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An Overlapless Problem Management Maturity Model For Multi-Framework Assessment (ITIL, COBIT, CMMI-SVC)

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Resumo

As Tecnologias da Informação (TI) expandiram-se drasticamente nas últimas três décadas mudando a forma como as organizações interagem, planeiam, projetam, entregam, operam e controlam os serviços de TI de forma a obterem vantagem competitiva e melhor custo-benefício melhorando os seus processos e medindo o desempenho para uma melhoria continua. Para alcançar a eficiência e eficácia operacional desejada, as organizações precisam adotar um ambiente estruturado. Muitas ferramentas de TI diferentes foram propostas para ajudar as organizações a se tornarem mais eficientes em termos de custo, gerindo a sua prestação de serviços. As ferramentas de TI apresentam algumas semelhancas, até chegam mesmo a partilhar alguns dos processos. A maior preocupação entre as organizações é obter o melhor de todas as ferramentas de acordo com suas necessidades de negócios e, por vezes, difíceis de implementar, as organizações acabam por fazer algum trabalho redundante e como também as ferramentas se sobrepõem umas às outras, tornam a sua implementação simultânea ainda mais difícil de ser realizada pelas organizações.

Esta tese propõe o desenvolvimento de um modelo de maturidade para o processo para a Gestão de Problemas (GP) que abranja as ferramentas de TI mais populares e usadas pelas organizações. A metodologia de pesquisa utilizada é Design Science Research (DSR). Entrevistas semi-estruturadas foram utilizadas em cinco organizações para demonstrar e avaliar a proposta. Esta pesquisa torna-se uma vantagem para o mundo profissional pois permite avaliar o estado actual de eficacia e eficiencia operacional da sua organização sem a sobreposicao, identificando tambem as etapas necessarias para a alcançar o nivel desejado. Por outro lado, esta pesquisa também é útil para o meio acadêmico porque distingue-se dos artefatos existentes por ser nova e inovadora, provando ser efetiva em cenários reais. No entanto, também é escalável porque sua pesquisa pode ser expandida para outros processos. Além disso, também reforça o problema de sobreposição das ferramentas e proporciona a consciencialização das organizações em relação ao nível real de maturidade do PM.

Palavras-Chave: Tecnologia da Informação; Gestão de servicos de tecnologia da Informação; gestao de problemas; itil; cobit; modelo de maturidade

Abstract

Information Technology (IT) has expanded dramatically in last three decades and changed how organizations interact, plan, design, deliver, operate and control IT services to achieve competitive advantage and more cost effective through the achievement of operational improvements on their processes as well as understand how to measure performance and continuously improve. To achieve operational efficiency and effectiveness, organizations need to adopt a structured environment. Many different IT frameworks have been proposed to help organizations to become more cost effective by managing their service delivery. The IT frameworks have some similarities and even share some processes. One of the most concerns among organizations is to get the best of all frameworks according to their business needs and sometimes organizations consider difficult to implement, ending up doing some redundant.

This thesis proposes a Maturity Model (MM) for the Problem Management (PM) process that covers the most popular and used IT frameworks. The research methodology used is Design Science Research (DSR). In addition, semi-structured interviews were used in five organizations to demonstrate and assess the proposal. This research reckons a novel insight to the actual Body of Knowledge (BoK). Practitioners consider the proposed maturity model as useful and complete. For them, the main contribution of this research is possibility to assess their current operational efficiency and effectiveness state and identify the required steps to reach the desired level. In other hand, this research is also useful for the academics because it distinguishes itself from the existing artefacts by being new and innovative, proving to be effective in real scenarios. Nevertheless, it is also scalable because this research can be expanded for other IT processes.

In addition, it also bolsters up the well-known framework overlap problem and prop up the awareness of the organizations regarding the actual PM maturity level.

Keywords: information technology; service management; problem management; Information Technology Infrastructure Library; Control Objectives for Information and Related Technologies; maturity model;

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List of Abbreviations and Acronyms

APO	-	Align, Plan and Organize
BAI	-	Build Acquire and Implement
BOK	-	Body of Knowledge
CAR	-	Causal Analysis and Resolution
CMF	-	CMMI Model Foundation
CMM	-	Capability Maturity Model
CMMI	-	Capability Maturity Model Integration
CMMI-SVC	-	Capability Maturity Model Integration for Services
CSI	-	Continual Service Improvement
COBIT	-	Control Objectives for Information and Related Technologies
DSS	-	Deliver, Service and Support
EDM	-	Evaluate, Direct and Monitor
IT	-	Information Technology
ITIL	-	Information Technology Infrastructure Library
ITSM	-	Information Technology Service Management
PM	-	Problem Management.
PAM	-	Process Assessment Model
PRM	-	Process Reference Model

MEA	-	Monitor, Evaluate and Assess
MM		Maturity Model

Chapter 1 – Introduction

Beginning in the 1980s manufacturing companies started to implement improvement programs to achieve competitive advantage and become more cost-effective through the acquirement of operational improvements (Marrone & Kolbe, 2011). The presence of computer and IT in today's organizations has expanded dramatically (Pereira & Mira da Silva, 2010). This expansion has driven IT functions to become more service-oriented so that they can be more cost-effective and aligned with the business objectives of their organisations (Wui-Gee Tan, 2007).

Nowadays, organizations are starting to be entirely dependent on IT (Cassidy, 2016) and how they interact, plan, design, deliver, operate and control IT services offered to customers. One of most complex parts of organizations is the IT departments (Pereira & Mira da Silva, 2010) (Sharifi, Ayat, Ibrahim, & Sahibuddin, 2009). IT departments consider their complexity increased significantly and identified that some processes have received inadequate attention causing detrimental effect on service performance.

To deal with the increase of IT complexity many IT frameworks have been developed and proposed. For example: IT Infrastructure Library (ITIL), Control Objectives for Information and Related Technologies (COBIT) and Capability Maturity Model Integration (CMMI), among others. All these frameworks have value to offer, and different strengths and weaknesses (Cassidy, 2016).

Over the years, organizations have focused heavily on improving their IT processes to be able to bring remarkable benefits. One of the ways to organize IT processes is using IT frameworks (Pereira & Silva, 2012) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018) and many organizations use them to guide, standardize, fine-tune, and streamline IT processes (Herath, Prabhashini, & Katepearachchi, 2016). There are evidences that use of IT standards and best-practices can bring positive changes to an organization such IT implementations within organizations are associated with higher productivity and a reduction in inventory and cycle times, thus reducing overall operational costs and the

ability to create competitive advantage by leveraging IT and complementary organizational resources to develop unique, change-oriented capabilities that enable firms to meet customer needs and respond to competitors (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018) (Banker, Bardhan, Chang, & Lin, 2006). Some researchers have been reporting the benefits of using these IT frameworks (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018) (Banker, Bardhan, Chang, & Lin, 2006).

Nonetheless, not only IT frameworks are seen as complex (Serenko, Bontis, & Hull, 2014) as well as the lack of guidance for customization and implementation of such IT frameworks make it difficult for organizations to choose one (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018) since it is unclear which IT framework better suits (Ho, Chai, & Tan, 2016) within established IT environments (Pereira & Mira da Silva, 2010). Many times, the processes end by not being consistent and properly defined (Rohloff, 2008). Plus, most of these IT frameworks overlap each other (Pereira & Mira da Silva, 2010) (Haes, Grembergen, & Debrecen, 2013) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018). This implies a duplication of investment, cost and human resources for organizations (Gama, Sousa & Mira da Silva, 2013). Over time, with increasing utilization of IT frameworks and their importance within the organization, it has become increasingly evident that there are still problems to be solved in current IT frameworks. Therefore, as there no limitation they can be combined to narrow the gaps they have becoming more powerful than individually. Pereira and Mira da Silva (2010) identifies that IT frameworks can overlap each other due to use of multiple frameworks inside the same organization on parallel projects. This implies a duplication of investment, cost and human resources. By way of response, maturity models were introduced to assess the level of a process (Serenko, Bontis, & Hull, 2014) (Trinkenreich & Santos, 2016). A growing number of organizations are implementing process maturity models (Uskarci & Demirors, 2017) since they pave the way as a measure to evaluate the capabilities of an organization in a certain discipline (Bruin, Freeze, Kaulkarni, & Rosemann, 2005). However, most maturity models are too general and, as a result, not well defined and documented (Becker, Knackstedt, & Pöppelbuß, 2009). Moreover, the current maturity models do not address the overlap issue

identified by several researches (Pereira & Mira da Silva, 2010) (Sahibudin, Sharifi, & Ayat, 2008) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018).

Despite the popularity of some IT frameworks, there has been little academic research published to date about issues related to maturity model adoption and implementation (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018).

Among the most important processes proposed by IT frameworks is Problem Management (PM). However, implementing a PM process properly can be complex, long, expensive and many other reasons cause PM implementation to fail (Ghrab, Ketata, Loukil, & Gargouri, 2016). This will result on a poorly quality service delivery and faulty management e.g. resolution or priorities not defined properly among other issues. Which means that PM can shape how customers see the entire organization.

To sum up, IT frameworks allow organizations to mature and develop necessary organizational skills to provide value to the business processes that IT serves but they are too complex (Haes, Grembergen, & Debrecen, 2013) and can overlap each other (Pereira & Mira da Silva, 2010) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018). Maturity models are seen as alternatives to narrow such IT frameworks issues (Becker et al., 2009). Since PM is seen as one of the most important IT processes (Ghrab et al., 2016), this research aims to develop an overlapless PM maturity model.

1.1. Problem

The efficient use of IT by organizations is a goal to be achieved and has been sought after by many companies (Gehrmann, 2012). Some of these companies have already achieved the level of complexity required by the use of these technologies, acquiring a competitive edge in the marketplace where they belong. This level can be achieved through the management of IT according to best practices and guidance available on the IT standards and best-practices (Pereira & Mira da Silva, 2010). However, the management of IT has a much broader focus and is extremely complex. It contains much more

comprehensive actions than the administration of IT, for the users of these technologies and processes (Gehrmann, 2012).

The most important processes are the ones that contribute to immediate IT service provider capability to meet and eventually exceed business need. PM is one of most effective methods of reducing the frequency of service outages or degradation and hence its importance. PM can prevent future outages thus significantly improving service availability and quality as well reducing reactive efforts (and support efforts overall). However, implementing a PM process properly can be complex, long, expensive and many other reasons cause PM implementation to fail (Ghrab, Ketata, Loukil, & Gargouri, 2016) causing quality service degradation and faulty management issues (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018). This means that PM can shape how customers see the entire organization. Despite the existence of several IT standards and best-practises to help organizations, such are seen as complex (Serenko, Bontis, & Hull, 2014), hard to implement (Ho, Chai, & Tan, 2016), the IT standards and frameworks can easily overlap with each other (Schlarman, 2007) (Pereira & Mira da Silva, 2010), organizations may design their own practices and give guidance at the lowest level that is applicable generally (Radovanovic, Radojević, Lucic, & Šarac, 2010).

Table 1 - Problems identified in the application of IT standards and good practices

ID	Problem	Reference
P1	Different ways to document IT frameworks and best-practises, but it was unclear which ones were better.	(Ho, Chai, & Tan, 2016)
P2	IT standards and frameworks can easily overlap with each other.	(Schlarman, 2007) (Pereira & Mira da Silva, 2010) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018)
P3	Organizations may design their own practices and give guidance at the lowest level.	(Radovanovic, Radojević, Lucic, & Šarac, 2010)
P4	Do not ensure the alignment between specific process of service management	(Ho, Chai, & Tan, 2016)

	and the organization concepts in a standardized way, therefore becoming isolated and, eventually, turning inefficiently. Various approaches have been used to enhance processes, but it was unclear which ones actually were better.	
P5	The logic of flow and the interfaces between the processes are not in all cases consistent and properly defined.	(Rohloff, 2008)
P6	Hard to implement.	(Ho, Chai, & Tan, 2016) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018)
P7	IT standards and best-practices are complex to understand and implement.	(Serenko, Bontis, & Hull, 2014) (Pereira & Mira da Silva, 2010) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018)

Plus, IT standards do not ensure the alignment between specific process of service management and the organization concepts in a standardized way, therefore becoming isolated and, eventually, turning inefficiently. Various approaches have been used to enhance processes, but it was unclear which ones actually were better (Ho, Chai, & Tan, 2016). Table 1 describes the common problems associated with IT framework implementation. However, they can be combined to narrow the gaps and then become more powerful than individually (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018).

Therefore, this research aims to help solve the following problems:

- P2: IT frameworks can easily overlap with each other (Schlarman, 2007) (Pereira & Mira da Silva, 2010) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018).
- P7: IT frameworks are complex to understand and implement (De Haes, Van Grembergen, & Debreceny, 2013) (Serenko, Bontis, & Hull, 2014) (Pereira & Mira da Silva, 2010).

1.2. Motivation and rationale of the study

As mentioned before, an increasing number of organizations are implementing process maturity models as an attempt to improve their IT services efficiently and effectively (Uskarci & Demirors, 2017). However, on their own, they are not comprehensive enough to serve as efficient IT management system which results in not all implementations are successful and some companies have been disappointed with the outcomes.

Some of the common mistakes made by organizations when implementing IT frameworks are:

- Being too ambitious
- Lack of management commitment
- Spend too much time on complex process diagrams
- Focusing on wrong processes

Many other reasons cause IT implementations to fail (Rohloff, 2008) – such as organizational resistance to change, unproven business value, strong organizational culture and so on – are also to blame as IT implementations are usually based on complex IT platforms.

Despite the popularity of some IT standards and frameworks, only a few academic researchers have been published to date related to the adoption and implementation of maturity models and their issues (Pereira & Mira da Silva, 2010).

The problem we are trying to solve is thus worth of our research effort since most organizations are, in fact, implementing IT frameworks incorrectly and not getting the benefits from their implementations (Becker et al., 2009) (Rohloff, 2008). Many organizations have no idea which process to implement first and/or how far they should go with that process (Pereira & Mira da Silva, 2010). The problem is repeated over and over until they start to chase help to solve this problem.

1.3. Questions and research objectives

As previously stated, IT has become essential for organizations, but it also brings complexity. Existing IT frameworks provide guidance to help organization define and implement the most relevant IT processes and, likewise, existing IT maturity models provide guidance to help organizations prioritize the implementation of IT processes. The PM process is one of most effective methods to maintain service availability and therefore its importance. However, most of these frameworks and maturity models overlap each other leading to a waste of resources. On behalf of such evidences and grounded on the need of further investigation about multi-frameworks implementation and how they can be managed and measured (Haes, Grembergen, & Debrecen, 2013) this research intends to provide further information on research question presented at Table 2.

Table 2 - Research Question

ID	Research Question
RQ.1	Is it possible to develop an overlapless and yet complete IT Maturity Model for PM process?

The existing models does not provide a combination between top used frameworks and, for that reason this research proposes an overlapless maturity model for PM, combining the most used frameworks within organizations (ITIL, COBIT and CMMI) and yet providing a complete approach for PM.

