization.

# 5 ITI-MM Domains and Capabilities

The ITI-MM is composed of four building blocks (as a result of combining NIMM™ and GIMM): *levels*, *domains*, *capabilities*, and *perspectives*. This chapter discusses the ITI-MM's initial *domains* and *capabilities* together with their validation process. Once finished, several revisions are made in order to ensure that ITI-MM is applicable for use in real work settings, particularly within the DT organization, the pilot assessment target.

## 5.1 Initial Attempts

### 5.1.1 Domains

The ITI-MM possesses twelve *domains*. These *domains* cover both 'top-down' and 'bottom-up' approaches to managing IT infrastructure. Although combining two models does not necessarily result in all constructs together in one place, here, all *domains* fit and do not conflict with each other. In fact, taken together, they even enrich ITI-MM's coverage. Table 9 lists ITI-MM's twelve initial *domains*.

**Table 9: ITI-MM Initial Domains**

| Domains | Descriptions |
|---|---|
| Infrastructure Management | This *domain* describes the overall or general IT infrastructure management style and directions being performed. |
| Knowledge | This *domain* represents the level of knowledge sharing and management on IT infrastructure and its respective processes. |
| Infrastructure Provisioning | This *domain* describes how IT infrastructure is provisioned, both by business and IT organizations. |
| Service Management | This *domain* represents the service management level of an IT organization. |
| Solution Driver | This *domain* describes the drivers that trigger an infrastructure being provisioned in the first place. |
| Management Focus | This *domain* represents the focus of the IT infrastructure management team. |
| Organization | This *domain* represents IT infrastructure's managing organization or ownership. |
| Agility | This *domain* represents how quick IT infrastructure can adapt to changes. |
| Pricing Scheme | This *domain* describes the scheme of pricing structure offered by the IT infrastructure service provider. |
| Business Interface | This *domain* describes the Service Level Agreement (SLA) offered by IT infrastructure service provider related to the Quality of Service (QoS) promised. |
| Utilization | This *domain* represents the extend level of how IT infrastructure resources is being utilized. |
| Automation and Process Management | This *domain* represents the level of automation and process management within an IT organization. |

### 5.1.2 Infrastructure Capabilities Classification

Borrowing the assessment concept of NIMM™, ITI-MM contains a list of seventy-six IT infrastructure technical components and management processes. Each of them is referred to as 'a capability'. Given that this cannot be considered an exhaustive list for any organization now and in the future, and given that not all organizations possess the same components, a mechanism is needed to generate different sets of *capabilities* for different ITI-MM users. That can best be approached with the use of classification.

Figure 14 lists the initial classification of ITI-MM *capabilities*, based on those mentioned in NIMM™.

**Business Classes:**

1. **Governance** – How well is the IT infrastructure governed? How does it fit into the overall governance structure of IT? Are recognized IT Governance frameworks or best practices, such as COBIT and ITIL being used?
2. **Business Alignment** – How well are business needs and IT infrastructure aligned? How the business stakeholders express their needs for developing new infrastructure services? What processes are in place to measure how well IT infrastructure is aligned to business needs?
3. **Procurement** – How effective is the procurement of infrastructure products and services? How well are suppliers being managed?
4. **People and Skills** – Do the people delivering and supporting infrastructure service have the right skills? Is the staff involved in delivering and supporting infrastructure services used in the most effective way? How well is the impact of the change on people being anticipated and managed?
5. **Value Management** – How is the business value of IT infrastructure being evaluated? Are there disciplines in place to ensure that the realization of benefits is managed? Are business cases developed for infrastructure investment?
6. **Processes and Automation** – What administrative processes are in place to support the delivery of infrastructure services? To what extent are processes being automated to reduce costs and improve quality? Is process effectiveness being measured and improved when needed?

**Technology Classes:**

1. **Patterns and Practices** – The Principles, Standards, Procedures, and Guidelines used to create and deliver IT infrastructure services.
2. **IT Security and Information Governance** – Technology related to authentication and access control of both systems and information.
3. **End User Devices** – Devices used by end users to access infrastructure services, including PC, peripheral devices, PDAs, etc.
4. **Common Applications and Services** – Shared applications provided by the infrastructure, which are used by end users or other infrastructure components, including electronic mail, collaboration platforms, directory services, etc.
5. **Operating Systems** – Software platforms including PC operating systems, server operating systems, appliance operating systems, etc.
6. **Infrastructure Hardware Platforms** – Hardware platforms used to deliver shared infrastructure services.
7. **Network Devices and Services** – Devices and services that provide networking capabilities.

**Figure 14: ITI-MM initial capabilities classes**

## 5.2 Validation Process

To validate ITI-MM's *domains* and *capabilities*, a focus group discussion with several experts from DT was organized, since they are the stakeholders motivating this research and there was limited time to validate them with a bigger audience. This approach is consistent with Santana Tapia's recommendation to use a focus group session to gain insight into the preliminary results of a maturity model design [36].

The focus group session was held 1 June 2010 at DT headquarters, located in Bonn, Germany. Twenty-five internal professionals were invited, all responsible or connected to IT infrastructure in their daily jobs. The DT project supervisor collected their names and contact details.

Although the formal invitation was sent a month in advance, only three were present in the first discussion. Others indicated they were unable to attend either due to other, higher priority projects or vacation. They came from different organizations within DT.

The focus group was conducted in a manner consistent with the steps described by Morgan, et al. in their book about moderating a focus group [43]. First, the goal of the focus group was explained: "to understand how suitable and complete ITI-MM *domains* and *capabilities* are". After that, the session was divided into three rounds of discussion held during three different periods. In the first round, participants were given an opportunity to express their general ideas about IT infrastructure and maturity models. They were asked the following questions:

1. *If you hear the word 'IT Infrastructure', what comes to mind?*
2. *From your point of view, what does a 'star' or good IT infrastructure look like? What are the characteristics an IT Infrastructure should have in order to be considered a good IT Infrastructure?*
3. *From those 'star' characteristics, which are the most important ones? Which characteristics are needed first?*
4. *From those 'star' characteristics, which are least important or just 'nice to have'?*
5. *Given your view of good IT Infrastructure, what gap do you see in most current IT Infrastructures? What are the negative aspects or practices of current IT Infrastructure that you think need to be avoided?*
6. *If you hear the word 'maturity model', what comes to mind?*
7. *There are many different maturity models. What kind of maturity model would you like to use? What characteristics of a good maturity model do you consider useful?*
8. *If there is a maturity model that can be used to assess IT infrastructure, what are the key aspects that model needs to address? What characteristics do you expect to see in that model?*

This was followed by a presentation of the initial ITI-MM together with its building blocks: *levels*, *domains*, *capabilities*, and *perspectives*. At the same time the research process followed was also described, in order to give them the appropriate context in which ITI-MM was developed.

In the second discussion round, they were asked to judge whether each ITI-MM *domain* is relevant for DT. They were also asked about any possible omissions or needed additions to the *domains* list.

After the break, the discussion continued about whether each *capabilities* class is relevant for DT. They were again asked about any possible omissions or needed additions to the *capabilities* classification. The focus group discussion finished by discussing the

possibilities of carrying out a pilot assessment once the model was updated with the improvement suggestions they provided.

During this focus group discussion session, we took the position as facilitator, leading the discussion. In addition, the project supervisor took the role of co-researcher, taking notes and participating in the discussion, contributing his experience and knowledge. His additional insights were considered helpful, especially when there was a need to develop some examples directly related to DT's business environment.

All focus group session discussions were recorded using an audio recorder for further analysis. Anonymity of the participants is upheld and their particular comments are highly appreciated. The fully-transcribed audio recording is not open and presented in this thesis due to the agreement made at the beginning of the session.

## 5.3 Validation Results

Several key points were identified as a result of the focus group discussion:

1. Although participants recognized how important people's roles are in an IT infrastructure context, they considered that as part of the managing process. This aligns with the definition of IT infrastructure used in this research (see Section 2.1.1). But it differs from our earlier assumption: that most people will see IT infrastructure only in terms of its technical components, such as servers, storage, networks, etc.
2. In general, the participants expressed that a good IT infrastructure should be flexible and allow the organization to deal with unplanned changes. They argued that many unforeseeable things are out there and cannot be planned for beforehand. This is in line with Davenport and Linder's thoughts on how flexibility and robustness needs to be a core competence of any IT organization in the future [6].
3. For one participant, a good maturity model should supply a complete set of methods to help organizations become mature. It is like a 'cookbook'. During the discussion, we argued that different organizations might have and need different 'cookbooks'. The best approach may be to develop their own 'cookbooks' according to their unique business requirements. ITI-MM can help organizations develop the intended 'cookbook', or, roadmap for an IT infrastructure's development and growth.
4. The ITI-MM lacks metrics of importance. When the ITI-MM was presented, two participants asked about metrics allowing one to score something as important or not. Since opinions vary, ITI-MM should provide something that allows this to be measurable. In this case, they were looking for KPIs. Here, we argued that different organizations might have different KPIs depending on their business context. It is true that ITI-MM does not yet provide sets of KPIs that users can utilize during the assessment session. But there is always the possibility that users define their own sets of KPIs once they conduct their first assessment and have agreed on several improvement numbers. These numbers can then be assessed in following sessions. In other words, ITI-MM users can generate their own KPIs during their assessment sessions and then need to assess them again to see whether the improvement plans worked.
5. All the initial *domains* are important for DT.
6. As to the *capabilities* classification, several concerns arose:
    a. **Governance**: ITI-MM should also consider TM Forum, which manages governance specific processes for the Telecommunication industry.

b. **Procurement**: in DT, SLA management is part of Service Management operations.
c. **IT Security**: in DT, Data Privacy and Data Security are two separate issues.
d. **Operating System**: there are many more concerns related to infrastructure software besides Operating Systems. They include middleware, database, containers, etc.
e. **Network**: besides IP based network hardware, DT also owns and manages others, such as submarine cables, microwaves, transmission networks, etc.
f. The infrastructure's physical location, such as a Data Center, is also important.

## 5.4 Revised ITI-MM Domains and Capabilities

Based on the focus group results, several revisions need to be undertaken in order to make the ITI-MM more applicable in the real-life context. The following sub-sections describe the revisions in detail:

### 5.4.1 Domains

A new *domain* was added to the ITI-MM model, '**Ecosystem Relationship**'. Its importance is acknowledged not only in DT's context, but is also relevant to other organizations. Here we argue that good solutions and business outcomes will arise as a result of good relationships between an organization' business and IT ecosystems. Nachira, et al. [44] also argue in their book that information technologies shape modern business ecosystems, and bring out greater benefits for the current and future knowledge economy world. Combining the Digital Ecosystem (which in their research is referred as IT infrastructure), with socio-economic dimensions delivers significant outputs, such as: open knowledge, open governance and most importantly, economic empowerment for organizations that participate in their surrounding ecosystems.

This new *domain*'s development in ITI-MM is based on an interpretation and analysis of the connectedness between it and other *domains*. Its description in each maturity level is described as follows:

- **Level 1: Passive Observer**
  At this level, the IT organization usually utilizes technologies available in the market with no or only little adjustment to their overall business objectives. They use Commercial Off-the-Shelf (COTS) applications directly for which they were designed, with the expectation of solving their current short-term requirements.