1.4. Structure of the Thesis

The following sections follow the methodology's steps. “Chapter 2 - State of Art” or “Literature review” covers the aims and objectives as the awareness and recognition of a problem from a literature review giving us the issues that must be addressed. Afterwards, the research is presented and led a proposal as an attempt to solve the problem described previously based on the most popular IT frameworks. In Chapter 5 – Demonstration and evaluation describes the assessment of the model and to conclude, in Chapter 6 –

Conclusion, we validate our research contribution and expose our conclusions by doing an overview of our work, identifying limitations and steps for further work.

Chapter 2 - State of Art

A fundamental step in every research is the review of relevant literature to reveal areas where further research is required and establish a foundation that supports the theory development. This is vital to promote and guarantee the knowledge advancement (Webster & Watson, 2002).

IT is growing tremendously over the time. (Rapp, 2002). Organizations are starting to be entirely dependent on IT and how they plan, design, deliver, operate and control IT services offered to customers. To deal with the increase of complexity, several IT based frameworks and standards has been propounded by institutes, companies and organizations such as ITIL, COBIT, CMMI, among others. These frameworks are as a rule-oriented processes that represent each of who, a raised area in the IT management in organizations. These frameworks are essential to maintain successful corporate performance.

ITSM evolved naturally as services became underpinned in time by the developing technology. In its early years, IT was mainly focused on application development – all the new possibilities seeming to be ends in themselves. Harnessing the apparent benefits of these new technologies meant concentrating on delivering the created applications as a part of a larger service offering, supporting the business itself (Office & Orr, 2011) e.g. in a financial organization (bank, insurance) or in a food distribution organization. ITSM is the discipline that strives to better the alignment of IT efforts to business needs and to manage the efficient provision of IT services with guaranteed quality. (Brenner, 2006).

2.1. IT Frameworks

Many IT frameworks have been created to manage, measure, and align IT objectives with the organization’s objectives. Among the most known, important and used IT frameworks, ITIL, COBIT and CMMI-SVC stand out.

2.1.1. IT Information Library (ITIL)

The ITIL framework is a set of publications providing the best practises (Axelos, 2018) (Cabinet Office, 2011) and one of the most widely accepted approach to ITSM in the world (Axelos, 2011) (Pereira & Mira da Silva, 2010). Developed by the Central Computer and Telecommunications Agency (CCTA), a British Government agency, in the eighties to promote efficiency and cost-effective through the achievement of IT operational improvements within government computing centres. The framework is currently administrated by the Office of Government Commerce (OGC) and has evolved into the ISO/IEC 20000 standards (International Organization for Standardization, 2018) (Cater-Steel & Pollard, 2008).

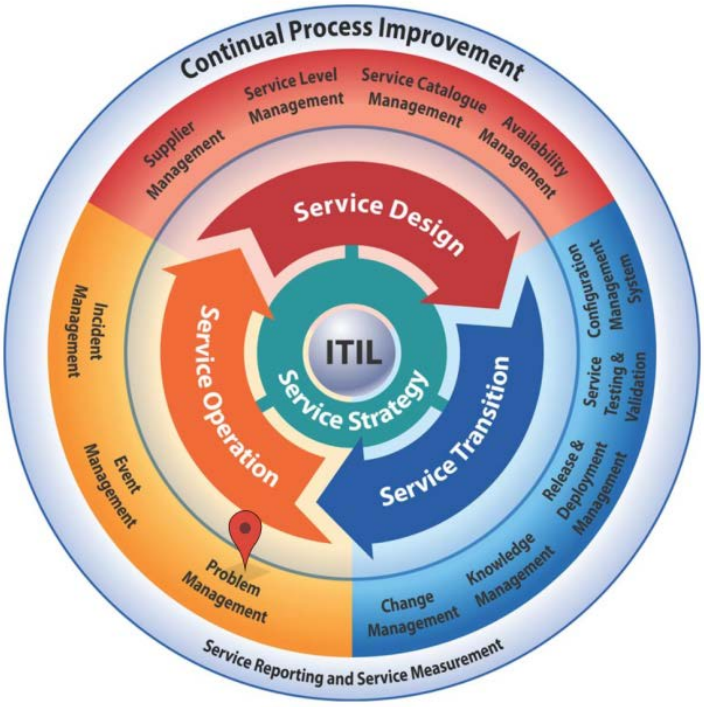

Figure 1- ITIL v3 Service Lifecycle (source: Axelos)

It provides a cohesive set of best practices to more effectively manage IT services. The third version became available in 2007 and does not focus on processes like previous versions but rather on services. The last version was released on 2011 as an updated to

correct some errors and inconsistencies across whole suite. Currently, ITIL version four is under revision with a scheduled release for the first quarter of 2019.

As illustrated on Figure 1, the third version of ITIL consists of five core books covering the service lifecycle composed by Service Strategy, Service Design, Service Transition, Service Operation, and Continuous Service Improvement. It describes activities and practices of the service lifecycle in detail, linked to customer/business requirements using business metrics and reinforcing continuous improvement. Based on a clear specification and a "Code of Practice", it draws on many other standards and helps managers develop their own ITSM System.

ITIL has become the "bible" of many IT operational managers (Guldentops, 2007) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018). There are 26 processes and 4 functions described within the ITIL core guidance. Processes (Service Strategy, Service Operation, Service Design and Service Transition) and functions operate across the entire service lifecycle but belong predominantly to one lifecycle stage (Axelos, 2013).

Since the focus of this thesis is PM, we will focus to describe the importance of this process in ITIL lifecycle and their relation between other processes and activities. The PM is located at Service Operation process. This process is intended to embody practices in the management of Service Operation.

The purpose of the service operation is to ensure that IT services are supported and delivered effectively and efficiently to ensure value to the customer and the service provider (Axelos, 2011).

ITIL defines a 'Problem' as the unknown cause of one or more Incidents. PM is the process responsible for managing the lifecycle of all problems (Cabinet Office, 2011).

The primary objectives of PM are to prevent Problems and resulting Incidents from happening, to eliminate recurring Incidents and to minimize the impact of Incidents that cannot be prevented. It includes the activities required to diagnose the root cause of incidents and to determine the resolution to those problems. It is also responsible for

ensuring that the resolution is implemented through the appropriate control procedures, especially Change Management and Release Management (Cabinet Office, 2011).

PM consists of two major processes:

- Reactive PM, which is generally executed as part of Service Operation – and is therefore somehow covered in this thesis.
- Proactive PM, which is initiated in Service Operation book, but generally driven as part of Continual Service Improvement (CSI) process.

Reactive PM aims to find and eliminate the root cause of the known incidents (Cabinet Office, 2011). In other hand, proactive PM aims to identify and prevent future incidents from recurring by identifying and eliminating the root cause (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018).

2.1.2. COBIT

Control Objectives for Information and related Technology (COBIT) is an IT framework created by the Information Systems Audit and Control Association (ISACA), and the IT Governance Institute (ITGI) in 1996. It ensures quality, control, and reliability of information system in an organization. (ISACA, 2012). Current version is the fifth, COBIT 5, and is available since April 2012. COBIT aids organizations to improve their value by maintaining a balance between achieving benefits and set right risk levels, resource usage, enables IT to be governed and managed, taking the whole-time business and IT functional areas of responsibility. It provides a set of generally accepted measures, indicators, processes and best practices to managers, auditors, and IT users helping them maximizing the benefits derived through the use of IT and developing appropriate IT governance and control in an organization.

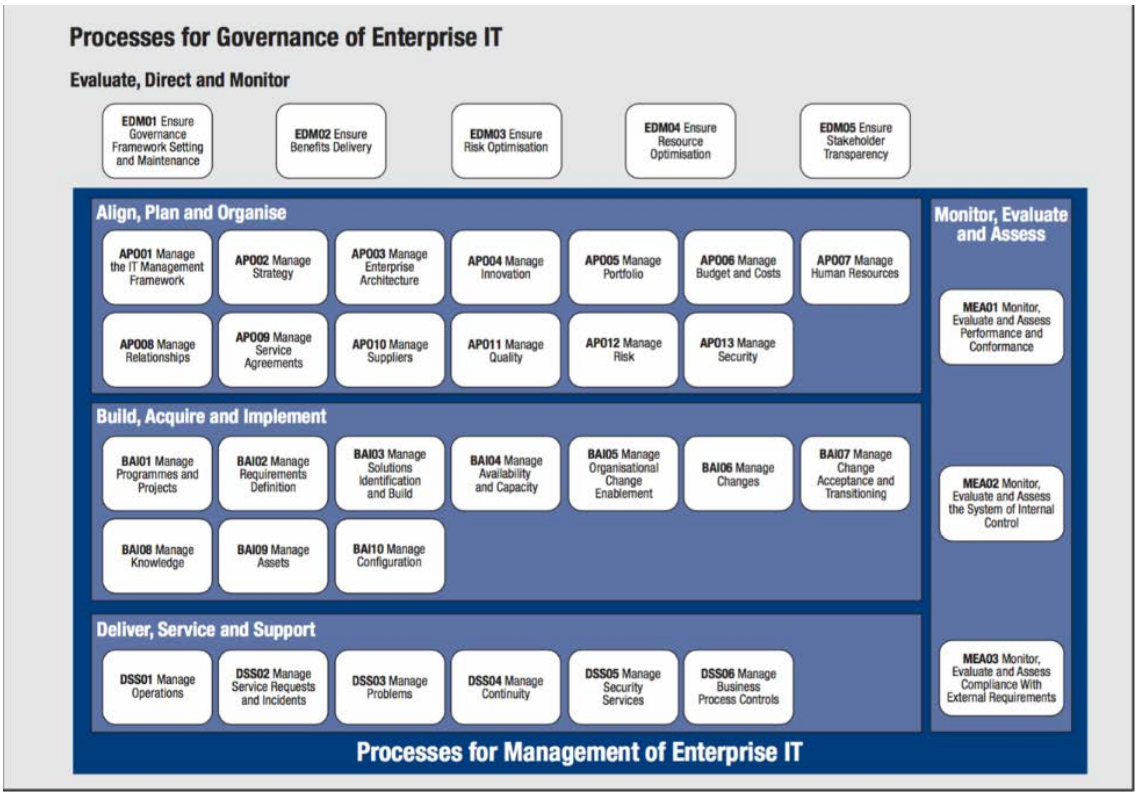

Figure 2 - COBIT Processes Reference Model (PRM) (source: ISACA)

The framework is generic and useful for enterprises of all sizes (Manzano, Moreta, Cobián, & Sánchez, 2015), whether commercial, not-for-profit or in the public sector (ISACA, 2012).

In the 5th edition, COBIT changed their approach and moved their control objectives to five principles and seven enablers. A control objective is the key to maintaining profitability in a technologically changing environment by measuring and control information systems. It included statements of desired results or purposes to be achieved by implementing the control objectives throughout high-level IT processes (Figure 2). Based on five principles and seven enablers, COBIT 5 uses governance and management practices to describe actions that are examples of good practices to effect governance and management over enterprise IT. Many of these practices and the supporting activities exert 'control' over the process to deliver the required outcome (ISACA, 2012). The COBIT 5 framework provides enhanced process reference model (PRM) guidance for governance

and management, as shown in Figure 2. It provides definitions of processes in a life cycle (PRM), together with an architecture describing the relationships amongst the processes.

COBIT 5 PRM is composed of 5 domains and a total of 37 processes describing a life cycle for governance and management of enterprise IT. In this model, processes are further organized into groups:

- For governance of enterprise IT, there is one group of five processes, namely the Evaluate, Direct and Monitor (EDM) domain.
- For management, there are four groups of processes: Align, Plan and Organize (APO) composed by 13 processes; Build Acquire and Implement (BAI) composed by 10 processes; Deliver, Service and Support (DSS) composed by 6 processes; and Monitor, Evaluate and Assess (MEA), composed by 3 processes.

The **PM** process is available at COBIT under "Management" area and DSS domain.

Table 3 – DSS processes of COBIT

DSS01	Manage Operations
DSS02	Manage Service Requests and Incidents
DSS03	**Manage Problems**
DSS04	Manage Continuity
DSS05	Manage Security Services
DSS06	Manage Business Process Controls

This domain includes all management and service activities related to delivery and support systems. Table 3 lists the high-level processes for the DSS domain. COBIT defines a 'Problem' as a management system which identifies and classifies problems and their root causes to prevent recurring incidents. Effective PM requires the identification and classification of problems, root cause analysis and resolution of problems.

The PM process also includes the formulation of recommendations for improvement, maintenance of problem records and review of the status of corrective actions. By reducing

the number of operational problems throughout an effective PM process, it increases system availability, improves service levels and reduces costs (ISACA, 2012). Table 4, lists the PM process practices under COBIT 5 theory.

Table 4 - COBIT management practises

Management Practise	Description
DSS03.01 Identify and classify problems.	Describe the problem identified through the appliance of some criteria, including classification, categorization and prioritization of problems.
DSS03.02 Investigate and diagnose problems.	Investigate and diagnose problems using relevant root causes.
DSS03.03 Raise known errors.	As soon as the root causes of problems are identified, a known-error record should be raised and then provided an appropriate alternative or workaround and identified potential solutions.
DSS03.04 Resolve and close problems.	Finding sustainable solutions addressing the root cause, all changes must use the change management process established. It is necessary to ensure that all affected persons are aware of the actions taken and of the plans developed to prevent future incidents from occurring.
DSS03.05 Perform proactive PM	Collect and analyse current data to identify imminent trends that may point out to problems. Raise a problem records to enable their assessment.

2.1.3. CMMI

Capability Maturity Model Integration (CMMI) models are IT frameworks that help and assist organizations on their process improvement. CMMI (Figure 3) is an evolution of the initial standard Capability Maturity Model (CMM) developed in 1986 by the Software Engineering Institute (SEI), a research centre at Carnegie Mellon University. This centre

was established and funded by United States Department of Defence (DoD) (Software Engineering Institute (SEI), 2009).

Figure 3 – CMMI Overview (source: SEI)

The last version released is v1.3, in November 2010. The CMMI Framework provides the structure needed to produce CMMI models, training, and appraisal components. To allow the use of multiple models within the CMMI Framework, model components are classified as either common to all CMMI models or applicable to a specific model. The common material is called the "CMMI Model Foundation" or "CMF" (Software Engineering Institute (SEI), 2009).

The best practices described in a CMMI standard are grouped into three interest areas denominated constellations (Moreta, 2015). A "constellation" is defined as a collection of components that are used to construct models, training materials, and appraisal materials

in an area of interest (e.g., services, development) (Software Engineering Institute (SEI), 2009).

The CMMI provides models for three constellations: Capability Maturity Model Integration for Development (CMMI-DEV), Capability Maturity Model Integration for Acquisitions (CMMI-ACQ) and Capability Maturity Model Integration for Services (CMMI-SVC). The Capability Maturity Model Integration for Services (CMMI-SVC) focuses on activities for providing quality services to customers and end users. CMMI-SVC draws on concepts and practices from CMMI and other service-focused standards and models, including: ITIL, ISO/IEC 20000, COBIT, and IT Services Capability Maturity Model (ITSCMM) (Software Engineering Institute (SEI), 2009) This constellation is composed by 24 processes areas that are characterized by specific goals and specific practices, considering that some generic goals and generic practices can be used for all the processes. Of those, 16 are CMMI Model Foundation (CMF) or core process areas, one is a shared process area and seven are service-specific process areas that include one addition.

Since the focus of this thesis is PM**,** CMMI identifies and manage their problems in the process "Causal Analysis and Resolution (CAR)". The purpose of this process is to identify the causes of defects and problems and take measures to prevent them from occurring in the future. CAR improves quality and productivity by preventing the introduction of defects and occurrence of problems (Software Engineering Institute (SEI), 2009). The CAR process area involves the activities described in Table 5.

Table 5 – CAR Process Activities

Activity	**Description**
CAR1	Identify and analyse causes of defects and problems.
CAR2	Taking actions to remove causes and prevent the occurrence of those types of defects and problems in the future.

All type of defects and problems are analysed in order to identify patterns or trends. After understanding how the process is defined and works, the next step is to find the rout cause of the problem or defect and determine their impact in the future (Software Engineering Institute (SEI), 2009). There are two specific goals, “Determine Causes of Defects and Problems” and “Addresses causes of defects and problems” and five specific practises.

2.1.4 Summary

All IT frameworks have value to offer, and there have different strengths and weakness. Picking the right controls in each of these best practice, framework or standard may help you to increase the productivity and efficiency in IT department. The Table 6 lists the difference between each most adopted and used frameworks.

Table 6 - IT frameworks summary

	ITIL v3	**COBIT 5**	**CMMI-SVC**
Founded	OGC	ISACA	Software Engineering Institute (SEI)
Last Update	July 2011	April 2012	November 2010
What are these framework/ approaches?	Set of guidelines based on industry best practice.	Good-practices framework for IT management and IT governance.	Framework for managing processes and integrating activities across an organization
Focus	Service	Service	Service
PM	Yes	Yes	Yes
Name of Process	PM	Manage Problems	CAR
Number of Processes	26	37	24

1.2. Maturity Models

The following section describes IT Maturity models. A MM consists of a sequence of maturity levels for a class of objects. It represents an anticipated, desired, or typical evolution path of these objects shaped as discrete stages. Typically, these objects are organizations or processes (Becker et al., 2009). The use of MMs allows organizations to have their methods and processes evaluated according to good management practices and with a set of external parameters. Maturity is indicated by the assignment of a particular maturity level. Considering the objective (O1) of this research, the following sections synthesize the most relevant MMs. Both scientific and practitioner's maturity models are discussed.

2.2.1. ITIL Maturity Model

The ITIL Maturity model and self-assessment service has been developed by AXELOS to help organizations improve their ITSM within the ITIL framework (Axelos, 2013).

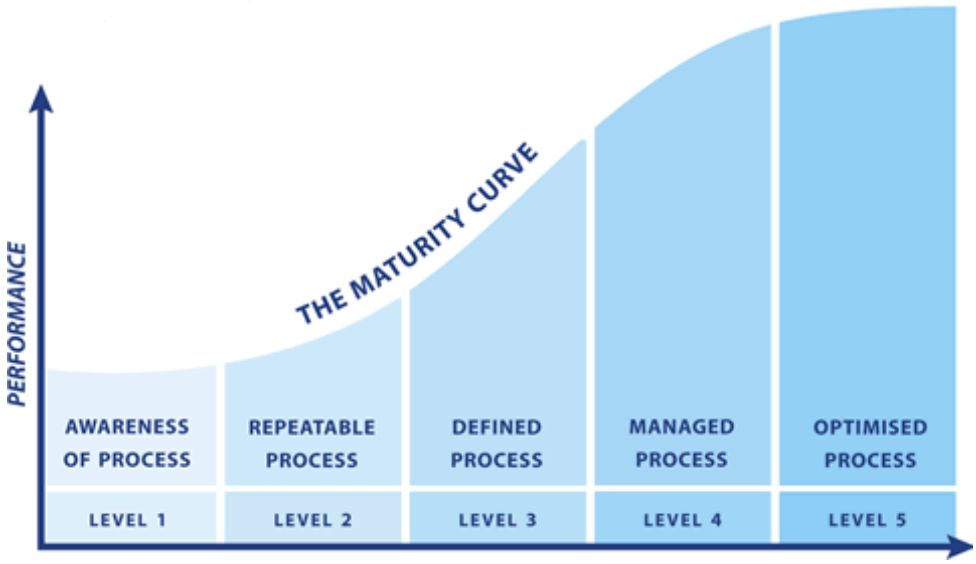

Figure 4 - ITIL Maturity Model (Axelos, 2013)

The ITIL Maturity Model and Self-Assessment Service are based on five levels of maturity: Initial, Repeatable, Defined, Managed, and Optimized. A process or function that is completely absent is directly considered to be at Level 0 (Chaos). These maturity level definitions are aligned with COBIT and CMMI definitions.

Whilst there are five levels defined against which maturity is assessed, in the full or primary absence of any process or function, the pre-eminent state is defined as one of chaos or at a Level 0. In this state, even if there is a degree of process or function, it is characterized by being without any structure, defined responsibilities or consistency in terms of its operation. What is an important point to make about chaos, is that it can be both a state from which one matures up through levels 1 to 5, or a state that one descends into from levels 1-5 with the latter prospect highlighting the importance of continuous process improvement in the organization.

An ITIL Maturity self-assessment consists of completing a collection of questionnaires for each of the processes and functions spanning the ITIL Service Management Lifecycle. The questionnaires are made up of the following parts:

- Process/function demographic questions.
- Process/function-generic attributes
- Process/function-specific attributes
- Process/function outcomes and outputs
- Interfaces and inputs

Apart of the demographic questions, all answers for each question will be marked a Yes or a No.

2.2.2. CMMI-SVC

The model, called CMMI for Services (CMMI-SVC), contains service best practices from government and industry and provides a comprehensive integrated set of guidelines for providing superior services (Software Engineering Institute (SEI), 2010).

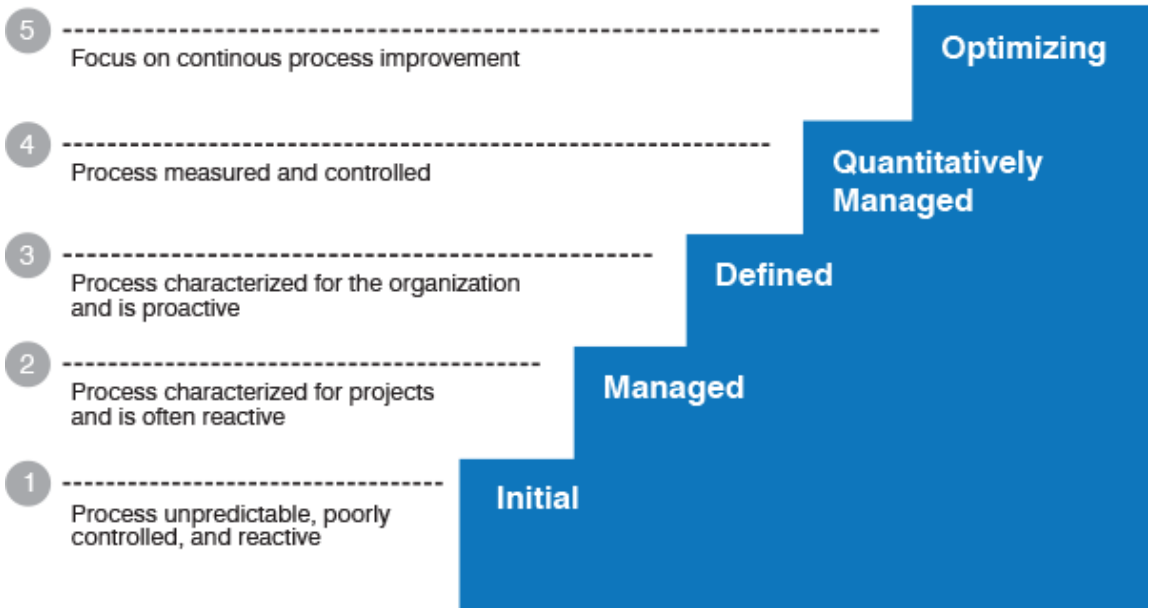

Figure 5 - The five maturity levels of CMMI model (Source: SCI)

Best practices in the CMMI model focus on activities for providing quality services to customers and end users. CMMI- SVC includes all guidance for a service provider and is based on the CMF (model with components common to all CMMI models) and incorporates work by service organizations to adapt CMMI for service industry usage (Software Engineering Institute (SEI), 2010). Also, CMMI-SVC provides a comprehensive set of best practices for providing services.

The organization should have its service processes mapped to the model process areas, to ensure that progress can be tracked according to the CMMI-SVC model. The level provides a way to characterize the organization's capacity and their actual performance

and, recommended steps to improve existing processes. It can also be a way of evaluating (Software Engineering Institute (SEI), 2010).

CMMI supports two improvement methods using levels:

- Capability Levels - Helps organizations to improve their processes incrementally and corresponds to an individual or group of process area chosen within the organization.
- Maturity Levels - Allows the organization to improve a set of related processes by incrementally addressing successive sets of process areas.

There are two approaches regarding process improvement, the continuous and staged, respectively for each of the capability and maturity levels. Regardless of the approaches, the level of concept is the same. The levels are used to characterize an organization's capability and performance to determine improvements and steps required to meet their objectives. Each maturity level forms a necessary foundation for the next level. To be in a specific level, all requirements of a specific process area or set of processes should be fulfilled, regardless of the type of the level (capacity or maturity).

2.2.3. COBIT Process Assessment Model (PAM)

The COBIT 5 PAM is composed of a set of indicators of process performance and process capability. The indicators are used as a basis for collecting the objective evidence that enables an assessor to assign ratings (ISACA, 2013). PAM combines COBIT 5 process details with ISO/IEC 15504-2 (ISACA, 2018) and provides the basis for a robust, dependable assessment approach.

The PAM is a two-dimensional model (2D) of process capability. In one dimension, the process dimension, the processes are defined and classified into process categories. In the other dimension, the capability dimension, a set of process attributes grouped into capability levels is defined. The process attributes provide the measurable characteristics of process capability. The process assessment model conforms to ISO/IEC 15504-2 requirements (ISACA, 2018) for a process assessment model and can be used as the basis for conducting an assessment of the capability of each COBIT 5 process (ISACA, 2013).

The capability dimension provides a measure of a process's capability to meet an enterprise's current or projected business goals for the process.

The process capability is expressed in terms of process attributes grouped into capability levels, as shown in figure 6. The capability level of a process is determined on the basis of the achievement of specific process attributes according to ISO/IEC 15504-2:2003 (ISACA, 2013).

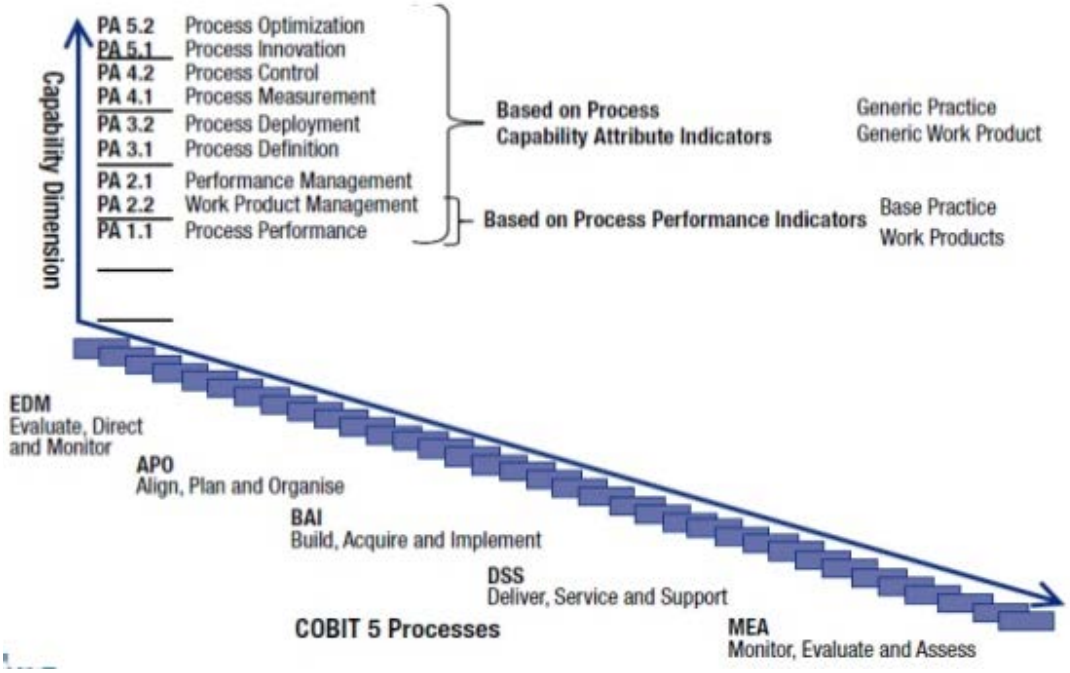

Figure 6 - Process Assessment Model (adapted from ISO/IEC 15504-2:2003)

Assessment indicators are used to assess whether process attributes have been achieved. There are two types of assessment indicators: Process capability attribute indicators, which apply to capability levels 1 to 5 and Process performance indicators, which apply exclusively to capability level 1 (ISACA, 2013)

Process performance indicators (base practices and work products) are specific for each process and are used to determine whether a process is at capability level 1. These performance indicators consist of base practices and work products and are exclusive to level 1. The process capability attribute indicators are generic for each process attribute for

capability levels 1 to 5. Level 1, however, has only a single generic practice indicator for capability that aligns directly to the achievement of the specific performance indicators. The process capability attribute indicators used in the COBIT 5 process capability assessment are: Generic practice (GP) and Generic work product (GWP) (ISACA, 2013).

2.2.4. Comparison of Maturity Models

This section aims to compare all maturity models covered. The analysis is structured in three sections, starting with a descriptive comparison of the models available in each framework. Subsequently we will compare the maturity levels available for each framework and to conclude, amount of activities for each level.

The adopted variables were:

- Number of levels: to know how many levels of maturity they have.
- Staged Model / Continuous Model: to understand what kind of model approach is used by each model.
- Scope: to know the area in each model is applicable.
- Based on: to understand if the model was based in other models.

The Table 7 lists the different characteristics (model, number of levels, scope, level of detail and base for) of all three IT frameworks. The Table 8 lists the amount of maturity levels and their respective ratings for each IT framework.

All compared maturity models have 5 levels. PAM ground their theory in ISO/IEC 15504. The most interesting fact is that all the described maturity models have an individual approach by focusing only on their own theory. It should be highlighted that none of these maturity models solve the IT frameworks overlap issue.