- **Level 2: Active Listener with self-reflecting actions**
  The organization starts to participate in several activities, either within their industry or in a wider scope such as in scientific conferences. They try to capture new knowledge as much as possible and start to implement it in their infrastructure architecture. They learn all these new things within the skeleton of industry and from other already defined common norms.

- **Level 3: Start to contribute as active member**
  At this level, the IT organization starts to contribute as an active member of their ecosystem. They start to actively attend conferences, share their experience and knowledge with other communities, without trying to disrupt the norms and patterns. In adopting standardization, they also try to align themselves with their partners, at least those directly connected within their supply chain.

- **Level 4: Drive ecosystem, with controlled exception**
  The organization starts to bring its ecosystem in alignment with their business objectives. They start to use their leveraged position to drive suppliers or solution vendors to align with their unique business requirements. They also start to actively contribute at conferences, in expert forums, and during other kinds of community activities, trying to engage their partners together to build a solid ecosystem according to their business strategy and direction. However, if they must use technologies or standards not yet fully aligned with their roadmaps, they will compromise using a controlled exception handling mechanisms.

- **Level 5: Actively innovate the ecosystem**
  The organization uses their influence and knowledge to innovate the ecosystem. They are involved in new technology and best practice research and development. They participate actively in the creation of national, regional, even global standards and regulations, which produce the optimum benefits aligned with their business objectives and strategies. The organization is also strategically involved in political, economic and societal decision-making processes.

### 5.4.2 Capabilities

Several revisions on *capabilities* classification were made based on focus group feedback:

1. The **Business Alignment** class was omitted and its content was moved to the **Governance** class. For DT, the business-IT alignment issue is already part of the company's strategy.
2. The **Operating System** class was also omitted and its content together with additional infrastructure software like middleware, containers, etc. moved into a new class called **Infrastructure Software Platforms**.
3. A **Physical Infrastructure Location** class was added to the list.

For an additional list of *capabilities* in each class, the components and processes described in several standards, such as COBIT, ITIL, TM Forum, and ISO27001 for security, are taken. The new list of *capabilities* classess are found in Figure 17 – Section 6.3.1, while the *capabilities* list for all classes based on the DT case study can be found in Appendix C.

## 5.5 Summary

The building blocks: *levels*, *domains*, *capabilities*, and *perspectives* form part of the ITI-MM design and were developed by combining the NIMM™ and GIMM. By their constructs, *levels* and *domains* together illustrate what an IT infrastructure organization should look like or have at each maturity level; *capabilities* break down all the technical components and processes that an IT organization utilize on a daily basis; while *perspectives* make several sets of questions available to help ITI-MM users shape their way of thinking during assessment discussions.

To check its potential application within DT, the initial design of ITI-MM needed to be validated. Of the four building blocks, *domains* and *capabilities* were chosen. These two were selected because of their natural usage and role in shaping the ITI-MM.

The validation process was undertaken using a focus group discussion with several professionals from DT internal groups. Based on session feedback, it was evident that the ITI-MM fulfills their needs, although some adjustments were needed to make the model even more applicable and suitable for them.

Chapter 6 presents a full description of the revised model.

# 6 The IT Infrastructure Maturity Model (ITI-MM)

Chapter 4 and 5 described ITI-MM's design process together with its *domains* and *capabilities* validation. Here, ITI-MM's model, level descriptions and assessment tools are delineated. It also includes guidelines on how organizations can employ ITI-MM to assess their infrastructure. Assessment samples of one capability, Electronic Mail, will end this chapter.

## 6.1 ITI-MM Model

Starting with a general description, ITI-MM is a maturity model that portrays IT infrastructure in five incremental levels: *Basic*, *Controlled*, *Standardized*, *Optimized* and *Innovative*. Each level is constructed of thirteen improvement *domains*, which reflect *what* an IT infrastructure should look like at each level. By employing ITI-MM as an assessment tool, users evaluate their infrastructure components one-by-one against the improvement *domains*. In the ITI-MM, an infrastructure component is called '**a capability**'. However, instead of assessing each capability towards one *domain* at a time, users evaluate against an entire levels' description, to see whether the assessed capability already fulfills or is able to achieve the IT infrastructure environment portrayed at that level. Figure 15 depicts the ITI-MM model.

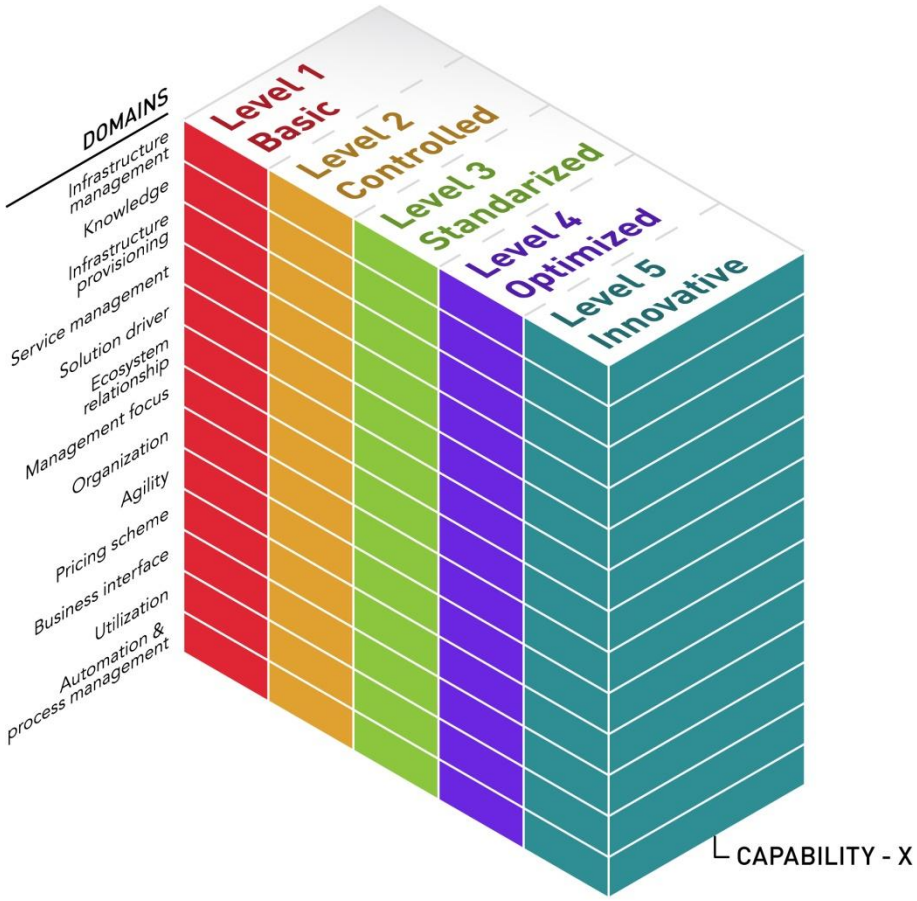


**Figure 15: ITI-MM Model**

## 6.2 ITI-MM Level Descriptions

Based on the thirteen improvement *domains*: *Infrastructure Management*, *Knowledge*, *Infrastructure Provisioning*, *Service Management*, *Solution Driver*, *Ecosystem Relationship*, *Management Focus*, *Organization*, *Agility*, *Pricing Scheme*, *Business Interface*, *Utilization*, and *Automation and Process Management*; each maturity level is described as depicted by Figure 16. Looking at its complexity and the broad range of improvement objectives, ITI-MM employs generic statements to delineate 'what an IT infrastructure should look like' at each maturity level. The following sub-sections discuss them further:


**Figure 16: ITI-MM model's levels description**

### 6.2.1 Level 1 (Basic)

Organizations at Level 1 are characterized by ad-hoc manual infrastructure management and support processes.

At this level, an organization has no effective control of its infrastructure. There are no infrastructure principles, standards, procedures and guidelines in place for the most basic capabilities such as IT security, desktop management, network services and common infrastructure services. The focus of the IT organization at this level is to avoid downtime.

The most basic configuration information about existing infrastructure is lacking, making it difficult to effectively diagnose problems and assess the impact of changes. Many changes are made outside of the control of the IT organization. The overall health of infrastructure devices and services is unknown because there is a lack of tools or architecture to enable remote service monitoring; this forces the IT organization to operate in a purely reactionary mode.

Similarly, there is no vehicle for sharing knowledge across the organization. While some staff may take the time to capture information and lessons learned in any number of folders and databases, there is no centralized repository, their efforts are rarely refreshed, few people contribute and even fewer search for or reuse the data captured.

The interface with business is somewhat ad-hoc – no realistic service-level agreements (SLAs) are in place, and, in fact, many business organizations or business units have their own IT resources.

At this level, the IT organization usually utilizes technologies available in the market with no or only little adjustment to their overall business objectives. They use Commercial Off-the-Shelf (COTS) applications directly for which they were designed, with the expectation of solving their current short-term requirements.

Organizations with level 1 infrastructure find their environments extremely hard to control, have very high desktop and server management costs, are generally reactive to security threats, and have very little positive impact on the ability of the business to benefit from IT.

### 6.2.2 Level 2 (Controlled)

The usual motivation for moving to this level is the need to have a better and more consistent view of the existing infrastructure, and to take control.

Organizations at Level 2 have the ability to exercise adequate levels of control over key infrastructure components such as IT security, desktop management, network services and other common infrastructure services. It is achieved by starting to implement standards to reduce complexity, maximize process and staffing efficiency, and create the potential for automated administrative tools. At this level, organizations also start to apply standards control to track IT asset inventory – life cycle standards from acquisition to retirement. With this standardization, IT organizations will reduce costs through more-centralized buying power and complexity reduction; improve agility through the ability to redeploy assets and some administrative automation; and increase service levels through less diversity and increased automation.

Most people accept that sharing knowledge plays an important part in both the success of an IT department and the wider organization. At this level, people are using some of the tools available to help learning and sharing and some IT managers give people time to share and learn. But there is little visible support from the top. Nevertheless, most IT teams in the organization capture lessons learned after a project and look for previously captured knowledge before starting a project.

The organization has invested in people, processes and technology that provide IT with remote management capabilities. Changes can therefore be implemented without the need for physical access to an end-user device. Consequently, IT teams can respond in a more timely manner to end-user requests and problems.

The organization starts to participate in several activities, either within their industry or in a wider scope such as in scientific conferences. They try to capture new knowledge as much as possible and start to implement it in their infrastructure architecture. They learn all these new things within the skeleton of industry and from other already defined common norms.

### 6.2.3 Level 3 (Standardized)

The motivation for moving to this level of maturity is usually a need to reduce errors and improve consistency by adopting standardized, best practices and repeatable ways of delivering infrastructure services.

Organizations that achieve Level 3 have a highly standardized infrastructure which uses the control capabilities achieved in Level 2 to implement principles, standards, procedures and guidelines for managing key infrastructure capabilities such as IT security, desktop management, network services and common infrastructure services. IT staff use a common set of tools to help with learning and to share knowledge and best practices.

The standardization achieved at this level provides IT with up-to-date, complete and accurate configuration information about the existing infrastructure. Wherever possible, complexity has been removed and a configuration management function has been established which maintains a configuration management database (CMDB). The CMDB enables better decision making for both planned and emergency changes to the infrastructure, and gives the IT department the ability to manage risks and be proactive in anticipating problems before they have an impact upon the organization.