Table 7 - Frameworks characteristics comparasion

Models	**ITIL / AXELOS**	**CMMI-SVC**	**COBIT PAM**
It is a success staged model (SM) / continuous model (CM)?	Medium Staged model	High Both	Medium Staged model
Number of maturity levels	SM: 1-5	SM: 1-5 CM: 0-5.	SM: 0-5
Scope	Service	Services	Services
Detail level	Medium	High	Medium
Base for	Any model	Any model	ISO/IEC 15504.
Frameworks overlap	Not addressed	Not addressed	Not addressed

Table 8 - Frameworks levels comparison

Level	**ITIL**	**CMMI-SVC**	**COBIT PAM**	**ISO 15004 (SPICE)**
Level 0	Chaos	(not applicable)	Incomplete	Incomplete
Level 1	Initial	Initial	Performed	Performed
Level 2	Repeatable	Managed	Managed	Managed
Level 3	Defined	Defined	Established	Established
Level 4	Managed	Quantitatively Managed	Predictable	Predictable
Level 5	Optimized	Optimizing	Optimizing	Optimizing

Regarding the levels, it is noticeable how COBIT and ISO/IEC 15004 also known as SPICE share the same level names. The comparison will be between ITIL, CMMI-SVC and COBIT. At level 0, COBIT considers it as Incomplete whereas ITIL consider it as Chaos. CMMI-SVC does not consider any Level 0. At level 1, CMMI-SVC and ITIL share the same level name whereas COBIT is named as “Performed”. At level 2, all maturity models consider it as “Managed” whereas ITIL is named “Repeatable”. At level 3, ITIL and CMMI-SVC share the level name “Defined” and in other hand COBIT names it “Established”. At level 4, ITIL names level as “Managed” where CMMI-SVC consider it

as “Quantitatively Managed”. COBIT consider it as “Predictable”. At level 5, ITIL consider it as final stage, “Optimized” whereas the rest maturity models names it as continuous “Optimizing”.

Chapter 3 – Research Methodology

The following section describes the meaning, objectives, approaches and significance of research approach adopted.

A methodology is "a system of principles, practices, and procedures applied to a specific branch of knowledge" (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007-8). The methodology describes how to select the specific methods and considers the accuracy and efficiency of the methods chosen, a way to systematically solve the research problem. The methodology could start by simple observation, usage of interviews, collection data through questionnaires, schedules, warranty cards, audits, etc., and could include both present and historical information. For this thesis, the research methodology approach adopted was Design Science Research (DSR). Vaishnavi, Kuechler, & Petter (2014) and De Maere & De Haes (2017) says this methodology can be applied in IT Governance, covering a broad range of IT related processes. Design science research (DSR) aims to improve/design new means for acting in the world in order to change and improve reality (Venable, Pries-Heje, & Baskerville, 2017). As a result, the model differs from other research paradigms since DSR re-creates reality through creating and evaluating artefacts that serve human purposes and solve human problems (March & Smith, 1995; Simon, 1996). As stated by (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007), for DSR, a methodology would include three elements:

- Conceptual principles, to define what is meant by design research
- Practise rules.
- Process, for carrying out and presenting the research.

3.1 Conceptual Principles

According to (Hevner, March, Park, & Ram, 2004), knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact.

Hevner (2004) provides the practice rules for conducting a DSR by following seven guidelines (Table 9) that describe the characteristics of a research project.

Table 9 - Design Science Research Guidelines by Hevner

Guideline	**This investigation**
Guideline 1: **Design as an Artefact**	The proposed artefact in this research is a model.
Guideline 2: **Problem Relevance**	The artefact must be able to eliminate framework overlap through multi-framework implementation.
Guideline 3: **Design Evaluation**	The artefact is evaluated through semi-structured interview and the four Principles proposed by (Österle, et al., 2011)
Guideline 4: **Research Contributions**	A new and innovative artefact missing on body of knowledge (BoK).
Guideline 5: **Research Rigor**	Design: DSR Construction: Becker guidelines Evaluation: Interviews
Guideline 6: **Design as a Search Process**	The outcome is unknown because is the result of a combination of pre-established and well-known frameworks, with the application of relevant techniques.
Guideline 7: Communication of Research	The evaluation will be done through practitioners and later submission to reference journals.

In other words, design-science research requires the creation of an innovative, purposeful artefact (Guideline 1) for a specified problem domain (Guideline 2). Due the fact of the artefact is purposeful, it must yield utility for the specified problem. Hence, thorough evaluation of the artefact is crucial (Guideline 3). The newness is importance since the artefact must be innovative, solving an unsolved problem or solving a known problem in a more effective or efficient manner (Guideline 4). So, design-science research is differentiated from the practice of design. The artefact itself must be rigorously defined, formally represented, coherent, and internally consistent (Guideline 5). The process by which it is created, and often the artefact itself, incorporates or enables a search process whereby a problem space is constructed, and a mechanism posed or enacted to find an effective solution (Guideline 6). Finally, the results of the design-science research must be communicated effectively (Guideline 7) both to a technical audience (researchers who will extend them and practitioners who will implement them) and to a managerial audience (researchers who will study them in context and practitioners who will decide if they should be implemented within their organizations). In the artefact evaluation and its results, I also used the Four Principles proposed by (Österle, et al., 2011) in the design of an artefact as listed in Table 10.

Table 10 - Four Principles proposed by Osterle

Principle	This investigation
Abstraction	A new model artefact is proposed by this research and consequently it must be abstract enough to generalize the IT PM domain.
Originality	The artefact proposed is new and not present in the BoK.
Justification	The methods proposed in the artefact evaluation should justify it.
Benefit	An IT PM maturity model that does not contain an overlap framework and capable to provide a global view to the organizations, helping to reduce the actual costs. In addition, it is also important step in multi-framework assessment research (Gama, Sousa, & Silva, 2013).

3.2 Procedures

Prior research has introduced principles that define what DSR is (Hevner, March, Park, & Ram, 2004), and what goals it should pursue (Fulcher, 1996), as well as practises rules that provide guidance for guidance for conducting and justifying it (Reich, 1994). Nevertheless, principles and practise rules are only two out of the three characteristics of a DSR methodology. The missing part is a procedure that provides a generally accepted process for carrying it out.

Several researches have contributed ideas for process elements. (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007-8) merged that information and proposes a DS research process model consisting of six activities as described in Table 11.

Table 11 - DSR process model by Peffers

Activities	This investigation
Problem identification and motivation	1.2 Motivation and rationale of the study
Definition of the objectives for a solution	1.3 Questions and research objectives
Model design and development	Chapter 4 – Proposal
Demonstration	Chapter 5 – Demonstration and evaluation
Evaluation	Chapter 5 – Demonstration and evaluation

Chapter 4 – Proposal

This section describes the appliance of the research approach adopted. As previously stated, recent studies (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018) have shown a lack of a cross-model causing a gap between IT frameworks. This research proposes a PM maturity model grounded on the most known IT frameworks. It aims to create a model easy to apply and capable to improve PM process within organizations, regardless of the size of the organization.

For the development of maturity models, (Becker et al., 2009) identifies the artefact requirements necessary for their development and thus, our proposal is tandem with these requirements as follows. Our proposal was developed in compliance with (Becker et al., 2009) requirements for development of maturity model (Table 15).

The development of this maturity model had three-steps:

1. Analysis and identification of activities on the most well-known frameworks.
2. Elimination of existing overlap.
3. Attribution of a maturity level to each of the collected activities.

The first step is obtained by the analysis of all PM activities present in ITIL, COBIT and CMMI-SVC frameworks, identifying those relevant to the process. Due to space limitations, only a sample of activities on a Table 12 is presented. At the end of this step, 349 activities were collected as identified in the following table (Table 13). To achieve accuracy in the list and finalize this step, the author performed four interactions.

Table 12 - Sample of pre-overlap activities among IT frameworks

Activity	IT Framework
The defect or problem is identified? If yes, what relevant defect data is included: 1. Defects reported by customers or end users?	CMMI
A problem record is raised? If yes, the problem contains all relevant details?	ITIL
The problem is prioritized?	ITIL
The problem impact is defined?	ITIL
The problem frequency is defined?	ITIL
The defect or problem contains service details?	COBIT
Does Know Error Database (KEDB) exist?	COBIT
The action proposal (to prevent the future occurrence of similar defects and problems) are documented?	CMMI
Do you usually look for similar causes in other processes and work products?	CMMI

At the end of this step, 349 activities were collected as identified in the following table (Table 13). To achieve accuracy in the list and finalize this step, the author performed four interactions.

After step one complete, initial list with pre-overlap activities, it is time to start the second step to eliminate the overlapping activities within initial collected list (pre-overlap list). In this step, all activities were grouped by process areas (detection, logging, categorization, etc.) in order to be easier to identify the overlapped activities. The Table 14 demonstrates how this phase was achieved. At the end of this step, 46 activities were identified as being overlapped among the chosen IT frameworks, meaning 13% of all activities collected were overlapping. After merging all the unique activities and

eliminating the overlapping ones, our post-overlap dataset consisted of 303 activities, as mentioned in Table 13. To finalize this step, the author performed three interactions.

To accomplish each of previous steps, the author performed three interactions.

Table 13 - PM activities results after applying the first two steps

	PM process name	**Number of activities (nº)**	**Percentage (%)**
ITIL	PM	*153*	*44%*
COBIT	PM	*85*	*24%*
CMMI-SVC	CAR	*111*	*32%*
Pre-overlap activities		*349*	*100%*
Overlapped activities		*46*	*13%*
Post-overlap activities		*303*	*87% of pre-overlap*

Lastly, to complete the processes in the development of the maturity model, each activity was assigned a level of maturity. The maturity levels were assigned based on the description of the activity against the description of maturity levels of the CMMI-SVC maturity model (Appendix H). The Table 17 reveal the development of the artefact following the previous phases. It is possible to denote the existing overlaps in some activities and also, verify the levels of maturity attributed to each one of the activities. As example, only one activity sample was provided for each existing maturity level. An activity classified as level 2 is considered a basic activity in PM process since is the first step for information collection. An activity classified as level 3 is mostly standards, procedure or methods. An activity ranked as level 4 is focused on process measurement; they're usually metrics to be considered to measure a specific process aspect. Finally, an activity classified as level 5 is focused on process continuous improvement and all activities to pursue this kind of activity type. More details about the demonstration of the artefact and his evaluation can be found in the next chapter.

Table 14 - Demonstration of the Merging Process

Activity	ITIL	COBIT	CMMI-SVC
Are the problems identified?	A problem record is raised?	The problem or defect is identified?	The problem is identified?
Do you usually try to find a workaround to solve the problem?	Do you usually try to find a workaround to temporary solve the problem?	-	After problem identified, do you usually develop a suitable workaround?
Do you usually analyse the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	-	Do you usually analyse the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	-
The lessons learned from the review is presented into a service review meeting with the business customer?	The lessons learned acquired from the review is presented into a service review meeting with the business customer?	-	-

Table 15 - Proposed artefact in compliance with Becker requirements

Requirement	**Description**
Comparison with existing maturity models	A comparison between IT frameworks should be made, mainly focus in the most-known and relevant for the case. This comparison may be found in the Chapter 2 - State of Art.
Iterative procedure	An iterative procedure should be throughout each phase development. In addition, the author considers interviews as an interaction due the continuous feedback received from practitioners in order to improve the artefact.
Evaluation	For the assessment of the artefact, five semi-structured interviews were performed keeping in mind the interactive process used in all interviews.
Multi-methodological procedure	Several methodologies were used for model creation: state of art, cross frameworks and semi-structure interviews.
Identification of problem relevance	Pereira e Mira (2012) has identified one of the problems saying that IT framework can overlap between each other's. In addition, Gama (2013) says IT frameworks are simultaneously often used in parallel projects and consequently implying the double of the cost regarding investments, human resources, etc. Moreover, De Haes (2013) incentives the multi-frameworks implementation and explains how it can be managed and measured.

Problem definition	There's no limitation in the appliance of the proposed maturity model unless the existence of the PM. It can be applied in all organizations. The main expected benefit of this model is the prior identification of activities overlapped that may save resources and time in future implementations.
Target presentation of results	Based on results collected throughout maturity model assessment, it's possible to provide two types of reports: individual of each organization or a global / cross-organization report. The individual report can provide information regarding current organization maturity level, a maturity roadmap including the required steps to reach to reach next level and information about achieved activities and identification of which framework comply as well missing activities identified in the roadmap. According to this information, organizations are able to become more efficient saving resources in future multi-frameworks implementations. The global reports is achievable by combining and crossing all information received from all assessments performed.
Scientific documentation	Due to time limitation, it's not possible to provide a full document. In meantime, the author is open and available to share other kind of information collected throughout the development of this thesis, despite of information already available in this document.

Table 16- Example of the overlap elimination process with its maturity levels

Activity	Maturity Level	ITIL	CMMI-SVC	COBIT
Are the problems identified?	2	A problem record is raised?	The problem or problem is identified?	The problem is identified?
Do you usually try to find a workaround to solve the problem?	3	Do you usually try to find a workaround to temporary solve the problem?	-	After problem identified, do you usually develop a suitable workaround?
Do you usually analyze the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	4	-	Do you usually analyze the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	-

The knowledge learned from the review is incorporated into a service review meeting with the business customer?	5	The knowledge learned from the review is incorporated into a service review meeting with the business customer?	-	-

Table 17- Example of the overlap elimination process with its maturity levels

Activity	Maturity Level	ITIL	CMMI-SVC	COBIT
Are the problems identified?	2	A problem record is raised?	The problem or problem is identified?	The problem is identified?
Do you usually try to find a workaround to solve the problem?	3	Do you usually try to find a workaround to temporary solve the problem?	-	After problem identified, do you usually develop a suitable workaround?
Do you usually analyse the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	4	-	Do you usually analyse the change in process performance of the affected processes or sub processes for the work? If yes, do you measure it?	-

The lessons learned from the review is presented into a service review meeting with the business customer?	5	The lessons learned acquired from the review is presented into a service review meeting with the business customer?	-	-

Chapter 5 – Demonstration and evaluation

The following section describes how the author have tested the proposed artefact, from data collection to further analysis and demonstration.

In order to demonstrate the artefact, the author has searched for companies that have the process management process in place (up and running), unfortunately the PM is a process that is not yet present in many companies. Five companies accepted the invitation to proceed to evaluate the proposed artefact where the method used for data collection was through semi-structured interviews with respective organization experts.

5.1 Data collection

The interviews were conducted in different organizations (industry, size, culture, etc.) and with different roles (IT Team Leaders, IT Coordinators and IT Directors) since they were the most suitable decision-makers to assess and provide information about the PM process. It should be taken in account that some of the companies may act in the same area, but their business is completely different, which bring different inputs. Details about the interviewers can be found below, in Table 18.