Level 3 necessitates mature availability (and disaster recovery) technologies for the more consolidated IT assets, as well as improved configuration, problem and change management. Infrastructures will use software distribution and configuration management tools – and, eventually, full provisioning tools. These provisioning tools are the beginning of virtualization by allowing whole assets to have changing roles, but with granularity limited to hardware (element) boundaries.

At this level, the IT organization starts to contribute as an active member of their ecosystem. They start to actively attend conferences, share their experience and knowledge with other communities, without trying to disrupt the norms and patterns. In adopting standardization, they also try to align themselves with their partners, at least those directly connected within their supply chain.

Organizations also start to introduce pooled resources and begin to break the resource chargeback boundary. At this level, chargeback starts to become a question of portions of physical assets.

### 6.2.4 Level 4 (Optimized)

The usual motivation for moving to this level is the need to drive operational efficiency by eliminating non-value adding services and introducing a number of optimization and lean initiatives.

At this level, organizations will have optimized their infrastructure to the point where the costs involved in delivering and managing core infrastructure are low compared to similar industry norms. Processes and policies will also be optimized to support technology, enable agility and help the organization achieve its strategic goals.

This optimization is reached by virtualization that takes a step further by reducing boundaries within and between those IT assets – for example, moving from hard/static partitions to virtual/dynamic partitions in servers. Virtualization focuses on removing boundaries and pooling resources into shared assets, thereby increasing efficient and dynamic allocation of assets. It reduces costs by squeezing the maximum utilization of assets through resource sharing. It also increases agility significantly through dynamic, granular scaling without hard resources boundaries. Service levels improve through more-dynamic resource allocation based on requirements. Virtualization is the foundation on which service-level automation can be built.

At this level, chargeback is based on actual usage that may vary somewhat over time. The IT organization must develop mechanisms to charge on a usage/tiered basis – and the business needs to adapt to that kind of chargeback.

Security will be very proactive with a rapid and controlled response to threats and challenges. The use of zero-touch business desktop deployment will help minimize cost and provide 'without delay' services to end-users, who will have what they need when they need it.

There will also be a managed portfolio of baseline device' images and a very low-touch process for managing devices. This combination will reduce the total cost of ownership for devices to levels in line with world-class organizations.

Effective software asset management will facilitate full compliance with software licensing and cut costs by ensuring that only those licenses actually needed are purchased.

A general awareness and recognition exists of the importance attached to the organization's ability to develop and leverage its intellectual assets.

There will be an extremely proactive IT security and information governance, with well defined and fully enforced policies across all IT areas, from the devices estate to servers, and from firewalls to the extranet.

The organization starts to bring its ecosystem in alignment with their business objectives. They start to use their leveraged position to drive suppliers or solution vendors to align with their unique business requirements. They also start to actively contribute at conferences, in expert forums, and during other kinds of community activities, trying to

engage their partners together to build a solid ecosystem according to their business strategy and direction. However, if they must use technologies or standards not yet fully aligned with their roadmaps, they will compromise using a controlled exception handling mechanisms.

Finally, a collaboration strategy will be in place, but it may not yet always be linked to business results.

### 6.2.5 Level 5 (Innovative)

The motivation for moving to this level is to exploit the investment made in infrastructure maturity. The objective is to support the transformation of services and business changes based on innovation.

Organizations that achieve Level 5 will have a robust and agile infrastructure that is the acknowledged catalyst for technical and business innovation. The positive implications of this acknowledgement include:

- An executive team and other senior stakeholders who recognize the strategic value that their IT infrastructure provides in helping them to efficiently achieve their stated goals.
- A trusted partnership culture between executive and business stakeholders, end-users and IT service providers.
- Collaborative endeavor as a core infrastructure service that enables learning and knowledge sharing between users across traditional organizational boundaries.
- Mobile users have 'near on-site' levels of service and capability for all the devices they use, regardless of their location.
- Processes are fully automated and incorporated into all aspects of business-as-usual, allowing IT services to be delivered, consumed and managed according to business needs. Agility improves as business policies can change over time, with rapid reaction by IT.
- There is a program of investment in innovative technology yielding specific, rapid and measurable benefits for the organization. The program is supported by a culture of innovation based on organization-wide stakeholder partnerships.
- There are automated trade-offs on allocations of IT resources between services that are made based on objective business priorities and business values.
- The IT organization is no longer in the role of manually choosing how to allocate resources between services to deliver various service levels. Those choices are made by the business through mature service policy management layered on top of an infrastructure that can respond to those policies in a balanced, dynamic, and objective way.
- IT costs are tied directly to business priorities and service-level requirements, across all services provided. The business can make dynamic investment choices in various services, with the expectation of seeing that investment dynamically deployed in terms of IT assets.
- The IT infrastructure is trusted to be secure, yet has the flexibility to be an open forum for stimulating new ideas and learning opportunities.
- There are no hard-wired inhibitors. The organization is therefore able to engage with specialist, peer or national organizations to develop new and more productive ways of working in order to meet its own strategic objectives.
- The organization uses their influence and knowledge to innovate the ecosystem. They are involved in new technology and best practice research and development.

They participate actively in the creation of national, regional, even global standards and regulations, which produce the optimum benefits aligned with their business objectives and strategies. The organization is also strategically involved in political, economic and societal decision-making processes.

## 6.3 ITI-MM Assessment Tools

Unlike other assessment models, which might use several sets of questionnaires to scale answers and involve assessors from external organizations, ITI-MM urges its users to conduct an internal discussion between the IT infrastructure service provider and customer. ITI-MM is designed to be a *self-joint assessment* maturity model. During the discussion, every participant needs to express their concerns and offer improvement ideas that they think the organization needs to take into account in order to improve infrastructure services and ensure their alignment with business objectives. To help them structure the discussion session, ITI-MM prepares two complementing assessment tools: *ITI-MM Capabilities* and *ITI-MM Perspectives*.

*ITI-MM Capabilities* fragments an organization's IT infrastructure into several classes. These classes will further be used to determine the technical components and processes used on a daily basis. Each component or process is called '**a capability**'.

In order to assess a capability, organizations may employ *ITI-MM Perspectives*. There are five *perspectives*. Each is designed to help discussion participants structuring their way of thinking, by providing several guided questions. Using all five *perspectives* in an assessment session is recommended since this helps users evaluate a capability holistically.

In conclusion, using ITI-MM as an assessment tool requires its users to assess their infrastructure's *capabilities* with the help of *perspectives* to guide the discussion sessions. The scores and lines of reasoning derived from each *perspective* are then used as rational argumentation to arrive at the concluding maturity level for a capability.

Details on *ITI-MM Capabilities* and *ITI-MM Perspectives* are described in the following two sub-sections:

### 6.3.1 ITI-MM Capabilities

Since different organizations have different sets of infrastructure *capabilities*, ITI-MM provides several classes to help an organization define theirs. These classes are derived from the two major aspects of IT infrastructure covered by ITI-MM: *Technology* and *Business*. ITI-MM's users may develop their own list of infrastructure *capabilities* by following the classification presented in Figure 17. The sets of IT infrastructure *capabilities* derived from the DT case study can be found in Appendix C.

**Business Classes:**

1. **Governance** – How well is the IT infrastructure governed? How does it fit into the overall governance structure of IT? Are recognized IT Governance frameworks or best practices, such as COBIT and ITIL being used?
2. **Procurement** – How effective is the procurement of infrastructure products and services? How well are suppliers being managed?
3. **People and Skills** – Do the people delivering and supporting infrastructure service have the right skills? Is the staff involved in delivering and supporting infrastructure services used in the most effective way? How well is the impact of the change on people being anticipated and managed?
4. **Value Management** – How is the business value of IT infrastructure being evaluated? Are there disciplines in place to ensure that the realization of benefits is managed? Are business cases developed for infrastructure investment?
5. **Processes and Automation** – What administrative processes are in place to support the delivery of infrastructure services? To what extent are processes being automated to reduce costs and improve quality? Is process effectiveness being measured and improved when needed?

**Technology Classes:**

1. **Patterns and Practices** – The Principles, Standards, Procedures, and Guidelines used to create and deliver IT infrastructure services.
2. **IT Security and Information Governance** – Technology related to authentication and access control of both systems and information.
3. **End User Devices** – Devices used by end users to access infrastructure services, including PC, peripheral devices, PDAs, etc.
4. **Common Applications and Services** – Shared applications provided by the infrastructure, which are used by end users or other infrastructure components, including electronic mail, collaboration platforms, directory services, etc.
5. **Infrastructure Hardware Platforms** – Hardware platforms used to deliver shared infrastructure services.
6. **Infrastructure Software Platforms –** Software platforms used to deliver shared infrastructure services.
7. **Network Devices and Services** – Devices and services that provide networking capabilities.
8. **Physical Infrastructure Location** – Technology and other physical aspects of managing IT infrastructure including data center building, location architecture, data center security, etc.

**Figure 17: ITI-MM capabilities classification**

### 6.3.2 ITI-MM Perspectives

There are five *perspectives* that ITI-MM's users can utilize to shape their ways of thinking during the assessment discussion: *Process*, *Information Security*, *People and Organization*, *Technology*, and *Business Value and Strategy Alignment*. In each *perspective* there are several sample questions to structurally guide the discussion flow. Every organization may define its own sets of questions as long as they do not deviate too much from the initial context and samples. The five *perspectives*, including their sample questions, are described as follows:

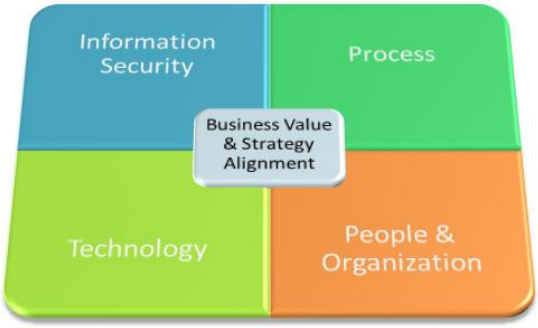


**Figure 18: ITI-MM Assessment Perspectives**

**a) Process Perspective**

When using this *perspective* to score an IT Infrastructure capability, users can use the following sample questions and score using the ITI-MM scale of 1-5 (change the word "[this]" into the assessed capability):

- How mature are the processes that enable, support and manage the ***delivery of [this] capability***?
  - Are the processes authoritative, generally accepted and followed?
  - How mature and optimized are the automation and workflow supporting the processes?
  - How mature is the management of process quality, consistency, and documentation?
  - Do these processes follow generally accepted best practices?
- How mature is the ability for the ***consuming processes*** to realize the potential benefits that ***[this]*** capability brings to the organization?
  - Have the processes that use the capability been modified so that they can benefit from what ***[this]*** capability has to offer?

**b) Information Security Perspective**

When using this *perspective* to score an IT Infrastructure capability, users can use the following sample questions and score using the ITI-MM scale of 1-5 (change the word "[this]" into the assessed capability):

- How mature are the IT security measures in place to ensure the trustworthy delivery of ***[this]*** capability?
- How mature is the security model for authentication and access in the use and delivery of ***[this]*** capability?