Table 18 - Details about the interviewees and respective interviews

Country	**Position**	**Experience in IT (years)**	**Duration of interview**	**Interview form**
Portugal	*IT Manager*	*18*	*2h40*	*Face to face*
Portugal	*IT Team Leader*	*8*	*1h50*	*Face to face*
USA	*Application Support Lead*	*12*	*1h30*	*Virtual*
Portugal	*IT Director*	*16*	*1h12*	*Virtual*
Portugal	*IT Director*	*20*	*1h20*	*Face to face*

The interviews were conducted between end February and early May of 2017. In a total of 5 interviews, 2 interviews were carried out by skype due unavailability and 3 were in personal. All interview durations have varied over time. The first interviews were clearly those that demanded more effort and time because there were doubts still were not in the tip and this made to lose a little more time. We had a total of 512 minutes spent in interviews which gives us an idea that the average time required for each interview is 103 minutes. The longest interview took 2h40 and the shortest interview, 1h 12 minutes. To prepare and help the interviewers before the assessment, a questionnaire was developed and delivered days before the interview happen and carried out by the same person to ensure scientific rigor.

In order to recognize patterns and promote some generalization by further researchers, organizations were classified regarding contingency factors (Table 19). Organizations' culture designation was assigned grounded on Matthyssens and Wursten (2002) theory.

During the interview process, it was important to recognize the maturity of each assessed organization and the gaps of the PM process in place, in order to provide later counselling about the roadmap to achieve the next level. After accomplishing these objectives, the author argue that the demonstration of the artefact was successfully achieved.

Table 19 – Factors analysis and details about interviewer's organization

Industry	**Size**	**Employees**	**Market**	**Strategy**	**Structure**	**Culture**
Telecommunication	*2100*	*400*	*Worldwide*	*Flexibility*	*Decentralized*	*Pyramidal*
Energy, Automation and Telecommunication	*1.400*	*28*	*Worldwide*	*Flexibility*	*Decentralized*	*Pyramidal*
Pharmaceutical	*42.000*	*1300*	*Worldwide*	*Efficiency*	*Federal*	*Contest*
Software	*13.000*	-	*Worldwide*	-	-	-
Banking	-	-	*Wordwide*	*Flexibility*	*Federal*	*Pyramidal*

5.2 Data analysis

According to Pereira and Mira (2012), in order to achieve a determined maturity level organization had to implement at least 75% activities of that corresponding level. Based on Figure 8 - Average , one can see level 2 is the most mature, followed by level 3, level 4 and level 5 respectively. Overall, organizations are more focused on definition and management activities but neglect metrics and measures to promote continuous improvement and predictive analysis.

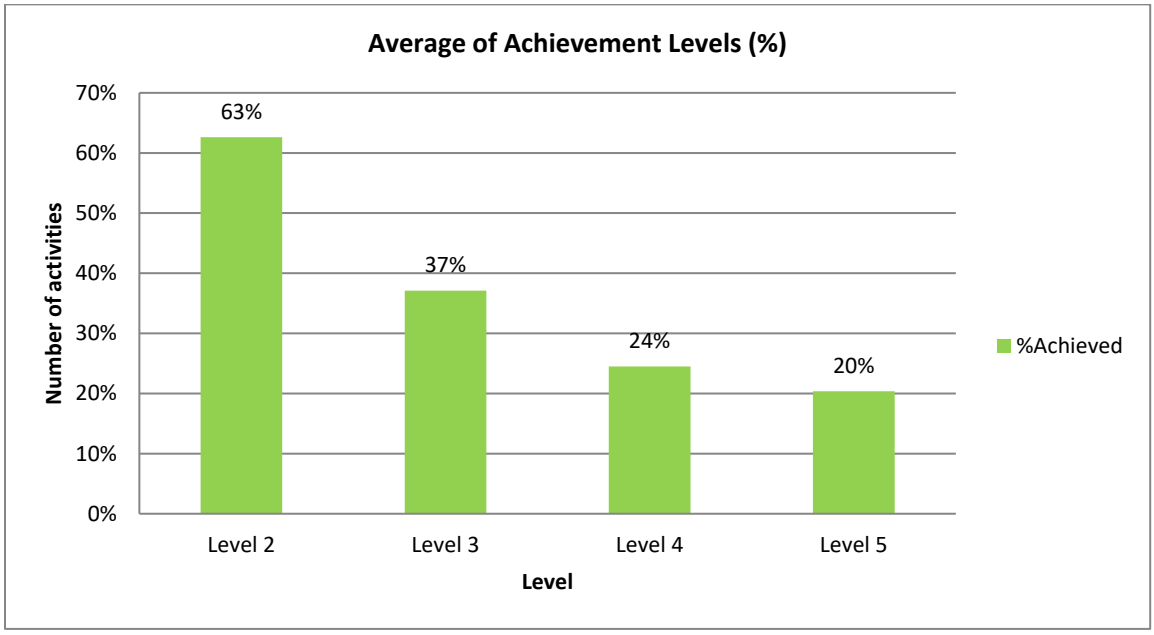

Figure 7 - Average of achievement levels of the interviewed organizations (%)

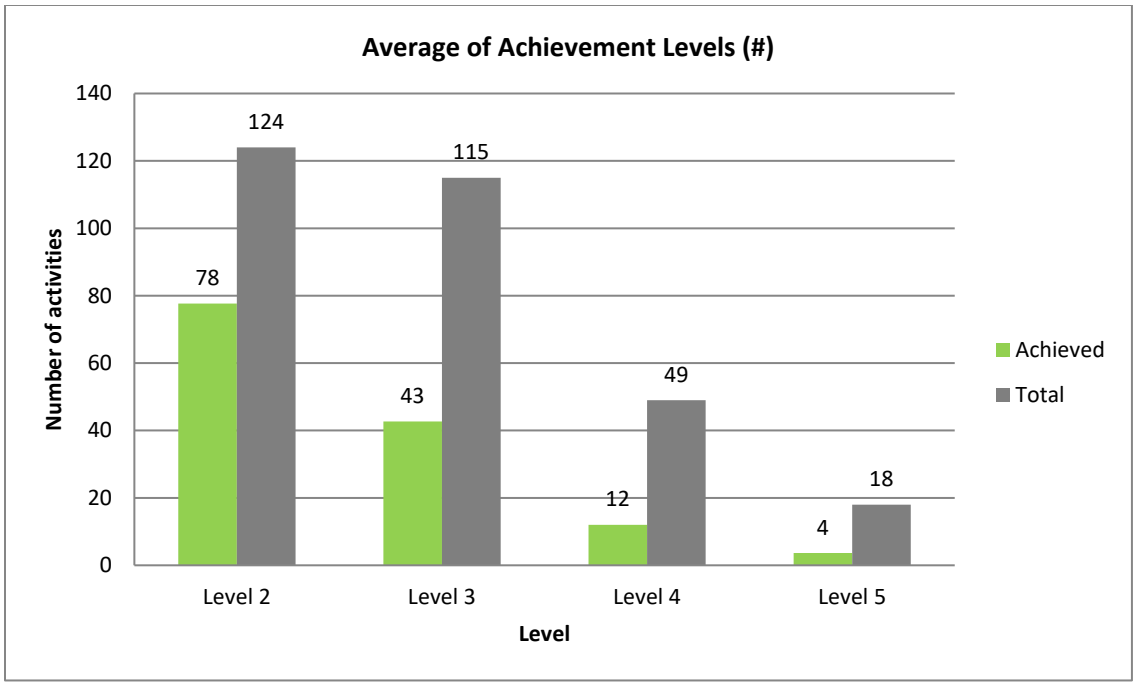

Figure 8 - Average achievement levels of the interviewed organizations (#)

As reported by Figure 9, all organizations are in a similar achievement for level 2 (Managed). The level 5 (optimizing) is still the lowest level, consequently level 4 (Quantitatively Managed) and finally level 3 (defined). Apparently, there is no visible disparity between the various types of organizations.

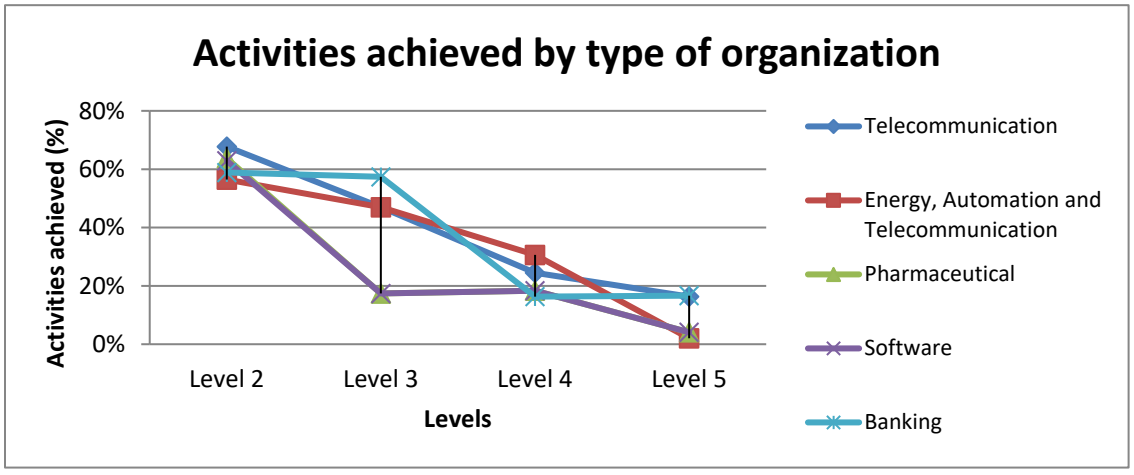

Figure 9 - Activities achieved by type of organization

To sum up, the author expected that some organizations were already at level 2 but none have fulfilled the requirements to reach that level. All the assessed organizations are at level 1 (initial). In average, organizations tend to focus their effort in the first level, level 2. To be considered a managed process (level 2) and reach level 3 (defined), organizations need to accomplish 75% of their activities.

At maturity level 2, activities are appropriately planned, staffed, monitored and controlled. Is collected enough information to identify the practices which are more effective (organization are producing expected results) and efficient (with less cost or effort). At level 3, the best practices are shared and managed across the organization, with measurements and lessons learned being collected to refine and improve them. Regarding the other levels, it is quite normal level 4 higher than level 5 because level 4 is usually used as an input to identify improvements areas or points within organizations and departments (level 5). Level 4 places the key practices (those most critical for customer satisfaction) under statistical control, allowing projects to rapidly identify any deviations and generating predictable results. Finally, at level 5, practices can be continuously improved based on a measured understanding of their cost and value and the possibility of predicting mathematically the probable impact of any proposed change to the process or the tools being employed.

As stated on Table 19, all the assessed organizations have more than 250 employees which means that they can be considered large organizations. Additional insights can be obtained regarding the IT frameworks adopted within each organization. Most of interviewed organizations pointed ITIL to be the most adopted IT framework (Figure 10).

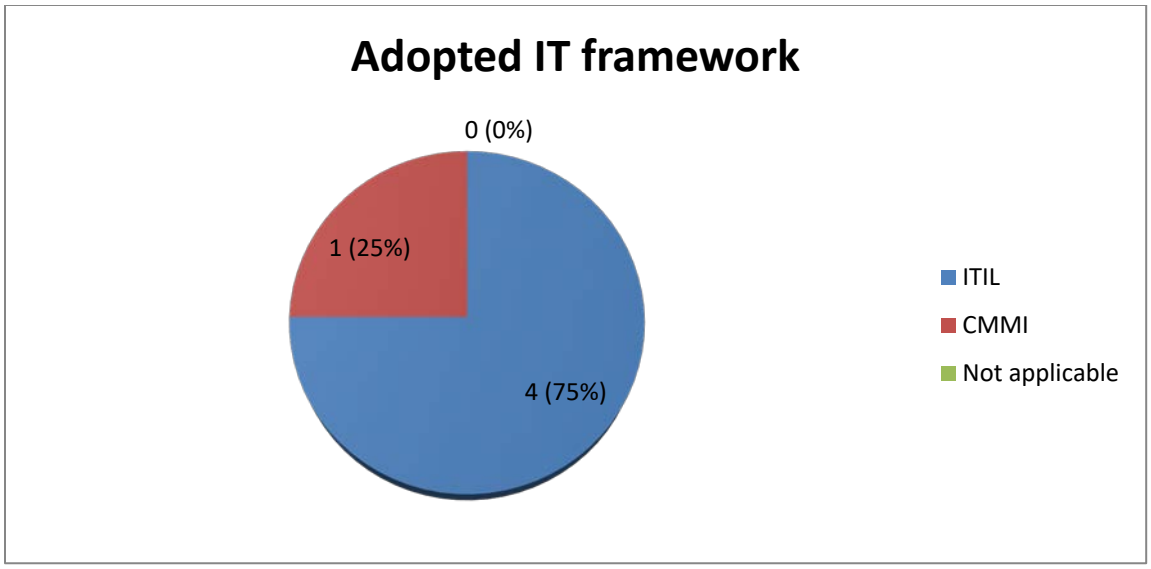

Figure 10 - Adoption or implementation of an IT framework within the organization

The source of most activities of the proposed model is the ITIL framework. Table 20 illustrates all insights obtained during assessment, view and adoption of each IT framework. One interesting insight was, one of the organizations indicated they use CMMI-SVC framework but it was not perceptible which I assume they ended to use the same activities CMMI have in common with the others frameworks.

Table 20 - Analysis of the adoption of each IT framework within the model

	ITIL	CMMI-SVC	COBIT	ITIL& CMMI-SVC	ITIL& COBIT	CMMI-SVC & COBIT	All	Total
Overall activities (nº)	*101*	*89*	*73*	*7*	*11*	*3*	*19*	*303*
Overall activities (%)	*33,33%*	*29,37%*	*24,09%*	*2,31%*	*3,63%*	*0,99%*	*6,27%*	*100%*
PM process overlap				***2,31%***	***3,63%***	***0,99%***	***6,27%***	***13%***
Average implemented activities (nº)	*90*	*72*	*65*	*4*	*9*	*2*	*15*	*257*
Average implemented activities (%)	*29.70%*	*23.76%*	*21.45%*	*1.32%*	*2.97%*	*0.66%*	*4.95%*	*12%*
Overall/average implemented (%)	*89.11%*	*80.90%*	*89.04%*	*57.14%*	*81.82%*	*66.67%*	*78.95%*	*77.66%*

5.3 Evaluation

After completing the interview process, the interviewees were invited to provide some feedback by answering some questions in order to evaluate the acceptance of our proposal and consequently the problem statement of our research study.

As illustrated in Table 21, from a global perspective the opinion was positive. Some interviewers mentioned mostly to be exhausting, too long or were very complete which is quite comprehensive. However, is consistent among the feedback received that the proposed is useful providing a complete vision about PM process based on three most-known frameworks.

Table 21 – Interviewee's acceptance regarding PM process maturity model

	Completeness	**Missing activities**	**Usefulness**
Interview 1	*Too long / Overtired*	*No*	*Yes*
Interview 2	*Very complete*	*No*	*Yes*
Interview 3	*Complete*	*No*	*Very*
Interview 4	*Very complete*	*No*	*Yes*
Interview 5	*Complete*	*No*	*Yes*

5.4 Synthesis

The efficient use of IT by organizations is a goal to be achieved and has been sought after by many companies (Gehrmann, 2012). Despite the existence of several IT standards and best-practises to help organizations, such are seen as complex (Serenko, Bontis, & Hull, 2014), hard to implement (Ho, Chai, & Tan, 2016), the IT standards and frameworks can easily overlap with each other (Schlarman, 2007) (Pereira & Mira da Silva, 2010) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018), organizations may design their own practices and give guidance at the lowest level that is applicable generally (Radovanovic, Radojević, Lucic, & Šarac, 2010). For this research, the author proposed an artefact able some of existing gaps in a multi-framework implementation such framework overlap and reduce complexity.

In order to proceed, a maturity model for PM process was developed by the author merging all details and knowledge of the three most well-known and used IT frameworks in the market. During the initial process in the creation of the model, through analysis of three most well-known and used IT frameworks (COBIT, CMMI-SVC; ITIL) that confirmed the existence of one of the research problems, framework overlap (13% of the activities identified were overlapping).

This research not only confirms the gaps found by other researchers but ease to solve with the proposed artefact. This model through prior identification of IT structures that overlap in the PM process helps to support future multi-framework implementations.

After the assessment complete, the feedback received from the interviewees was very encouraging. The interviewees considered the artefact as being useful, powerful and complete enough to mitigate some of the existing gaps and received some improvements. The assessment also sparked some ideas to the interviewee, who straight away identified some quick improvements to apply in their PM process.

As De Haes (2013), Aguiar, Pereira, Vasconcelos, & Bianchi (2018), Pereira & Mira da Silva (2010) and Ho, Chai, & Tan (2016) stated, implementing an IT framework is hard and implementing a multi-framework is quite a real challenge. The difficulty was noticeable when they wanted to implement more than one framework. Many organizations are not yet aware of its implementation and fail to get the best of them. It was clear that something was missing that could help improve the complexity of these frameworks at our disposal. The idea was to create a model that would concentrate the best of the PM process.

Finally, I consider that the research question was answered positively. This research, despite of providing quite important insight regarding IT framework overlap, it can help organizations to save and optimize the resources on a multi-framework implementation. The veracity of the research question was tested by choosing one of the most important processes in IT processes.

Chapter 6 – Conclusion

The following section restates our proposal and summarize of the main points, personal opinion and comments about the future based on what has been discussed and implications author of the future research.

The proposed to study the possibility of reducing or solving the framework overlap by creating an artefact to help organizations in a multi-framework implementation and artefact veracity was proved by answering the formulated research question (Is it possible to develop an overlapless and yet complete IT Maturity Model for PM process?).

A maturity model was created grounded on the three most well-known IT frameworks (COBIT, ITIL and CMMI-SVC) for one of the most important IT processes (PM).

Several contributions could be withdrawn at the end of this research:

1. This research confirms and reinforce IT frameworks overlap issue previously pointed by other researchers. From 349 PM activities elicited, 46 activities were identified as being overlapped among the chosen IT frameworks. This means that 13% of all activities are present at least in two of the three IT frameworks considered in this research (Table 13).
2. All the interviewees classified the artefact as useful and complete. They confirmed that implementing an IT framework is not straight forward and having an artefact to help them in a multi-framework implementation would be very useful (Haes, Grembergen, & Debrecen, 2013) (Aguiar, Pereira, Vasconcelos, & Bianchi, 2018). By recognizing the proposed artefact as complete the interviewees (PM experts) accept the artefact as helpful in a multi-framework implementation. Reasoning from this fact, it can be argued that this research objective was successfully achieved.
3. This research also reinforced that ITIL is the most widely used IT framework. Looking to the assessed organizations, four of them (80%) pointed ITIL as the

official IT framework (Figure 10). The fifth organization (20%) pointed CMMI as their official IT framework.

4. It is quite interesting to validate that organizations are becoming demanding regarding their maturity since they have an acceptable level for managed and defined. They do not respect 75% (minimum value for level acceptance) but are very close.
5. From cross studies is interesting to note that in a combined analysis both processes (IM and PM) tend to have a highest percentage of activities overlapped by all the IT frameworks and a lowest percentage of activities common between COBIT and CMMI-SVC

In consideration of the foregoing, more interviews could be achieved but only 5 organizations accepted to be assessed so far.

The main contribution of this research is a maturity model based on most popular IT frameworks used and adopted. This research reckons a novel insight to the actual BoK. Practitioners consider the proposed maturity model as useful and complete. For them, the main contribution of this research is they can assess their current operational efficiency and effectiveness state and identify the required steps to reach the desired level. In other hand, this research is also useful for the academics because it distinguishes itself from the existing artefacts by being new and innovative, proving to be effective in real scenarios. Nevertheless, it is also scalable because this research can be expanded for other IT processes. In addition, it also bolsters up the well-known framework overlap problem and prop up the awareness of the organizations regarding the actual PM maturity level. The most concern among organizations is to get the best of all frameworks according to their business needs and sometimes they are difficult to implement (Ho, Chai, & Tan, 2016), they end up doing some redundant work (Schlarman, 2007) (Pereira & Mira da Silva, 2010) and by identifying frameworks overlaps it becomes easier to implement for any process of IT multi-frameworks implementation upfront.

Regarding the research limitations, the author consider that the previous conclusions may not be the same for remaining IT processes and it is not possible to generalize our insights. Therefore, future research may pass by improving the maturity model with further IT frameworks and standards and develop the same maturity model approach for more IT processes. In a future, having a model able to cover the most used IT processes could be very useful and, at the same time, challenging which is one more reason to continue this research.

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Appendix A

Table 22 - List of CMMI activities collected

CMMI		
Management Practise	Activities	#
SG 1 Determine Causes of Defects and Problems		#
SP1.1 Select Defects and Problems. Select defects and problems for analysis.	The defect or problem is identified?	B1
	If yes, what relevant defect data is included: 1. Defects reported by customers or end users?	B2
	2. Defects reported by service teams?	B3
	3. Defects found in service verification?	B4
	4. Productivity measures that is higher than expected?	B5
	5. Project management problem reports requiring corrective action?	B6
	6. Process capability problems?	B7
	7. Resource throughput, utilization, or response time measurements?	B8
	8. Help desk calls, by time and incident category?	B9
	9. Inadequate availability of the service system?	B10
	10. Service fulfillment or service satisfaction problems?	B11
	11. Other _____	B12
	In order to analyze further, the problem outcome is determined? When determining which outcomes to analyze further, consider their source, impact, frequency of occurrence, similarity, the cost of analysis, the time and resources needed, safety considerations, etc.	B13
	If yes, what method for selecting outcomes is used? 1. Pareto analysis	B14
	2. Histograms	B15
	3. Box and whisker plots for attributes	B16

	4. Failure mode and effects analysis (FMEA) Cause and effects analysis (e.g., design failure mode and effects analysis for the service system being developed, process failure mode and effects analysis for service system development or service delivery)	B17
	5. Other _____	B18
	The scope of the analysis is defined? Including a clear definition of the improvement needed or expected, stakeholders affected, target affected, etc.	B19
SP 1.2 Analyze Causes Perform causal analysis of selected defects and problems and propose actions to address them.	A causal analysis with those responsible for performing the task is conducted? Causal analysis is performed, typically in meetings, with those who understand the selected outcome under study. Those who have the best understanding of the selected outcome are typically those who are responsible for performing the task. The analysis is most effective when applied to real time data, as close as possible to the event which triggered the outcome.	B20
	If yes, on which cases? 1. When a stable sub process does not meet its specified quality and process performance objectives, or when a sub process needs to be stabilized	B21
	2. During the task, if and when problems warrant a causal analysis meeting	B22
	3. When a work product exhibits an unexpected deviation from its requirements	B23
	4. When process performance exceeds expectations	B24
	5. At the start of a new phase or task	B25
	6. Other _____	B26
	The defects and problems are analyzed in order to determine their root causes?	B27
	If yes, what methods are used to determine root causes? 1. Cause-and-effect (fishbone) diagrams	B28
	2. Check sheets	B29
	3. Other _____	B30
	The selected defects and problems were grouped based on their root causes?	B31
	If yes, what kind of grouping is used? 1. Inadequate training and skills	B32

	2. Breakdown of communication	B33
	3. Not accounting for all details of a task	B34
	4. Making mistakes in manual procedures (e.g., keyboard entry)	B35
	5. Process deficiency	B36
	6. Other _____	B37
	The action proposal (to prevent the future occurrence of similar defects and problems) are documented?	B38
	If yes, what actions? 1. The process in question	B39
	2. Training	B40
	3. Tools	B41
	4. Methods	B42
	5. Communication	B43
	6. Work products	B44
	7. Other _____	B45
	The action proposal incorporates best practices such: 1. Creating activity checklists, which reinforce training or communications related to common problems and techniques for preventing them?	B46
	2. Changing a process so that error-prone steps do not occur?	B47
	3. Automating all or part of a process?	B48
	4. Reordering process activities?	B49
	5. Adding process steps, such as task kickoff meetings to review common problems as well as actions to prevent them?	B50
	6. Other _____	B51

	The action proposal usually documents the following: 1. Originator of the action proposal	B52
	2. Description of the outcome to be addressed	B53
	3. Description of the cause	B54
	4. Cause category	B55
	5. Phase identified	B56
	6. Description of the action Time, cost, and other resources required to implement the action proposal	B57
	7. Expected benefits from implementing the action proposal	B58
	8. Estimated cost of not fixing the problem	B59
	9. Action proposal category	B60
	10. Other _____	B61
SG2 Address causes of defects and problems		#
SP 2.1 Implement action proposals Root causes of defects and problems are systematically addressed to prevent their future occurrence.	Do you usually analyze the action proposal(s) is analyzed? Process performance models can be used to help identify interactions among multiple Action proposals.	B62
	If an action proposal(s) is analyzed, their priorities are determined?	B63
	If yes, what includes the criteria for prioritizing action proposals? 1. Implications of not addressing the defect or problem	B64
	2. Cost to implement process improvements to prevent the defect or problem	B65
	3. Expected impact on quality	B66
	4. Other _____	B67
	The action proposal(s) to be implemented is selected?	B68
	The action plans for implementing the selected action proposals were created?	B69

	The action plan includes the following: 1. Person responsible for implementation	B70
	2. Detailed description of the improvement	B71
	3. Description of the affected areas	B72
	4. People who are to be kept informed of status	B73
	5. Schedule Cost expended	B74
	6. Next date that status will be reviewed	B75
	7. Rationale for key decisions	B76
	8. Description of implementation actions	B77
	9. Other _____	B78
	The action plan is implemented?	B79
	If yes, the following tasks were performed? 1. Make assignments?	B80
	2. Coordinate the people doing the work	B81
	3. Review the results	B82
	4. Track action items to closure	B83
	5. Other _____	B84
	Experiments are conducted for particularly complex changes?	B85
	If yes, the experiments include: 1. Using a temporary modified process?	B86
	2. Using a new tool?	B87
	3. Other _____	B88
	Do you usually look for similar causes in other processes and work products?	B89
	If you found similar causes in other processes and work products, do you usually take actions as appropriate?	B90
SP 2.2 Evaluate the Effect of	Do you usually analyze the change in process performance of the affected processes or sub processes for the work?	B91

Implemented Actions Evaluate the effect of implemented actions on process performance.	If yes, do you measure it? An example of a change in the process performance of a service would be a change in the predicted ability of the design to meet the quality and process performance objectives. Another example would be a change in the cost of delivering the service after a change in the subprocess for integrating revised service system components. This change in performance would be determined through monitoring the delivered service before and after the improvement has been made and comparing these differences statistically (e.g., through hypothesis testing). On a statistical process control chart, this change in process performance would be represented by an improvement in the mean, a reduction in variation, or both	B92
	After analyzed and measure, the selected change has positively influenced process performance? Statistical and other quantitative techniques (e.g., hypothesis testing) can be used to compare the before and after baselines to assess the statistical significance of the change.	B93
	If yes, how much?	B94
	The impact of the change is determined? This sub practice determines whether the selected change has positively influenced the ability of the work group to meet its quality and process performance objectives by understanding how changes in the process performance data have affected the objectives. Process performance models can aid in the evaluation through prediction of impacts and return on investment.	B95
	If yes, it achieves: 1. Quality?	B96
	2. Process Performance objectives?	B97
	3. Other _____	B98
	If the process or sub process improvements did not result in expected benefits, do you usually: 1. Determine the appropriate actions?	B99
	2. Document the appropriate actions?	B100
	3. Other _____	B101
SP 2.3 Record data Record causal analysis and resolution data for use across the project and organization.	The causal analysis data is recorded?	B102
	If yes, causal analysis data includes what: 1. Data on outcomes that were analyzed?	B103
	2. Rationale for decisions?	B104
	3. Action proposals from causal analysis meetings?	B105
	4. Action plans resulting from action proposals?	B106
	5. Cost of analysis and resolution activities?	B107
	6. Measures of changes to the process performance of the defined process resulting from resolutions?	B108
	After causal analysis data recorded, the data is available for other work groups? To create appropriate process changes and achieve similar results.	B109
	The implemented actions are effective for working group?	B110

	When improvements are judged to be effective, the information can be submitted to the organizational level for potential inclusion in the organizational processes.	
	If yes, do you usually submit a process improvement proposal?	B111

Appendix B

Table 23 - Sample of activities collected for each framework analysed

Management Practise	**Activities**	**ITIL (A)**	**CMMI (B)**	**COBIT (C)**	Maturity Level
1 - Problem Detection. Ways of detecting problems within an organizations	Can the problem be detected through: 1. Service Desk - Service Desk has suspicion or detected a cause of one or more incidents? - Service desk may have resolved the incident but has not determined a definitive cause and suspects that it is likely to recur?	A1			
	2. Incident Management - Is immediately obvious from the outset that an incident, or incidents, is caused by a major problem? - Analysis of an incident by a technical support group revealed that an underlying problem exists, or is likely to exist?	A2			
	3. Event Management - Automated detection of an infrastructure or application fault, using event/alert tools automatically to raise an incident which may reveal the need for a Problem Record?	A3			
	4. Supplier and Contractor - Received a notification from a supplier or contractor that a problem exists that has to be resolved?	A4			
	5. Proactive problem management - Analysis of incidents as part of proactive Problem Management needs to raise a Problem Record so that the underlying fault can be investigated further?	A5			
	6. Others _____	A6		C5	Level 2
2 - Problem Logging. Ways of logging the problem	A problem record is raised?	A7	B1	C7	Level 2
	If yes, the problem contains all relevant details?	A8		C9	Level 2
	If yes, what kind of details? 1. User details?	A9			Level 2
	2. Service details?	A10	B3		Level 2
	3. Equipment details?	A11			Level 2