Consider as well the following qualitative measures when scoring a capability against this perspective:

- Security and Information Governance Compliance
- Contribution to protect IT infrastructure, business data and minimize the risk of business disruption
- Trustworthy, auditable and standards based
- Openness in the delivery which supports the identification issues

**c) People & Organization Perspective**

When using this *perspective* to score an IT Infrastructure capability, users can use the following sample questions and score using the ITI-MM scale of 1-5 (change the word "[this]" into the assessed capability):

- How well can the **providers' organizational structure** ensure the effective delivery of ***[this]*** capability in order to:
  - Ensure satisfaction of end users with the functionality provided

- Deliver the appropriate service levels
- Seamlessly integrate this capability into existing business processes or transform them
- Organizational responsiveness and communication

- How well suited is the organizational structure and people readiness of the **consuming organization** to ensure the maximum potential benefits to be realized from ***[this]*** capability?
  Consider the end user experience in terms of:
  - Accessibility
  - Convenience
  - Functionality

**d) <u>Technology Perspective</u>**

When using this *perspective* to score an IT Infrastructure capability, users can use the following sample questions and score using the ITI-MM scale of 1-5 (change the word "[this]" into the assessed capability):

- How mature is the functionality provided by ***[this]*** capability's technology?
- Does the technology of ***[this]*** capability follow generally accepted industry standards?
- How mature and transparent is the ability of the product used in ***[this]*** capability to tolerate and recover from component and environmental failure?
- How well does ***[this]*** capability's technology contribute to maintaining an integrated and standardized IT Infrastructure?

Consider as well the following qualitative measures when scoring a capability against this perspective:

- Dependable, manageable, and scalable
- Ease of acquisition, deployment, integration, and disposal

e) **<u>Business Value & Strategy Alignment Perspective</u>**

When using this *perspective* to score an IT Infrastructure capability, users can use the following sample questions and score using the ITI-MM scale of 1-5 (change the word "[this]" into the assessed capability):

- How well does the delivery of ***[this]*** capability align to and support the achievement of the organizations strategic goals?
- How mature is the ability of the organization to understand and realize the potential benefits that ***[this]*** capability brings?
- How transparent are the benefits, costs, and risks associated with ***[this]*** capability?
- Is there a standardized and mature approach in defining, measuring and managing the TCO of ***[this]*** capability?
- How mature is the strategy in realizing the business value and return on investment of ***[this]*** capability?
- How well does ***[this]*** capability exploit the Enterprise Wide Agreements and other preferential purchasing schemes?

## 6.4 ITI-MM Assessment Guidelines

In order to achieve optimum results from using ITI-MM, it is suggested that users follow the assessment guidelines as depicted in Figure 19. An ITI-MM assessment is divided into three sequential periods, named *Pre-Assessment* (preparation period to which users need to give much attention), *Assessment*, and *Post-Assessment* (activities that need to be done after conducting an assessment discussion session).

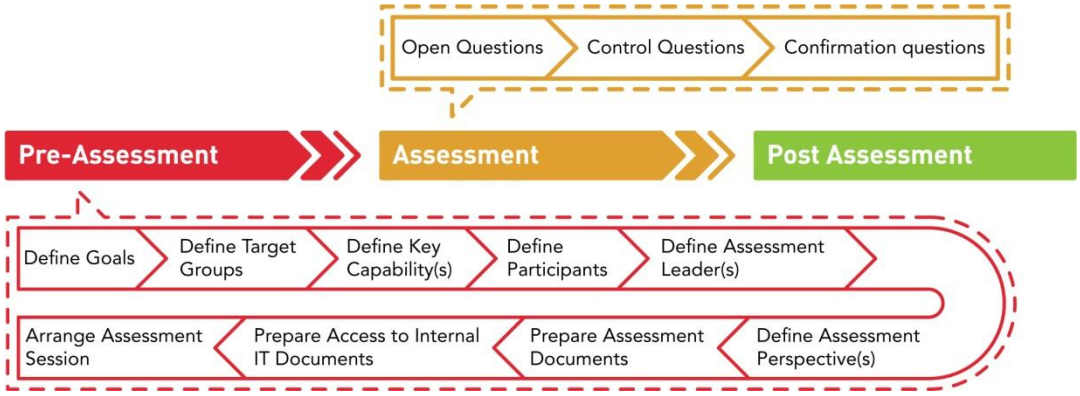


**Figure 19: ITI-MM Assessment Guidelines**

### 6.4.1 Pre-Assessment

In this planning phase, it is suggested that users prepare or consider several important aspects, such as:

1. **Goals**
   *What goal do users want to achieve by doing the assessment?* An ITI-MM assessment can be done to check an organization's current maturity level for a single capability, to test the maturity of a single process, etc. In ITI-MM's settings, users may define their own goals, including the desired maturity level they want to achieve based on their unique business characteristics and requirements. Not all organizations want and need to achieve the fifth level of ITI-MM's maturity, when they think level four is enough.

2. **Target Groups**
   After defining the goals, users need to define which group(s) should participate in the assessment session. Based on the defined goals, users can identify the targeted groups, such as for example:
   a. If users want to benchmark and improve their IT infrastructure delivery, then the assessment should be aimed at the IT infrastructure service provider.
   b. If users want to measure and improve the way their business organization uses IT services, then the assessment should be aimed at the service customers.
   c. If users want to highlight problems that they have in serving business, then the assessment should be aimed at both IT infrastructure service provider and customer.

3. **Key Capability(s)**
   Since every organization might have a broad range of IT infrastructure *capabilities*, users need to define which *capability*(s) they want to assess at each assessment session. They can select one or more suggested *capabilities* or they might define a

new *capability* that is not yet included in the samples list. The list of suggested key *capabilities* brought by ITI-MM, which is taken from the DT case, can be found in Appendix C.

4. **Participants**
   After defining the key *capabilities* and target groups to be assessed, users need to define the assessment's participants. They should come from different parts of organization that are responsible and/or have interest in the assessed *capabilities*. In addition, since ITI-MM stresses the importance of dialog between them, the number of participants should also be calculated carefully in relation to the assessment leaders' competency in moderating the sessions.

5. **Assessment Leader(s)**
   To guide an assessment discussion, users need to determine the assessment leader(s). This leader acts as the facilitator and moderator. In order to get a neutral view, the chosen leader is better selected from those who are not connected directly with the *capabilities* being assessed. Senior management or other high level managers are good candidates for this role.

6. **Assessment Perspective(s)**
   In assessing their IT infrastructure, users can use one or more ITI-MM *Perspectives*. The chosen *perspective* should be aligned with the goal and the participants of the assessment. For example, if users want to use the *Business Value and Strategy Alignment* perspective, then it is better not to involve a server administrator in the session. It is better to invite an Application Architect for instance, because they are more aware of calculating the benefits an IT infrastructure should provide the business in supporting a running application. However, to get a balanced and holistic view of the assessed capability, using the entire set of *perspectives* is recommended.

7. **Adapted Assessment Documents**
   Adapted ITI-MM documents are the documents to be used in the assessment session according to the previously defined aspects (point 1-6). Several documents that need to be prepared are:

   - **ITI-MM's model and level descriptions**. This document contains the ITI-MM model and level descriptions. It is created as a separate document in order to make it easier for participants to refer to whenever they want to see the description of each maturity level.
   - **ITI-MM's capabilities list and description**. To provide a deeper understanding, even if the participants might already be familiar with them, users need to prepare a document containing a list of the assessed *capabilities* and their respective descriptions. It should include some additional examples in order to better clarify each *capability*.
   - **ITI-MM's assessment form**. Since participants need to decide the maturity score of each *capability* as well as give suggestions for improvement, users need to prepare an assessment form, which has already been adjusted according to the assessed *capabilities*. Figure 20 depicts an example of assessment form that users may employ.

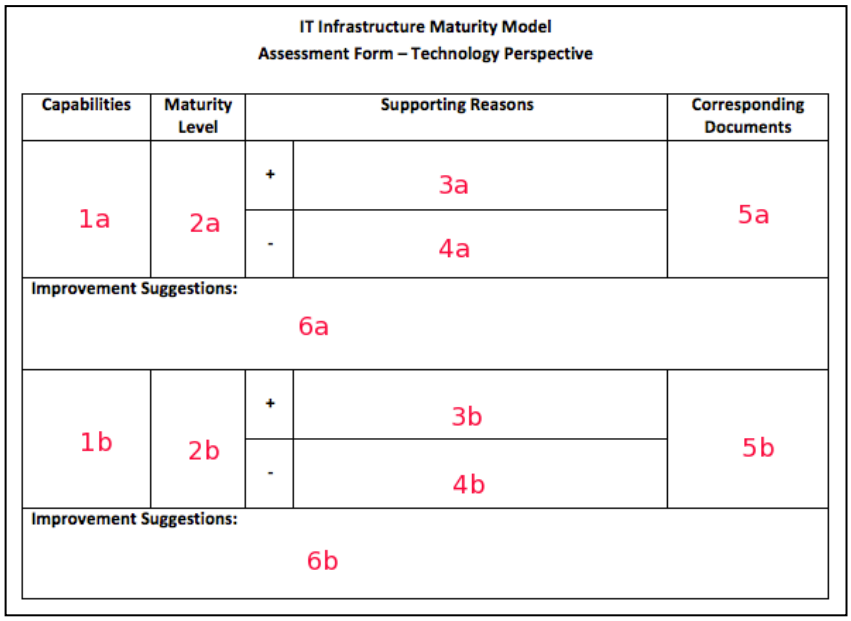


**Figure 20: An ITI-MM's assessment form example**

**Form description**:

- **1a and 1b**: These are the areas where users put the assessed *capabilities*.
- **2a and 2b**: These are the areas where the participants define the maturity level of the assessed *capabilities* based on their consensus.
- **3a and 3b**: These are the areas where participants write the strengths of the assessed *capabilities*.
- **4a and 4b**: These are the areas where participants write the weaknesses of the assessed *capabilities*.
- **5a and 5b**: These are the areas where the participants register the corresponding documents they know or have in the relation with the assessed *capabilities*.
- **6a and 6b**: These are the areas where the participants will define the suggested improvement action plans based on their consensus.

**8. Access to internal IT documents**

Users also need access to internal IT documents relating to the assessed *capabilities*. These documents could also be analyzed during the discussion, to check whether they are still applicable and/or able to support the achievement of the intended maturity level. The participants should refer to those documents in the assessment form.

**9. Assessment Arrangements**

Every assessment session needs to be well prepared. Time frame, location, participant's presence, etc., are important to include. To optimize the response during the discussion, users need a supportive environment, which usually is related to location settings and time arrangements. It is advisable that all participants are informed about the content and receive the documents users have prepared at least one week before the assessment day. A confirmation of each participant's presence is also important to ensure the optimum outcome.

### 6.4.2 Assessment

During the assessment session, three discussion phases need to be handled by the assessment leader(s):

1. **Open questions phase**
   In this first phase, the leader(s) can use an open-ended question such as: "*What do you think about our current capability or ways of working*?" or "*How mature does this capability work in our organization*?" This kind of question allows the participants to talk openly and freely about their current capability and ways of working without any boundaries.

2. **Control questions phase**
   Within the second discussion phase, leader(s) can use the guiding questions available in each *perspective*. With those questions, the leader(s) start to guide the process towards a conclusion on the current maturity level for each *capability* being assessed. During this phase, ideas to improve the maturity will also appear to surface, and the leader(s) should write them down.

3. **Confirmation questions phase**
   By the end of an assessment session, leader(s) should ask for confirmation from all participants on the current ITI-MM maturity level along with their ideas for improvement initiatives. Reaching agreement or consensus from the participants is crucial in this phase.