	4. Date/time initially logged?	A12			Level 2
	5. Priority and categorization details?	A13			Level 2
	6. Incident description?	A14			Level 2
	7. Details of all diagnostic or attempted recovery actions taken?	A15		C13	Level 2
	8. Others _____	A16			Level 2
	The problem record have date and time stamped to allow suitable control and escalation?	A17			Level 2
	Does the problem record reference the incident(s) that gave rise to the problem?	A18			Level 2
	If yes, does the problem record have all relevant details copied from incident record(s)?	A19			Level 2
3 - Problem Categorization. Ways of categorization the problem	The problem is categorized?	A20		C6	Level 2
	If yes, 1. The problem is categorized in the same way as incidents?	A21			Level 2
	2. The problem is categorized using the same coding system?	A22			Level 2
	3. Others _____	A23			Level 2
-4 - Problem Prioritization. Ways of prioritize the problems	The problem is prioritized?	A24		C17	Level 2
	The problem impact is defined?	A25	B13	C15	Level 2
	The problem frequency is defined?	A26	B13		Level 2
	The problem urgency is defined?	A27		C16	Level 2
	The problem severity is defined?	A28			Level 2
	If yes, is prioritized in the same way and for the same reasons as incidents?	A29			Level 2
	Is the prioritization taking in account / based on: 1. Frequency	A30			Level 2
	2. Impact	A31		C18	Level 2
	3. Severity	A32			Level 2
	4. Others _____	A33			Level 2

5 - Problem Investigations and Diagnosis. Ways of investigate and troubleshoot	The root cause of the problem is under investigation?	A34		C37	Level 2
	The level of resource and expertise is appropriated for: 1. Problem priority level?	A35			Level 2
	2. Service target	A36			Level 2
	3. Others _____	A37			Level 2
	To validate if the problem has occurred before, is there any problem-matching techniques being applied?	A38			Level 2
	If yes, what problem-matching techniques? 1. Keyword search?	A39			Level 2
	2. Others _____	A40			Level 2
	Does Configuration Management System (CMS) exist?	A41			Level 3
	If yes, 1. Is CMS used to help determine the level of impact?	A42			Level 3
	2. Is CMS used to assist in pinpointing and diagnosing the exact point of failure?	A43			Level 3
	3. Others _____	A44			Level 3
	Does Know Error Database (KEDB) exist?	A45		C27	Level 3
	A problem analysis, diagnosis and solving technique are applied?	A46			Level 3
	If yes, what techniques? 1. Chronological analysis	A47			Level 3
	2. Pain Value Analysis	A48			Level 3
	3. Kepner and Tregoe	A49			Level 3
	4. Brainstorming	A50			Level 3
	5. Ishikawa Diagrams	A51			Level 3
	6. Pareto Analysis	A52			Level 3
	7. Others _____	A53			Level 3
	It is possible to recreate the failure?	A54			Level 3
	A resolution to the problem was discovered?	A55			Level 3

	If yes, is the most appropriate and cost-effective resolution to the problem?	A56			Level 3
	The problem was recreated?	A57			Level 3
	If yes, in which system? 1. In a test system?	A58			Level 3
	2. Other_____	A59			Level 3
6 - Work around. Alternative ways to solve problems	Do you usually try to find a workaround to temporary solve the problem?	A60			Level 3
	In cases where a workaround is found, 1. The problem record remains open?	A61			Level 3
	2. The workaround details are documented within the Problem Record?	A62			Level 3
	3. Others _____	A63			Level 3
7 - Raising a known error record Ways to raise known-error	When the diagnosis is complete and a workaround is found, is a Known Error Record Raised?	A64			Level 3
	If yes, 1. Is placed in the Known Error Database (KEDB)?	A65			Level 3
	2. Other _____	A66			Level 3
8 - Problem Resolution. Ways of resolve problems	Do you usually try to find a solution to the problem?	A67			Level 3
	As soon as a solution is found, it is immediately applied?	A68			Level 3
	If a change in functionality is required, 1. Is there a RFC created?	A69			Level 3
	2. The RFC is approved?	A70			Level 3
	i.Is approved before the resolution can be applied?	A71			Level 3
	3. The RFC is scheduled?	A72			Level 3
	In cases when a problem is very serious and an urgent fix is needed for business reasons, is an Emergency RFC (ERFC) was created?	A73			Level 4

	The previous created ERFC is handled by the Emergency Change Advisory Board (ECAB)?	A74			Level 4
	If an ERFC is not raised, 1. The RFC usually is following Change Management process for that type of change?	A75			Level 3
	2. The resolution usually is only applied after the change approved and scheduled for release?	A76			Level 3
	The Know Error Database (KEDB) is used as part of problem resolution to help resolve quickly any further occurrences of the incidents/problems that occur? - Is this problem listed/described at Know Error Database (KEDB)? - The problem was created a record in Know Error Database (KEDB)?	A77			Level 5
	Is the business case for resolution capable to be justified? - Cases when impact is limited but the cost of resolution would be extremely high	A78			Level 2
	If no, any decision is taken to leave the problem record open and use the workaround described on KEDB?	A79			Level 3
9 - Problem Closure. Ways of closing problem	Do you usually close the problem record?	A80			Level 2
	If yes, 1. The change was completed?	A81			Level 2
	2. The change was successfully reviewed?	A82			Level 2
	3. The change resolution was applied?	A83			Level 2
	4. Is any related incident record is still open?	A84			Level 2
	The record contains full historical description of all events?	A85			Level 3
	After resolution applied, the status of any related Known Error Record is updated?	A86			Level 4

	After problem closure, a review is conducted?	A87			Level 4
10 - Major Problem Review Ways of reviewing problems	Do you usually review the problem?	A88			Level 4
	If yes, during the review did you examine: 1. Tasks done correctly?	A89			Level 4
	2. Tasks done wrong?	A90			Level 4
	3. What could be done better in future?	A91			Level 4
	4. How to prevent recurrence?	A92			Level 4
	5. Is there any 3rd party responsibility involved?	A93			Level 4
	6. Is any follow up action needed?	A94			Level 4
	According previous review points identified, are they part of any training and awareness activities for support staff, provided by Problem Manager?	A95			Level 5
	Do you document all your lessons learned in appropriate procedures, work instructions, diagnostic scripts or Known Error Records?	A96			Level 5
	The knowledge learned from the review is incorporated into a service review meeting with the business customer?	A97			Level 4
	The customer is aware of: 1. The actions taken?	A98			Level 5
	2. The plans to prevent future major incidents from occurring?	A99			Level 5
11 - Errors detected in the development environment Ways of detecting errors	The resolution to apply into Production environment includes known deficiencies?	A100			Level 4
	If yes, 1. It is logged a Known Error in the KEDB?	A101			Level 4
	2. The Known Error contains details of workarounds or resolution activities?	A102			Level 4
	3. Is there any formal step in the testing sign-off that ensures that this handover always takes place? (Service Transition)	A103			Level 4

12 - Triggers, input and output/inter-process interfaces Ways of logging the problem	The majority of Problem Records are triggered in reaction to: 1. Incidents?	A104			Level 4
	2. Service Desk staff?	A105			Level 4
	3. Stages of testing such User Acceptance Testing (UAT)?	A106			Level 4
	4. Supplier's notification?	A107			Level 4
	5. Other _____	A108			Level 4

Appendix C

The following section illustrates all activities collected for each level assigned.

Table 24 - List of activities for Level 2

Number	Activities for Level 2
1	Are the problems identified?
	If yes, through which proper problem identification mechanisms?
2	1. Service Desk
3	1.1 Defects reported by customers or end users?
4	1.2. Project management problem reports requiring corrective action?
5	1.3. Help desk calls, by time and incident category?
6	1.4. Inadequate availability of the service system?
7	1.5. Service fulfilment or service satisfaction problems?
8	1.6. Process capability problems?
9	1.7. Resource throughput, utilization, or response time measurements?
10	2. Incident Management
11	3. Event Management
12	4. Supplier and Contractor
	5. Proactive problem management
13	5.1. Defects reported by service teams?
14	5.2. Defects found in service verification?
15	6.Others _____
16	Is gathered any information about the identified problem?
	If yes,
	1. What kind of details?
17	1. User details?
18	2. Service details?

19	3. Last status of the problem?
19	3.1. The status “Open” is included?
20	3.2. The status “Reopen” is included?
21	3.3. The status “In Progress” is included?
22	3.4. The status “Closed” is included?
23	3.5. Others _____
24	4. Equipment details?
25	5. Date/time initially logged?
26	6. Priority and categorization details?
27	7. Related Incident details?
28	8. Details of all diagnostic or attempted recovery actions taken?
30	10. Information from IT configuration/asset
31	11. Reference the incident(s) that gave rise to the problem?
32	12. Source?
33	13. Frequency of occurrence?
34	14. Similarity?
35	15. Cost of analysis?
36	16. Time and resources needed?
37	17. Safety considerations?
38	18. Rationale for decisions?
39	19. Action proposals from causal analysis meetings?
40	20. Action plans resulting from action proposals?
41	21. Cost of analysis and resolution activities?
43	23. Others _____
44	2. Is the same information identified shared with the Service Desk?
45	After problem data identified, is the data is available for other work groups?
46	Does the SD keep the customers informed?

47	Does the SD keep IT management informed?
48	Is there a Problem Catalogue available?
	If yes,
49	1. Do you usually register the problem in the catalogue?
50	2. Does the catalogue have the details updated?
51	If there is reference of the incident that gave rise to the problem, does the problem record have all relevant details copied from incident record(s)?
52	Is the problem categorized?
	If yes,
53	1. Is there any criterion for problem registration?
54	2. Is the problem categorized using same criteria than incidents?
55	3. Is the problem categorized using the same coding system (matrix)?
56	4. Others _____
57	Is a support group defined for problem management?
	If yes,
	1. Are appropriate support groups defined to assist with:
58	a. Problem identification?
59	b. Root cause analysis?
60	c. Solution determination?
61	d. Work around?
62	2. Is the support group selected based on pre-defined categories?
63	If not, what is the rational for the selection of the support group? _____
64	Is the business impact defined?
65	Is the business urgency defined?
66	Is the problem frequency defined?
67	Is a priority level defined?
	If yes,

68	1. Is the priority defined based on business impact?
69	2. Is the priority defined based on business urgency?
70	3. Is prioritized using the same method like incidents?
71	4. Is the priority defined based on frequency?
72	5. Is the priority defined based on severity?
73	Is the problem severity defined?
74	Is any method being used for problem analysis?
	If yes,
75	1. Cause-and-effect (fishbone) diagrams
76	2. Check sheets
77	3. Pareto analysis
78	4. Histograms
79	5. Box and whisker plots for attributes
80	6. Failure mode and effects analysis (FMEA)
81	7. Chronological analysis
82	8. Pain Value Analysis
83	9. Kepner and Tregoe (5 phases)
84	10. Brainstorming
85	11. Ishikawa Diagrams
86	12. Other _____
87	Are the selected defects and problems grouped based on their root causes?
	If yes, what kind of grouping is used?
88	1. Inadequate training and skills
89	2. Breakdown of communication
90	3. Not accounting for all details of a task
91	4. Making mistakes in manual procedures (e.g., keyboard entry)
92	5. Process deficiency

93	6. Other _____
94	Is the scope of the problem analysis defined?
	If yes, what is included in the scope?
95	1. Definition of the improvement needed or expected
96	2. Stakeholders affected
97	3.Target affected
98	4. Other _____
104	Does a Configuration Management System (CMS) exist?
	If yes,
105	1. Is CMS used to help determine the level of impact?
106	2. Is CMS used to assist in pinpointing and diagnosing the exact point of failure?
107	3. Others _____
108	Is it possible to recreate the problem?
109	If yes, did you recreate the problem during the analysis process?
	If yes, in which system?
110	1. In a test system?
111	2. Other_____
112	Do you try to find a resolution to the problem?
113	If yes, is it the most appropriate resolution to the problem?
135	Do you usually try to find a workaround to temporary solve the problem?
136	After the problem identification, do you usually develop a suitable workaround?
	In cases where a workaround is found,
137	1. The problem record remains open?
138	2. The workaround details are documented within the Problem Record?
139	3. Others _____

140	The implemented actions are effective for working group?
	In your organization the Problem Records are triggered in reaction to:
251	1. Incidents?
252	2. Service Desk staff?
253	3. IT staff?
254	4. Stages of testing such User Acceptance Testing (UAT)?
255	5. Supplier's notification?
256	6. Other _____
	The majority of Problem Records are triggered in reaction to:
257	1. Incidents?
258	2. Service Desk staff?
259	3. IT staff?
260	4. Stages of testing such User Acceptance Testing (UAT)?
261	5. Supplier's notification?
262	6. Other _____

Table 25 - List of activities for Level 3

Number	**Activities for Level 3**
29	9. Information from the change management system
	Is the level of resource and expertise appropriated for:
99	1. Problem priority level?
100	2. Service target
101	3. Others _____
102	Is any validation done in order to identify if the problem existed previously?
103	If yes, to validate if the problem has occurred before, is there any problem-matching techniques being applied?

114	Do you usually propose / define any actions proposal to prevent the future occurrence of similar defects and problems?
115	If yes, the actions required (or actions proposal) are documented?
	If yes, does the documentation include:
116	1. Problem description / Description of the cause
117	2. Training
118	3. Tools
119	4. Methods
120	5. Communication
121	6. Work products
122	7. Activity checklists
123	8. Process changes so that error-prone steps do not occur
124	9. Automate all or part of a process
125	10. Reorder process activities
126	11. Process steps
127	12. Originator of the action proposal
128	13. Description of the outcome to be addressed
129	14. Problem cause category
130	15. Phase identified
131	16. Description of the action
132	17. Expected benefits from implementing the action proposal
133	18. Estimated cost of not fixing the problem
134	19. Other _____
141	If yes, do you usually submit a process improvement proposal?
142	Is there a database of known and suspected error (KEDB) defined?
	If yes,

143	1. The database includes known errors communicated by external vendors?
144	2. Do you usually try to identify the problem that may be a known error by comparing incident data with KEDB?
145	3. When the problem is already available in KEDB, do you usually classify it as a known error?
146	4. Do you usually associate the affected configuration items to the established/known error?
147	5. The Known Error contains details of workarounds or resolution activities?
154	When the diagnosis is complete and a workaround is found, is a Known Error Record Raised?
	If yes,
155	1. Is placed in the KEDB?
156	2. Other _____
157	The Know Error Database (KEDB) is used as part of problem resolution to help resolve quickly any further occurrences of the incidents/problems that occurred?
159	Do you usually try to find a solution to the problem?
160	As soon as a solution is found, it is immediately applied?
161	Is the business case for resolution capable to be justified?
162	If no, any decision is taken to leave the problem record open and use the workaround described on KEDB?
163	Do you usually close the problem record?
	If yes,
164	1. Is any related incident record is still open?
165	2. Have confirmed successful elimination of the known error?