Leader(s) should also emphasize the goals users want to achieve, especially during the discussion. It helps keep the session under control since the open-ended questions structure has the tendency to drive the discussion away from the initial topic. Here, the leader(s)' competency in moderating the discussion is very important.

### 6.4.3 Post-Assessment

Unlike other maturity assessments where the assessors decide on the corresponding maturity level, in ITI-MM, the leader(s) only need to summarize and write a report on the results after doing an assessment. This is possible because the participants themselves have already defined the level of maturity and the improvement action plans that need to be taken. Leader(s) can offer additional insights based on their observation and notes, but are not to change the essence of the agreed consensus. Afterwards, leader(s) have the obligation to send all documents to the participants and ask for their confirmation. If there are no objections or further feedback, their responsibility in the assessment is finished.

## 6.5 Assessment Samples

In order to provide a better understanding on how ITI-MM can be used in practice, Appendix D provides several samples of *perspectives* used to assess one *capability*, **Electronic Mail**. It also shows how different *perspectives* contribute to different maturity scores. At the end of the assessment session, the participants need to use those numbers and lines of reasoning as argumentation to conclude the rational maturity score of the *capability*. Each *capability* can only have one maturity score.

## 6.6 Summary

ITI-MM is an assessment maturity model that can be used by its users without any external assessors involvement. Its open discussion methodology results in a greater impact, because both IT infrastructure service provider and customer assess together. During the discussion, participants assess their infrastructure by scoring each *capability*, from 1 to 5, using one or more *perspectives* to help them shape their ways of thinking.

ITI-MM also gives a freedom and flexibility to its users in how they are going to employ it when assessing their infrastructure. Users can define their own goals, participants, *capabilities* to be assessed, *perspectives*, etc. They can adjust the ITI-MM to fit their internal culture without deviating too far from its default settings.

At the end of an assessment session, users end up with only a single maturity score for each *capability*. This final score is a result of the consensus reached by the participants using each *perspective*'s score and their lines of reasoning as argumentation.

# Part III

# Validation

# 7 Pilot Assessment

## 7.1 Introduction

ITI-MM is designed to help organizations understand the gap between the current and intended IT infrastructure, so they can develop better improvement plans and implementations. To evaluate and prove its applicability in a real-case scenario, a pilot assessment must be undertaken. By applying ITI-MM in this pilot assessment, and analyzing how its users perceive its applicability, one can measure whether the model is ready and applicable for practical fields.

This chapter presents the pilot assessment conducted with several experts from DT. It appraised two *capabilities* identified according to the Assessment Guidelines defined in Section 6.4. Using a focus group discussion setting, the pilot expects to produce an initial acknowledgement from these IT infrastructure practitioners on how ITI-MM's approach can facilitates an infrastructure's improvement. It is also interesting to see whether they are willing to utilize ITI-MM inside their organization, and to receive feedback on improvement ideas for the model itself.

In the remainder of this chapter, the assessment settings followed are described (Section 7.2), the perceptual evaluation conducted at the end of the assessment session is introduced (Section 7.3) and the results gained are discussed (Section 7.4). Furthermore several recommendations on how DT can improve its infrastructure, together with several suggestions it may follow to implement ITI-MM in the future are published (Section 7.5). Finally, Section 7.6 summarizes the chapter.

## 7.2 Assessment Settings

In this section we discuss the settings followed when preparing, conducting and concluding the pilot assessment based on the ITI-MM Assessment Guidelines described in Section 6.4.

### 7.2.1 Pre-Assessment

During this preparation phase, before the pilot assessment session was conducted, several important points were worked on, such as:

1. **Goals**
   Together with the company project supervisor, the pilot assessment's goal was defined as "testing ITI-MM's applicability within DT's context". It was desirable to evaluate whether ITI-MM's model and assessment method were useful for further development and use in the company.

2. **Target Groups**
   Since we planned to assess the complete ITI-MM philosophy, both IT infrastructure service provider and customer within the DT organizations were invited. The purpose was to address the problems they experience while serving business requirements using IT infrastructure.

3. **Key Capabilities**
   In order to obtain balanced views during the discussion, it was decided to assess two *capabilities* thought relevant to technical architecture scope within DT: *Server and Storage Management*, and *Network and Operating System Security*

*Management*. These two *capabilities* were also selected in order to further develop an organic discussion coming from the participants in the first focus group meeting. *Capabilities* that might be interesting for them, related to their responsibilities in data center operations, network, and security areas, were used.

4. **Participants**
   Of the twenty-five people first contacted, three attended the focus group discussion held on 1 June 2010 and at the end committed to join the pilot assessment, to see how ITI-MM really works. There were however, responses from several others who could not attend this first meeting, expressing their curiosity. Therefore all twenty-five invitees were again contacted after the session and four finally participated in the pilot assessment.

5. **Assessment Leader**
   For this pilot assessment it was agreed that the thesis project supervisor from the company act as leader. This is based on the fact that the two *capabilities* are part of his responsibility in the company. Given that he is not connected directly with the daily operations of both *capabilities*, his neutrality during the discussion could be assured.

6. **Assessment Perspectives**
   Given the goal to test the entire ITI-MM, all five *perspectives* were included.

7. **Adapted Assessment Documents**
   For this pilot assessment we prepared a document that includes:
   - Goals and remarks the participants need to prepare before coming to the assessment session
   - ITI-MM model and level descriptions
   - Assessment form, which encompasses the *capabilities* description and modified sets of questions for each *perspective* being used. The guiding questions can be found in Appendix E as part of the assessment form and results.

8. **Internal IT Documents**
   Because of the time limitation, and given the supervisor's work activities, it was not possible to provide access to all internal documents available related to the two *capabilities*. It was only possible to discuss which documents needed to be included in the discussion the night before the assessment day. Furthermore, it was impossible for participants to prepare them in time since the supervisor could only send the assessment document to all invitees the day before. Many documents are scattered across different locations and require different levels of access.

9. **Assessment Arrangements**
   Based on the first focus group meeting, it was agreed to hold the pilot assessment on 15 June 2010, at the same location. As described above, three participants committed to come. Therefore it was assumed that the discussion would run smoothly because they already knew each other and all shared the same vision of the ITI-MM.

### 7.2.2 Assessment

On the assessment day, there were four participants present. They came from different organizations within DT.

Before starting the assessment discussion, another presentation about the background of ITI-MM's development was given primarily for the benefit of the new participant who was not present at the first focus group session. The revisions made to the initial ITI-MM's design, based on their feedback were also presented.

While presenting the goals of the pilot assessment, one participant raised an issue about the content of the session. In his opinion, we were not discussing the real business case, and therefore the day's results could not be used as the real business case decision.

He also suggested we take one sample application as a case study, because DT's IT infrastructure could be very complex. He suggested it might be easier to drill down into the infrastructure focusing on one running application in the company. In response, another participant suggested assessing how the IT infrastructure supports SINTEL, an internal SAP-based financial system.

All the participants were there because of their experience and knowledge. However, since they work at a higher-level within the organization, the possibility was great that they could not be completely familiar with the daily core operations of IT infrastructure. Furthermore, managers in DT's business units work differently. They were there only to assess whether DT could use ITI-MM in the future.

The assessment discussion started with *Server and Storage Management*. The pilot assessment ended by asking the participants' views on ITI-MM's usability for the company. The details on this usability test will be further discussed in Section 7.3.

The entire assessment session was recorded using an audio recorder for further analysis.

### 7.2.3 Post Assessment

Not many activities followed the assessment session, only the recorded discussion was transcribed. However, as agreed to in the first focus group discussion, the fully transcribed audio recording is not opened and presented in this thesis. Using the transcription, together with notes taken during the session, the assessment form was completed. It was not possible to put the discussion comments directly into the form because of the limited time available for each *perspective*. The assessment results in the assessment form format can be found in Appendix E.

## 7.3 ITI-MM Usability Evaluation

In order to see how the pilot assessment's participants perceived the ITI-MM's model, assessment method, and results, they were asked several questions adapted from the Method Evaluation Model (MEM) created by Daniel L. Moody [42]. This evaluation method was used to see whether they are willing to use the ITI-MM in the future.

According to Moody [42], subjective perception plays a much more important role than objectively measured evidence when deciding whether to use a particular method or not. This is primarily due to the element of free will or intention in human behavior. Decisions

are based more on *how effective people think* a method is rather than on how effective a method is.

Table 10 lists the questions asked. They were constructed based on the three perception based variables defined in MEM [42]:

- Perceived Ease of Use (PE): the degree to which a person believes that using a particular method would be free of effort.
- Perceived Usefulness (PU): the degree to which a person believes that a particular representation method will be effective in achieving its objectives.
- Intention to Use (IU): the degree to which an individual intends to use a particular method.

**Table 10: Questions for ITI-MM Perception Evaluation**

| Questions | PE | PU | IU |
|---|---|---|---|
| 1.(a). Are the maturity scores reached in this session useful to you as a status picture of the current infrastructure?<br><br>(b). The improvement plans derived in this assessment session, are they useful for operational IT infrastructure management improvements?<br><br>Why or why not? | | √ | |
| 2. ITI-MM uses people's consensus to reach a maturity level score of an IT infrastructure. It also encourages discussion between assessment participants. However, other maturity models often use questionnaires to obtain a score.<br><br>Do you find the current ITI-MM assessment method appropriate? Or do you prefer a tool that collects numerical values from the assessment participants, without the need to meet each other?<br><br>Which one is better, scores from discussions or scores from questionnaire answers? And why? | √ | √ | |
| 3. ITI-MM produces optimal benefits in the case of a joint-self-assessment between the IT infrastructure service provider and customer. Although undertaking a separate assessment, based on one's own goals, is possible too, ITI-MM urges the service customer and provider to meet each other at the same time.<br><br>Do you think this setting helps you? Why or why not? | | √ | |
| 4. ITI-MM is intended as a self-assessment tool without an external assessor requirement.<br>After this session, would you be able to do or replicate the assessment by yourself in the future?<br><br>Why or why not? | √ | | |

| | | | |
|---|---|---|---|
| 5. (a). Would you use ITI-MM when there is a need to develop an improvement roadmap for IT infrastructure? Why or why not?<br><br>(b). Would you recommend ITI-MM to others when there is a need to assess IT infrastructure? Why or why not? | | | √ |

## 7.4 Pilot Assessment and Perception Evaluation Results

### 7.4.1 Pilot Assessment Results

***-Confidential-***

### 7.4.2 Perception Evaluation Results

Below is a summary of the pilot assessment participants' answers based on the questions listed in Table 10 – Section 7.3:

- **Question 1**
  As long as it is acknowledged that the pilot assessment only tests ITI-MM's applicability within the DT context and that its results do not reflect real business case decisions at DT, the results can be considered useful. Lots of perceptions arise on how each *capability* actually works in the company. The participants found the open environment conducive to getting results. The results might have been different if external assessors had conducted the session, because many topics would have been impossible to discuss due to internal security reasons.
  The SINTEL manager participant found the setting of the pilot assessment interesting. He was able to see much deeper into the vertical level of infrastructure where his application runs. Exchanging experiences between participants was also inducive to producing useful results.

- **Question 2**
  During the assessment session, the participants found the number scaling problematic because of the open-discussion method used in ITI-MM. However, they also argued that this method produces more realistic and better results since all numbers produced are backed-up with detail justifications. The discussion also forced people to spend more time thinking further about their answers, unlike questionnaires with fixed-numbers, which might be filled in only in seconds or minutes.
  Two participants argued that it would be interesting for them to see the combination of both direct scoring and discussion methods. They think the evaluation value produced by mathematical calculation compared to the consensus might allow deeper analysis. The discussion method also allows other aspects to influence the results, such as personal mood, surroundings phenomena, etc.

- **Question 3**
  This question was difficult to answer. They even asked whether business people would be interested in IT infrastructure. They argued that most business people

are usually only interested in the result of IT infrastructure services, which they can monitor and assess through SLAs. However, they might still join an assessment session if the goal is to evaluate something that is located in the interface area between a business application and the underlying infrastructure.

- **Question 4**
  All the participants think they can replicate the assessment session themselves in the future without external assessors. For them, ITI-MM is simple and easy to understand. However, there are several key points they need to prepare, such as: experienced and neutral moderators who have already worked in the group for a couple of years, and possibly professional moderators who can produce sets of questions that are easy to understand by the future participants. Furthermore, these future moderators will also need to act carefully, since in a real business setting many aspects will make the discussion more difficult, for example: the relationship between the participants and their suppliers or solution vendors.

- **Question 5**
  All the participants confirmed that they are willing to use ITI-MM in the future, although once a year might be enough to see whether the development processes undertaken really worked. Further, they even see the possibility of using ITI-MM's concept in their own fields, beyond infrastructure, because several elements of ITI-MM are generic enough to be used in other areas of IT. However, they could not give a final recommendation for ITI-MM's use in DT, since they are not in the position to assess the company's IT infrastructure. They suggested running the assessment session once again with people from the core infrastructure operations.

Based on their answers, in general it can be concluded that ITI-MM's model and assessment method are applicable for use in DT. The participants acknowledge that the model is simple and easy to understand. They also expressed their willingness to utilize ITI-MM in the future, beyond the scope of IT infrastructure.

## 7.5 Recommendations for DT

### 7.5.1 Recommendations on Infrastructure Improvements

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### 7.5.2 Recommendations on ITI-MM's Development and Utilization

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## 7.6 Summary

This chapter discussed the pilot assessment conducted to evaluate ITI-MM's usability in a real-life context. That is, two *capabilities*, which are part of the technical architecture scope within DT were appraised: *Server and Storage Management* and *Network and Operating System Security Management*.

Based on the assessment settings followed, the results of the pilot assessment and several recommendations that might be followed by DT to improve their infrastructure were presented. It also offered several recommendations in case DT wishes to develop ITI-MM further and implement it in their organization.

A perception-based evaluation method was used to determine people's perceptions about the model, the assessment method, and the results. According to their answers, ITI-MM is viewed as ready and applicable to be used in practice.

# Part IV

# Conclusion

# 8 Discussion and Future Work

Bringing IT infrastructure towards a particular desired level is not as easy as it sounds. This kind of improvement requires an active effort to evolve an infrastructure over time – a long-term strategic plan for the infrastructure. And a maturity model can help realize this goal. By assessing current infrastructure against the norms in each maturity level, organizations can identify the gap between their current situation and the one they want to obtain. Identifying the gap gives organizations the opportunity to develop better improvement plans that focus on what really matters to them.

Setting out not to "reinvent the wheel", this research selected the appropriate maturity models already described in the literature (Section 3.1). Using a set of evaluation criteria (Section 3.2.1), eight models were compared and two prominent ones were chosen as the result: NIMM™ and GIMM (Section 3.2.2). However, since neither of the two fulfills the criteria completely, both models were combined to form the core design of our new model, ITI-MM (Chapter 4).

Based on the two empirical studies carried out (Section 5.2 and Section 7.2), we conclude that ITI-MM is ready to be used in a real-life context, particularly within DT. In the pilot assessment conducted with several DT experts, ITI-MM proved itself as a simple and easy to understand maturity model. The results provided participants with a better understanding of their current infrastructure and enable them to produce better improvement ideas. The perception evaluation (Section 7.3), ascertained a higher level of people's awareness about what role a maturity model concept can play in other areas beyond IT infrastructure. These findings justify our argument that a maturity model can offer the solution to solving DT's problems.

In this chapter, more details concerning several reflective outcomes generated throughout the whole research process are discussed. It begins by answering all the research questions posed in the beginning, and continues by discussing the resulting contributions for both scientific and practical fields. Further, it describes the limitations and future potential research directions that might be followed by other researchers.

## 8.1 Revisiting the research questions

Since ITI-MM's development began by defining a set of research questions, it is important to revisit and see whether the processes followed answered them appropriately.

**RQ1: What is an IT infrastructure? What are the components that build it?**
In Section 2.1.1, several definitions of IT infrastructure were reviewed. According to Byrd and Turner [6], IT infrastructure is *"…the shared IT resources consisting of a technical physical base of hardware, software, communications technologies, data, and core applications and a human component of skills, expertise, competencies, commitments, values, norms, and knowledge…"*. Based on this definition, Weill and Vitale [3] conclude that an IT infrastructure consists of four components: IT components, shared IT services, shared and standard applications, and a human component (see Figure 3 – Section 2.1.2).

**RQ2: What IT infrastructure maturity models are available? What are the criteria to evaluate them?**
During the literature study, eight maturity models, built for assessing an organization's IT infrastructure were found (Section 3.1). They range from frameworks that cover partial to

complete aspects of the IT infrastructure. Based on the initial problem description, theoretical foundation and characteristics of future infrastructure any organization needs to attain, six comparison criteria were defined (see Table 7 – Section 3.2.1). These were then used as an evaluation tool in selecting the best possible solution. The criteria are structured in such a way as to describe what an IT infrastructure MM should include and what an IT infrastructure, covered by the MM, should look like at the highest maturity level.

Based on these criteria, two prominent models were identified, which together formed the core design of ITI-MM: the Gartner Infrastructure Maturity Model (GIMM) and the NHS Infrastructure Maturity Model (NIMM™).

**RQ3: What is the IT Infrastructure Maturity Model (ITI-MM)? What are the elements that compose the ITI-MM?**
Developed by combining two prior assessment approaches (see Chapter 4 for the design process, and Chapter 5 for *domains* and *capabilities* validation), ITI-MM is a model that describes an IT infrastructure's maturity in five incremental stages: *Basic*, *Controlled*, *Standardized*, *Optimized*, and *Innovative* (see Section 6.1). It is built on four building blocks: *levels*, *domains*, *capabilities*, and *perspectives*. *Levels* and *domains* illustrate what an IT infrastructure organization should look like at each maturity level, while *capabilities* break down all the technical components and processes that an IT organization possesses. *Perspectives* describe sets of questions, used as guidance tools to shape the assessment participants thinking.

Different from other maturity frameworks that might use sets of questionnaires and involve assessors from external organizations, the ITI-MM urges an organization to carry out internal discussions between IT infrastructure service providers and customers. This method prioritizes people's consensus over maturity scoring.

**RQ4: How to prove the validity of ITI-MM?**
In order to validate the model, two focus group discussion sessions with several experts from DT were conducted. The first one was done in order to validate ITI-MM's *domains* and *capabilities* (Section 5.2 and 5.3). After several revisions, a pilot assessment workshop was held in order to evaluate its applicability in a real work setting. Several perception-based questions were also asked, to ascertain whether ITI-MM is appropriate to be used and further developed by DT (Section 7.3).

The conclusion from those two sessions is that the ITI-MM is considered applicable for use and further development by DT.

## 8.2 Contributions

This thesis makes several contributions to both the practical and scientific fields. The first one is the ITI-MM itself. The pilot assessment conducted, proves ITI-MM applicability in a real case scenario, not just as a theoretical model. Although ITI-MM does not directly solve DT's problem, it can be seen as the first step in helping the company improve its services and support the achievement of their business goals. It helps the company develop a better strategic plan for their infrastructure evolution.

Given that the ITI-MM was designed by combining NIMM™ and GIMM, the second contribution of this thesis is empirical proof of the claim by NIMM™'s creator, about its

applicability outside NHS organizations [32]. Although it was built for use in a healthcare organization environment, NIMM™'s concept is also applicable in other industries. *Domains*, *perspectives*, and some *capabilities* from NIMM™ are considered important as well for DT, a telecommunication company. Together with GIMM, developed for broader industries' application, the ITI-MM has its chance to be used by others as well.

In this thesis Santana Tapia's maturity model development process [36] was adopted. Although not used structurally as presented in its original publication, here it is argued that the process is suitable when developing and describing the structure of a maturity model. Other researchers, with the same research objective of developing an MM, can use this systematic approach.

An additional *domain*, **Ecosystem Relationship**, added to the initial design of ITI-MM, can also be considered as a contribution to the socio-economics field. As more and more researchers and practitioners recognize the importance of social business relationships, in order to face the challenges in the current and future knowledge economy world [44], DT's acknowledgement of this *domain*'s relevance proves its significance. Although it has not been tested further, this new *domain*'s description at each maturity level can be seen as the first step in developing improvement stages to support a business ecosystem's development.

### 8.2.1 IT Governance and Enterprise Architecture

ITI-MM also brings significant implications on IT Governance and Enterprise Architecture. It supports organizations running the effective IT Program Management, and helps IT Architects to define the Target Technical Architecture along with its roadmap.

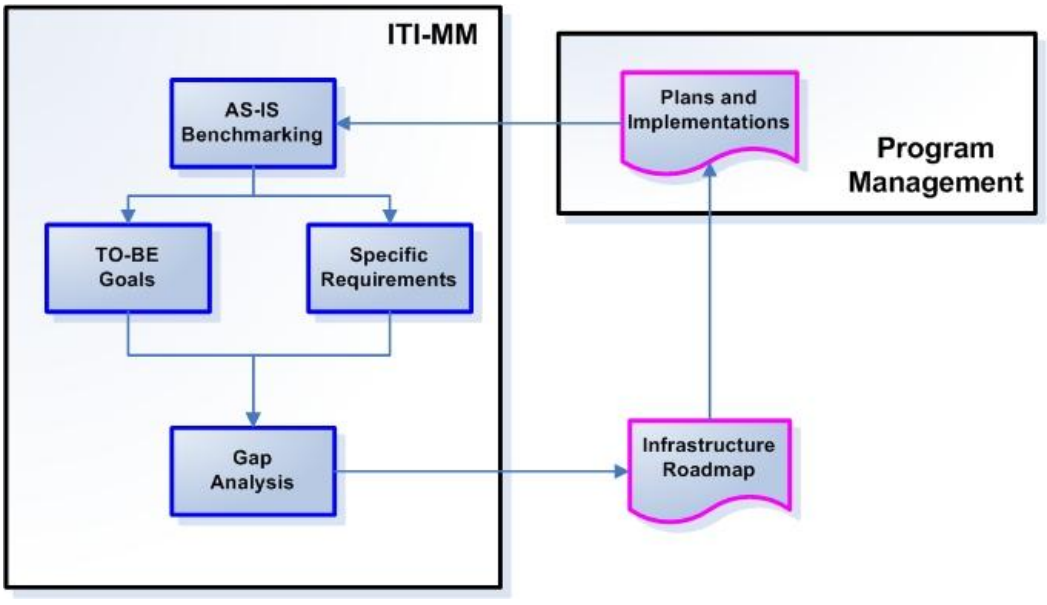


**Figure 21: ITI-MM for effective Program Management**

IT Governance, by Weill and Ross, is defined as specifying the decision rights and accountability framework to encourage behavior in using IT [59]. For them, IT Governance always encompasses five major decisions: the IT Principles, IT Architecture, IT Infrastructure, Business Application Needs, and Prioritization and Investment [60]. When an organization performs IT Governance well, the results will be reflected in delivering IT projects' value on time, with the appropriate functionality and the intended benefits [62]. In reality, although IT investments can be aligned with the business strategy, they might

still unable to deliver the required business value. For this reason, an effective IT Program Management, which is the coordinated management of interdependent IT projects over a finite period of time, is needed [61]. Figure 21 illustrates how ITI-MM can be used by organizations to run the effective IT Program Management. It helps them prioritizing their IT investments by focusing only on the projects that are essential to the business. The infrastructure roadmap produced helps the organizations to plan and implement improvement projects better, since it is built upon the real gap they face.

Further, as Enterprise Architecture (EA) is also considered important in providing a long-term view of an organization's processes, systems, and technologies [64], EA function commonly determines end-to-end target architecture, and develop the roadmaps of change over time [63]. Defining the baseline and target architecture before drawing the roadmaps are also the best practices mentioned in TOGAF, the *ad-hoc* EA framework used by many organizations [8]. Therefore, ITI-MM helps the IT Architects in defining the Target Technical Architecture and its roadmap, since it can be used as a reference model for IT infrastructure development.

## 8.3 Limitations

There are several limitations that might have influenced the results of this research in one-way or another. They are:

1. **Number of validation sessions and their participants**.
   Due to the time limitation, it was only possible to conduct one focus group discussion to verify ITI-MM's *domains* and *capabilities*, and one pilot assessment session. The participants were also limited, only three and four experts at each session. Although it can be considered sufficient for this kind of qualitative research, the results might not be representative enough given DT's complex and diverse business units.

2. **Flaws in the pilot assessment session**.
   The pilot assessment conducted did not completely conform with ITI-MM Assessment Guidelines (see Figure 19 – Section 6.4). DT's IT documents were not discussed and most of the participants represented the IT infrastructure service provider, or at least heavily leaned in that direction rather than the business side. Without the presence of business people, especially those responsible for defining an application's business requirements, it was not possible to observe the real benefits of having a *joint-self-assessment* session, which is what ITI-MM focuses on.

## 8.4 Possible Directions for Future Work

Given the model's potential for use beyond that presented in this thesis, it is perhaps useful to mention areas of future research here.

1. **Further validations**.
   Since ITI-MM may be applicable in other sectors besides telecommunication and healthcare (which DT and NHS form part of), further empirical research is needed to validate its applicability. This research might include generalizing sets of *capabilities* that are applicable to many industries. To increase its acceptance, consideration should be given to using MEM's statistical approach [42].

2. **Scoring Method for ITI-MM**.
   Although ITI-MM focuses on gaining consensus among participants rather than producing a maturity score, the possibility to include a scoring methodology without prior discussion could be explored. As two participants in the pilot assessment acknowledged, it might be interesting to analyze whether both methods derive different maturity scores. Many cases illustrate how people tend to overvalue or undervalue the services being delivered.

3. **ITI-MM KPIs**.
   In Section 5.3 it was argued that sets of KPIs are unique for each organization. And although there are not many common KPIs available for IT infrastructures, it would be interesting to see whether those KPIs, or any other new development, can be included in ITI-MM's model description (especially for each *domain*'s quantitative measurement).

4. **ITI-MM Monitoring Tools.**
   Big organizations such as DT usually have a very broad range of infrastructure *capabilities*. Given ITI-MM's assessment setting, which utilizes discussion to enable deeper analysis of each *capability*, it may not be possible to cover many *capabilities* in one assessment session. Two to three per session is recommended. Tools that can track the *capabilities* assessment progress and monitor improvement plans undertaken as a result, might be useful for ITI-MM's users.

5. **ITI-MM vs. Other Frameworks or Standards**.
   There are many frameworks available related to IT infrastructure and its management. For example: TOGAF for Enterprise Architecture, ITIL for IT service management, etc.
   Although ITI-MM is built specifically to assess IT infrastructure, its application and discussion approach touch upon many aspects beyond this area. Process management, business requirements, etc. are some areas that ITI-MM's users need to consider during the assessment sessions. Studying its correlations with other frameworks and standards might help researchers and practitioners develop a better application of them. Many frameworks and standards are not yet operational.

6. **ITI-MM and Business-IT Alignment**.
   As ITI-MM urges its users to reach a consensus between IT infrastructure service provider and customer in order to develop an improvement action plan, the model can also provide a way to help organizations align business and IT. Another interesting topic to study could be whether ITI-MM could also be employed to assess an organization's business-IT alignment.

# Appendices

# A DT Corporate IT Structure

***-Confidential-***

# B Interviews

In this section we described the interview questions we prepared for problem investigation. The corresponding answers are confidential.

## B.1 IT Organization and Enterprise Architecture

1. What is the role and responsibility of IT Governance – Group Enterprise Architecture (GEA) within DT?
2. What is the line of authority between GEA and other IT functions in the business units?
3. What GEA working results influence other IT functions in business units?
4. To what extend are the work results of GEA followed by other IT functions in business units?
5. Does DT already have defined principles and goals, related to IT Architecture and maybe Enterprise Architecture, they want to achieve or that need to be followed by all the business units?
6. If yes, what is their status right now? To what extend do business units comply with those principles and goals?
7. In GEA's point of view, what problems do T-Systems and other business units related to IT Infrastructure services face?
8. In GEA's point of view, what is the impact of this problem (for T-Systems, other business units, and DT as a group)?
9. In GEA's point of view, what is the root cause of this problem?
10. Which stakeholders within DT are interested or affected by this problem, and could be influenced as well with the derived solution?
11. What are those stakeholders' role and responsibility in relation to the problem?

## B.2 Problem Investigation

### B.2.1 IT Service Customer

1. What IT functions running in your organization are not outsourced to T-Systems?
2. What is your main concern related to IT services provided by T-Systems?
3. What do you see as the current problem with services provided by T-Systems?
4. How does the problem affect you?
5. What is a possible solution to the problem?
6. With respect to communication, how do you usually communicate with T-Systems? What forms or documents do you use to monitor the services they provide?
7. What forms or documents do you usually get from T-Systems regarding the services they provide?
8. What document components for points 6 and 7 do you consider very important? And what do those components mean?
9. What do you need from T-Systems as service provider to improve in the future (in terms of services and communication)?
10. What things do you need DT's Group Enterprise Architecture to produce in order to help you manage problems and provide solutions?

### B.2.2 IT Service Provider

1. What IT functions or services do you provide to for other business units?
2. What primarily concerns you in relation to the services that you provide to other business units?
3. What do you see as the current service problem when providing services to other business units?
4. How does the problem affect you?
5. What do you see as a possible solution to the problem?
6. With respect to communication, how do you usually communicate with other business units? What forms or documents do you use to promote your services and ask about their needs?
7. What forms or documents do you usually receive from other business units regarding the services they want?
8. What document components in points 6 and 7 do you find very important? And what do those components mean?
9. What do you need the service consumer in other business units to improve upon in the future (in terms of requirements and communication)?
10. What things do you need DT's Group Enterprise Architecture to produce in order to help you manage problems and provide solutions?

# C ITI-MM Capabilities

In this section the list of infrastructure capabilities derived from the Deutsche Telekom AG case study is presented.

## C.1 Business Classes

### Governance

| | |
|---|---|
| IT Infrastructure Governance | The mechanisms specifying a decision rights and accountability framework to encourage desirable behavior in using IT infrastructure. |
| IT Infrastructure Strategy and Planning | The mechanisms that support specifying strategies and action plans in developing, maintaining, and using IT infrastructure. |
| IT and Business Alignment Strategy | Strategy that helps to achieve a desired state in which a business organization is able to use information technology (IT) effectively to achieve business objectives – typically improved financial performance or marketplace competitiveness. It could also be referred to as the harmony between IT and business strategies. |
| Collaboration and Knowledge Management Strategy | The mechanism specifying strategies to encourage and exploit the practice of knowledge management and a collaborative working style using the underlying IT infrastructure. |
| Product/Service Catalogue | A list of products or services offered by the underlying IT infrastructure. |
| Infrastructure Architecture | The topology of the deployment environment including protocols, security levels, and services. This architecture provides a logical mapping to the deployment environment, such as the data center. |
| IT Service and Business Continuity | The process of assessing and managing risks associated with IT organizations services. It involves the evaluation of values, threats, risks, vulnerabilities and development of countermeasures to ensure continuation in the event of a disaster. |
| Naming Convention | It is a convention for naming things. It can be how to name a user and resource attribute. |

### Procurement

| | |
|---|---|
| Supplier and Vendor Strategy | Strategy for selecting solution vendors and products or services from suppliers according to an organization's business objectives. |
| Procurement Strategy | Strategy for ordering, buying, and developing solutions together with suppliers and partner vendors, based on an organization's internal roadmaps. |

## People and Skills

| | |
|---|---|
| IT Staff Training | It is a series of connected education and training programs and support services that enable IT staff to secure their employment, and to advance over time to successively higher levels of education and employment. |
| IT Staff Performance Management | The activities and mechanisms to ensure that IT staff consistently meet the organization's goals and objectives in an effective and efficient manner. It is based on the principles of measurement, appraisal, action and monitoring. |
| IT Workforce Development and Planning | The activities and mechanisms used to predict and supply the future demand for different type of IT staff and skills needed by organization, so as to achieve greater success for both individuals and employers. |
| End User Training | The process business users employ to learn how to use and exploit the underlying IT infrastructure supporting their daily works. |

## Value Management

| | |
|---|---|
| TCO Management | The mechanisms to calculate and manage the total costs of purchasing and operating a technology product or service over its productive life cycle. |
| ROI Management | The mechanisms to calculate and manage the ratio of money gained or lost on IT infrastructure investment relative to the amount of money invested. |
| Portfolio Management | The application of systematic management to classes of items managed by an IT organization by enabling measurement and objective evaluation of investment scenarios. |
| Industry Accounting System | A system or mechanism for standard products in order to manage organization's cost model. |
| General Cost Consideration | General cost generation factors put into IT services and products starting with their requirements until testing and operations. |

## Processes and Automation

| | |
|---|---|
| Infrastructure Processes Documentation | The mechanisms to create and manage documents related to IT infrastructure processes. |
| Infrastructure Processes Automation | The mechanisms or technologies being used to monitor and manage IT infrastructure processes automatically. |
| Infrastructure Processes Quality Management | The mechanisms to control, assure, and improve the quality of IT infrastructure processes being delivered. |

## C.2 Technology Classes

### Patterns and Practices

| | |
|---|---|
| Change Management | The mechanisms to ensure that standardized methods and procedures are used for efficient and prompt handling of all changes to a controlled IT infrastructure, in order to minimize the number and impact of any related incidents upon service. |
| Infrastructure Configuration Management | The mechanisms that focus on establishing and maintaining consistency of a system's or product's performance and its functional and physical attributes with its requirements, design, and operational information throughout its life. |
| Release and Deployment Management | It is a software engineering process intended to oversee the development, testing, deployment and support of software releases. The practice of release management combines the general business emphasis of traditional project management with a detailed technical knowledge of the systems development lifecycle (SDLC) and IT Infrastructure Library (ITIL) practices. |
| Knowledge Management | It is a range of strategies and practices used in an organization to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insights and experiences comprise knowledge, either embodied in individuals or embedded in organizational processes or practice. |
| Problem Management | The mechanisms to find and resolve the root cause of a problem and prevent incidents. |
| Incident Management | The mechanisms to restore normal service operation as quickly as possible and minimize the adverse effect on business operations, thus ensuring that the best possible levels of service-quality and availability are maintained. |
| Service Desk | The Single Point of Contact between the Service Provider and the Users. A typical Service Desk manages Incidents and Service Requests, and also handles communication with the Users. |
| Capacity Management | It is the discipline that ensures IT infrastructure is provided at the right time in the right volume at the right price, and ensuring that IT is used in the most efficient manner. |
| Availability Management | The practice of identifying levels of IT Service availability for use in Service Level Reviews with Customers. |
| Resource Strategy and Planning | The mechanisms that are used to plan the provisioning of infrastructure resources in order to fulfill an organization's business objectives. |
| Service Monitoring | An activity that provides an awareness of the state of a service. |
| Asset Management | All infrastructure and processes necessary for the effective management, control and protection of the organization's assets throughout all stages of their life cycle. |
| Testing | It is an investigation conducted to provide stakeholders with information about the quality of the product or service under test. |
| Resource Addresses and Names Management | The mechanisms to produce and maintain resource addresses and names based on standard norms and the defined naming convention. |

| | |
|---|---|
| User Names Management | It refers to the creation, maintenance and deactivation of user name attributes, as they exist in one or more systems, directories or applications, based on the defined naming convention. |

## IT Security and Information Governance

| | |
|---|---|
| Information Security Policies | Organizational documents that have usually been ratified by senior management and distributed throughout the organization to anyone with access rights to the organization's IT systems or information resources. |
| Data Security | The means of ensuring that data is kept safe from corruption and that access to it is suitably controlled. |
| Data Privacy | The relationship between collection and dissemination of data, technology, the public expectation of privacy, and the legal and political issues surrounding them. |
| Information security awareness, education, and training | It refers to training and other mechanisms to ensure employee awareness about security. It can be done via off-site security training or embedded in daily work systems. |
| User Access Management | Mechanisms to ensure authorized user access and to prevent unauthorized access to information systems. They include user registration, privilege management, user password management, and review of user access rights. |
| Network Security Management | Mechanisms to ensure the protection of information in networks and the protection of the supporting infrastructure. |
| Operating Systems, Applications, and Information Access Control | Mechanisms to prevent unauthorized access to operating systems, applications, and other information systems services. |
| Malicious and Mobile Code Protection | Mechanisms to detect, prevent, and protect information and its infrastructure from malicious code. Where the use of mobile code is authorized, the configuration shall ensure that the authorized mobile code operates according to a clearly defined security policy, and unauthorized mobile code shall be prevented from executing. |

## End User Devices

| | |
|---|---|
| Device Asset Management | All the infrastructure and processes necessary for the effective management, control and protection of end-user devices assets throughout all stages of their life cycle. |
| Device User Management | It is the means of ensuring and managing the relationships between users and their devices, including their rights to use. |
| Device Data Security | It is the means of ensuring that end-user device data is kept safe from corruption and that access to it is suitably controlled. |
| Device Asset Security | It is the means of ensuring that end-user devices are kept safe from theft and that access to them is suitably controlled. |
| Device Data Synchronization | Mechanisms to ensure that essential data in different user devices can be synchronized with one another in order to ensure a single working environment. |
| SIM Card Management | Mechanisms to manage SIM Cards that are produced, used, and distributed to end-customers. |

## Common Applications and Services

| | |
|---|---|
| Electronic Mail | A system of world-wide electronic communication in which a computer user can compose a message at one terminal which can be regenerated at the recipient's terminal when the recipient logs in. |
| Unified Communications | It is the integration of real-time communication services such as instant messaging (chat), presence information, Telephony (including IP telephony), video conferencing, call control and speech recognition with non real-time communication services such as unified messaging (integrated voicemail, e-mail, SMS and fax). Unified Communication is not a single product, but a set of products that provides a consistent unified user interface and user experience across multiple devices and media types. |
| Collaboration Applications | A collaborative application is a software application that (a) interacts with multiple users, that is, receives input from multiple users and creates output for multiple users, and (b) links these users, that is, allows some input of some users to influence some output created for some other users. |
| Knowledge Management Systems | It is an IT-based system for managing knowledge in organizations to support the creation, capture, storage and dissemination of information. |
| Location and Directory Services | It is the software system that stores, organizes and provides access to information in a directory. |
| Enterprise Content Management | It is an application or service that is used to capture, manage, store, preserve, and deliver content and documents related to an organization and its processes. |
| Enterprise Search | It is an application or service that makes content from multiple enterprise-type sources, such as databases and intranets, searchable to a defined audience. |
| Printing | It is an application or service that facilitates the process for reproducing text and image, typically with ink on paper. |
| Office and Other Nucleus Client Suites | They include any standardized applications that users have inside their desktop environment. |

## Infrastructure Hardware Platforms

| | |
|---|---|
| Server Management | It includes several issues, such as: reuse, resource delivery, and virtualization. |
| Storage Management | It includes several issues, such as: Storage Area Network (SAN), Network-Attached Storage (NAS), and storage policies. |
| Global-Local Data Center Set Up | It includes several issues, such as: security management, infrastructure architecture, and data privacy. |
| Operation & Maintenance of the platforms | |

## Infrastructure Software Platforms

| | |
|---|---|
| Operating System | It is the software on a computer that manages the way different programs use its hardware, and regulates the ways that a user controls the computer. |
| Middleware | Software facilities, other than the operating system, which provide services to an application program (i.e. anything which runs above the operating system, but below the application program). |
| Database | A logical collection of interrelated information that is managed and stored as a unit, usually on some form of mass-storage system such as magnetic tape or disk. |
| Containers | It is a class, a data structure, or an abstract data type (ADT) whose instances are collections of other objects. In other words, they are used to store objects in an organized way following specific access rules. |
| Run-Time Environments | The execution environment provided by the Process Manager and other system software services. |
| Messaging Services | It is a messaging standard that allows application components to create, send, receive, and read messages. It enables distributed communication that is loosely coupled, reliable, and asynchronous. |
| Lightweight Directory Access Protocol (LDAP) | A software protocol for enabling anyone to locate organizations, individuals, and other resources such as files and devices in a network, whether on the public Internet or on an internal intranet. |
| Network Time Protocol (NTP) | It is a protocol for synchronizing the clocks of computer systems. |

## Network Devices and Services

| | |
|---|---|
| Satellite Base Stations | |
| Sub-Marine Cables | |
| Microwaves | |
| Land Lines | |
| Wireless LAN | It is a network in which computers are connected to a shared access point using radio frequencies. |
| Fixed LAN | It is a network in which computers are connected through network cables. |

## Physical Infrastructure Location

| | |
|---|---|
| Power Management | It refers to managing the sourcing and utilization of power sources used to keep the facility functional. |
| Equipment Hosting | It includes the physical location where the infrastructure is located and its planning, designing, and managing process for optimal access and security. |
| Environmental Conditioning and Alert Systems | It includes controlling temperature, humidity, air quality, and ensuring that the infrastructure is free from environmental risks, such as fire, flooding, etc. |
| Physical Access Control | Mechanisms to prevent unauthorized access to physical location and infrastructure components. |

# D Assessment Samples

Here are several samples of perspectives used to assess Electronic Mail capability.

| Capabilities | Maturity Level | Supporting Reasons | Corresponding Documents |
|---|---|---|---|
| Electronic Mail | 2 | **Strengths**: To provide a new e-mail account the standard human resource management workflow is already followed. We also already manage the e-mail system as a single service centrally.<br>**Weaknesses**: Providing a new account can take 1-2 weeks. Each business unit has different management processes, which in turn produce different sets of data input into the e-mail management system. | E-Mail Users Management v5.doc |
| **Improvement suggestions**:<br>Standardize e-mail provisioning processes in all business units, including its data components. Automate e-mail request procedures in the HR department so that we don't need to re-enter the data manually into the e-mail management system anymore. | | | |

**Figure 22: Assessment Sample - Process Perspective**

| Capabilities | Maturity Level | Supporting Reasons | Corresponding Documents |
|---|---|---|---|
| Electronic Mail | 3 | **Strengths**: We use several security measurements including anti-virus to scan outgoing and ingoing messages; personal username and password, where every six months the password is changed. We also use connection and device authentication for users to open their email messages.<br>**Weaknesses**: Our e-mail system cannot be accessed via mobile phones and/or any public internet connection. This creates difficulties sometimes when employees are travelling. | E-Mail Security Management v4.doc |
| **Improvement suggestions**:<br>Improve e-mail accessibility by providing the ability to access the system via mobile handhelds or public Internet connections. For security reasons, a special token for this situation could be added. | | | |

**Figure 23: Assessment Sample - Information Security Perspective**

| Capabilities | Maturity Level | Supporting Reasons | Corresponding Documents |
|---|---|---|---|
| Electronic Mail | 3 | **Strengths**: IT personnel responsible for managing e-mail systems already follow the standard mechanism based on ITIL. We also employ the federated service desk for e-mail systems in our business units.<br>**Weaknesses**: Our e-mail system is still not embedded into our workflow systems. It's just not handy to have to use two systems every time we are going to send working documents for example. Its inaccessibility from our handheld devices is also problematic for those of us with high mobility. | IT-Service Desk Jobs and Responsibilities v2.doc |
| **Improvement suggestions**:<br>Try to embed the e-mail systems into other workflow systems. Make e-mail accessible via mobile handhelds. E-Mail problem tracking should be possible via the ticketing system. | | | |

**Figure 24: Assessment Sample - People and Organization Perspective**

| Capabilities | Maturity Level | Supporting Reasons | Corresponding Documents |
|---|---|---|---|
| Electronic Mail | 3 | **Strengths**: We use open standard protocols for e-mail service. We also provide several classes of e-mail service depending on user requirements.<br>**Weaknesses**: We use old-fashioned e-mail management tools. This makes it difficult to add, edit, or even delete e-mail accounts. | E-Mail Technology Standards v3.doc |
| **Improvement suggestions**:<br>Upgrade the management tools with the newest ones. Update the standard documents since their contents are no longer applicable to our current settings. | | | |

**Figure 25: Assessment Sample - Technology Perspective**

| Capabilities | Maturity Level | Supporting Reasons | Corresponding Documents |
|---|---|---|---|
| Electronic Mail | 4 | **Strengths**: In this company, e-mail is a very important communication tool alongside the telephone. We use e-mail heavily to communicate with our customers and partners. So far, we have never heard any complaints about our e-mail services, especially in terms of correspondence activities with our customers. They always receive our mails in their inbox, not in Junk or Spam folders.<br>**Weaknesses**: Our e-mail system isn't yet connected to our workflow systems, which we use heavily for our main jobs. We always need to write, attach, and send message including files manually. And given the very basic features offered, the service price is still too high. | E-Mail Service Plans v3.doc |
| **Improvement suggestions**:<br>Lower the service price and update the service plans document with the new structure. Embed our personal e-mail into our workflow engines. | | | |

**Figure 26: Assessment Sample - Business Value and Strategy Alignment Perspective**

# E Pilot Assessment Results

## E.1 Server and Storage Management

***-Confidential-***

## E.2 Network and Operating System Security Management

***-Confidential-***

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