166	3. Agreement with the business on how to alternatively handle the problem?
167	The record contains full historical description of all events?
168	After resolution applied, the status of any related Known Error Record is updated?
169	After problem closure, a review is conducted?
	Do you usually inform the Service Desk (SD) about:
170	1. The schedule of problem closure?
171	2. The schedule for fixing the known errors?
172	3. The possible workaround or the fact that the problem will remain until the change is implemented
173	4. The consequences of the approach taken?
174	5. Other _____
180	Are there major problems?
181	If yes, the success of resolutions of major problems is usually reviewed and confirmed?
182	In a service review meeting with the business customer, do you usually share the knowledge learned from review?
183	Do you usually analyse the action proposal(s)?
184	After proposal(s) analysis, priorities are determined?
	If yes, what includes the criteria for prioritizing action proposals?
185	1. Implications of not addressing the defect or problem
186	2. Cost to implement process improvements to prevent the defect or problem
187	3. Expected impact on quality
188	4. Other _____
189	Do you always select the action proposal(s) to be implemented?

190	The action plan to implement the selected action proposals is created?
	If yes, the action plan includes the following:
191	1. Person responsible for implementation
192	2. Detailed description of the improvement
193	3. Description of the affected areas
194	4. People who are to be kept informed of status
195	5. Schedule Cost expended
196	6. Next date that status will be reviewed
197	7. Rationale for key decisions
198	8. Description of implementation actions
199	9. Other _____
200	The action plan is implemented?
	If yes, are the following tasks performed?
201	1. Make assignments?
202	2. Coordinate the people doing the work
203	3. Review the results
204	4. Track action items to closure
205	5. Other _____
206	Experiments are conducted for particularly complex changes?
	If yes, the experiments include:
207	1. Using a temporary modified process?
208	2. Using a new tool?
209	3. Other _____
210	Do you usually look for similar causes in other processes and work products?
211	If you find similar causes in other processes and work products, do you usually take actions?

	The customer is aware of:
225	1. The actions taken?
226	2. The plans to prevent future major problems from occurring?
227	The process owners and managers meet regularly to discuss known problems?
	If yes, the managers are from which area?
228	1. Incident Management?
229	2. Problem Management?
230	3. Change Management?
231	4. Configuration Management?
232	5. Other _____
233	The process owners and managers meet regularly to discuss future planned changes and corrective actions?
	If yes, the managers from which area?
234	1. Incident Management?
235	2. Problem Management?
236	3. Change Management?
237	4. Configuration Management?
238	5. Other _____
239	Do you document all your lessons learned?
	If yes, what do you document?
240	1. Appropriate procedures
241	2. Work instructions
242	3. Diagnostic scripts
243	4. Known Error Records
	The resolution to apply into production environment includes:
247	1. Extracted and registered Known-Errors?

248	2. Ad-hoc errors
	If yes,
249	1. A Known Error is logged in the KEDB?
250	2. Is there any formal step in the testing sign-off that ensures that this handover always takes place?
275	2. Other _____
277	Is any process available for escalation of problems, e.g. escalation to a higher management?
	If yes,
278	1. Is the escalation of problem according to agreed-on criteria?
279	2. The escalation includes contacting external vendors?
280	3. The escalation includes referring to the change advisory board to increase the priority of an urgent request for change (RFC) to implement a temporary workaround?
283	Do you measure your effectiveness and efficiency of PM process or its operation?

Table 26 - List of activities for Level 4

Number	Activities for Level 4
42	22. Measures of changes to the process performance of the defined process resulting from resolutions?
	Do you usually produce reports to communicate the progress
148	1. In resolving problems?
149	2. To monitor the continuing impact of problems not solved?
150	3. Others _____
151	Is the status of problem-handling process being monitored?
	If yes,

152	1. Throughout its life cycle including input from change and configuration management?
153	2. Other _____
158	The problem is processed via change management, based on a cost-benefit business case and business impact and urgency?
	Do you usually keep informed
175	1. The affected users?
176	2. The affected customers?
177	3. Other _____
178	Throughout the resolution process, do you usually obtain regular reports from change management on progress in resolving problems and errors?
179	The impact of problems and known errors on services is continuing monitored?
	If the information is communicated to key stakeholders, how is the information communicated?
220	a. Reports?
221	b. Periodic meetings?
222	c. Other _____
223	Is there a problem manager?
224	According previous review points identified, are they part of any training and awareness activities for support staff, provided by the Problem Manager?
244	The knowledge learned from the review is incorporated into a service review meeting with the customer?
	If yes, which customer?
245	1. Business Customer
246	2. Other _____
265	The impact of the change/solution applied is determined?

	If yes, it achieves:
266	1. Quality?
267	2. Process Performance objectives?
268	3. Other _____
276	Is any report produced to monitor the problem resolution against the business requirements and SLAs?
	If yes, what metrics do you use?
284	1. Is the total number of problems recorded in the period?
285	2. Is the percentage of problems resolved within SLA targets?
286	3. Is the percentage of problems unsolved within SLA targets?
287	4. Is the number and percentage of problems that exceeded their target resolution times?
288	5. Is the backlog of outstanding problems and the trend analysed? (static, reducing or increasing)
289	6. Is the average cost of handling a problem calculated?
290	7. Is the number of major open problems registered?
291	8. Is the number of major closed problems registered?
292	9. Is the number of major backlog problems registered?
293	10. Is the percentage of Major Problem Reviews successfully performed?
294	11. Is the number of Known Errors added to the KEDB calculated?
295	12. Is the percentage accuracy of the KEDB (from audits of the database) measured?
296	13. Is the percentage of Major Problem Reviews completed successfully measured? and on time.

297	14. Is the percentage of Major Problem Reviews on time successfully measured?
	In cases where a metric is used, the metrics are broken down by:
298	1. Category
299	2. Impact
300	3. Severity
301	4. Urgency
302	5. Priority Level
303	6. Other _____

Table 27 - List of activities for Level 5

Number	Activities for Level 5
212	Do you usually review the problem?
	If yes, during the review do you:
213	1. Examine tasks done correctly?
214	2. Examine tasks done wrong?
215	3. Examine what could be done better in future?
216	4. Examine how to prevent recurrence?
217	5. Examine is there any 3rd party responsibility involved?
218	6. Examine is any follow up action needed?
219	7. Communicate information to key stakeholders?
263	Do you usually analyse the change in process performance of the affected processes or sub processes?
	If yes, do you measure it?
264	The selected change has positively influenced process performance?
	If the process or sub process improvements did not result in expected benefits, do you usually:

269	1. Determine the appropriate actions?
270	2. Document the appropriate actions?
271	3. Other _____
272	The total costs of problems are monitored?
273	The change efforts resulting from problem management process activities are captured?
	If yes,
274	1. Are made reports about those change efforts?
281	Can you track the problem trends?
282	Have been identified and initiated sustainable solutions (permanent fix) addressing the root cause, and raise change requests via the established change management processes?

ISCTE – Instituto Universitário de Lisboa

Problem Management Maturity Model

Assessment

(Questionnaire)

Appendix D

PURPOSE AND INSTRUCTIONS

The purpose of this study is to obtain current information on your Problem Management (PM) process based on PM process activities gathered from the following frameworks and standards such ITIL, COBIT and CMMI-SVC.

We appreciate your participation in this study in advance. If you have further questions or concerns about this study, you can contact the project supervisor, Dr. Ruben Pereira at ruben.pereira@iscte.pt; Rafael Cardoso at rmcos@iscte.pt.

Please return this questionnaire to project owner or supervisor.

A. INTERVIEWEE:

Your Name: _____

Years of Experience IT: _____

Job Title:_____

Job Position:_____

Experience in Problem Management: _____years _____ months

B. COMPANY:

Name: _____

Industry: _____

Number of employees:_____

International: Yes / No

Industry:___IT / Others_____

C. PROCESS:

For problem management, what maturity level do you think your organization is?

1 / 2 / 3 / 4 / 5

Did you perform an official implementation regarding PM adopting some of the following frameworks?

CMMI / COBIT / ITIL / Other / None

Did you know what is the structured used in your organization?

Centralized / Decentralized / Federal

Did you know what kind of IT strategy is used in your organization?

Comprehensiveness / Flexibility / Efficiency

B. QUESTIONNAIRE

Please answer each question / affirmation by selecting only the answer that best reflects your organization's PM process (one answer per question). You can change your answers at any time while filling in the questionnaire - just select a different option.

Typically, you can select from a range that ranges from "Have" (left) to "Don't Have" (right). If you consider that is in progress, please select "W" for Work In Progress. If you consider that is not applicable, please select "NA" for Not Applicable. The L is the level of the maturity assigned and T is the type for Operational or Management.

Table 28 - Maturity assessment questionnaire

	Activities	H	DH	W	NA	L
1	Are the problems identified?					2
	If yes, through which proper problem identification mechanisms?					2
2	1. Service Desk					2
3	1.1 Defects reported by customers or end users?					2
4	1.2. Project management problem reports requiring corrective action?					2
5	1.3. Help desk calls, by time and incident category?					2
6	1.4. Inadequate availability of the service system?					2
7	1.5. Service fulfilment or service satisfaction problems?					2
8	1.6. Process capability problems?					2
9	1.7. Resource throughput, utilization, or response time measurements?					2
10	2. Incident Management					2
11	3. Event Management					2
12	4. Supplier and Contractor					2
	5. Proactive problem management					2

13	5.1. Defects reported by service teams?					2
14	5.2. Defects found in service verification?					2
15	6.Others _____					2
16	Is gathered any information about the identified problem?					2
	If yes,					2
	1. What kind of details?					2
17	1. User details?					2
18	2. Service details?					2
19	3. Last status of the problem?					2
20	3.1. The status “Open” is included?					2
21	3.2. The status “Reopen” is included?					2
22	3.3. The status “In Progress” is included?					2
23	3.4. The status “Closed” is included?					2
24	3.5. Others _____					2
25	4. Equipment details?					2
26	5. Date/time initially logged?					2
27	6. Priority and categorization details?					2
28	7. Related Incident details?					2
29	8. Details of all diagnostic or attempted recovery actions taken?					2
30	9. Information from the change management system					3
31	10. Information from IT configuration/asset					2
32	11. Reference the incident(s) that gave rise to the problem?					2
33	12. Source?					2
34	13. Frequency of occurrence?					2
35	14. Similarity?					2
36	15. Cost of analysis?					2
37	16. Time and resources needed?					2
38	17. Safety considerations?					2
39	18. Rationale for decisions?					2
40	19. Action proposals from causal analysis meetings?					2
41	20. Action plans resulting from action proposals?					2
42	21. Cost of analysis and resolution activities?					2
43	22. Measures of changes to the process performance of the defined process resulting from resolutions?					4
44	23. Others _____					2
45	2. Is the same information identified shared with the Service Desk?					2

46	After problem data identified, is the data is available for other work groups?					2
47	Does the SD keep the customers informed?					2
48	Does the SD keep IT management informed?					2
49	Is there a Problem Catalogue available?					2
	If yes,					2
50	1. Do you usually register the problem in the catalogue?					2
51	2. Does the catalogue have the details updated?					2
52	If there is reference of the incident that gave rise to the problem, does the problem record have all relevant details copied from incident record(s)?					2
53	Is the problem categorized?					2
	If yes,					2
54	1. Is there any criterion for problem registration?					2
55	2. Is the problem categorized using same criteria than incidents?					2
56	3. Is the problem categorized using the same coding system (matrix)?					2
57	4. Others _____					2
58	Is a support group defined for problem management?					2
	If yes,					2
	1. Are appropriate support groups defined to assist with:					2
59	a. Problem identification?					2
60	b. Root cause analysis?					2
61	c. Solution determination?					2
62	d. Work around?					2
63	2. Is the support group selected based on pre-defined categories?					2
64	If not, what is the rational for the selection of the support group? _____					2
65	Is the business impact defined?					2
66	Is the business urgency defined?					2
67	Is the problem frequency defined?					2
68	Is a priority level defined?					2
	If yes,					2
69	1. Is the priority defined based on business impact?					2
70	2. Is the priority defined based on business urgency?					2
71	3. Is prioritized using the same method like incidents?					2
72	4. Is the priority defined based on frequency?					2
73	5. Is the priority defined based on severity?					2

74	Is the problem severity defined?					2
75	Is any method being used for problem analysis?					2
	If yes,					2
76	1. Cause-and-effect (fishbone) diagrams					2
77	2. Check sheets					2
78	3. Pareto analysis					2
79	4. Histograms					2
80	5. Box and whisker plots for attributes					2
81	6. Failure mode and effects analysis (FMEA) (e.g., design failure mode and effects analysis for the service system being developed, process failure mode and effects analysis for service system development or service delivery)					2
82	7. Chronological analysis					2
83	8. Pain Value Analysis					2
84	9. Kepner and Tregoe (5 phases)					2
85	10. Brainstorming					2
86	11. Ishikawa Diagrams					2
87	12. Other _____					2
88	Are the selected defects and problems grouped based on their root causes?					2
	If yes, what kind of grouping is used?					2
89	1. Inadequate training and skills					2
90	2. Breakdown of communication					2
91	3. Not accounting for all details of a task					2
92	4. Making mistakes in manual procedures (e.g., keyboard entry)					2
93	5. Process deficiency					2
94	6. Other _____					2
95	Is the scope of the problem analysis defined?					2
	If yes, what is included in the scope?					2
96	1. Definition of the improvement needed or expected					2
97	2. Stakeholders affected					2
98	3.Target affected					2
99	4. Other _____					2
	Is the level of resource and expertise appropriated for:					3
100	1. Problem priority level?					3
101	2. Service target					3
102	3. Others _____					3
103	Is any validation done in order to identify if the problem existed previously?					3

104	If yes, to validate if the problem has occurred before, is there any problem-matching techniques being applied?					3
105	Does a Configuration Management System (CMS) exist?					2
	If yes,					2
106	1. Is CMS used to help determine the level of impact?					2
107	2. Is CMS used to assist in pinpointing and diagnosing the exact point of failure?					2
108	3. Others _____					2
109	Is it possible to recreate the problem?					2
110	If yes, did you recreate the problem during the analysis process?					2
	If yes, in which system?					2
111	1. In a test system?					2
112	2. Other_____					2
113	Do you try to find a resolution to the problem?					2
114	If yes, is it the most appropriate resolution to the problem?					2
115	Do you usually propose / define any actions proposal to prevent the future occurrence of similar defects and problems?					3
116	If yes, the actions required (or actions proposal) are documented?					3
	If yes, does the documentation include:					3
117	1. Problem description / Description of the cause					3
118	2. Training					3
119	3. Tools					3
120	4. Methods					3
121	5. Communication					3
122	6. Work products					3
123	7. Activity checklists (Which reinforce training or communications related to common problems and techniques for preventing them?)					3
124	8. Process changes so that error-prone steps do not occur					3
125	9. Automate all or part of a process					3
126	10. Reorder process activities					3
127	11. Process steps (Such as task kick-off meetings to review common problems as well as actions to prevent them)					3
128	12. Originator of the action proposal					3
129	13. Description of the outcome to be addressed					3

130	14. Problem cause category					3
131	15. Phase identified					3
132	16. Description of the action (Time, cost, and other resources required to implement the action proposal)					3
133	17. Expected benefits from implementing the action proposal					3
134	18. Estimated cost of not fixing the problem					3
135	19. Other _____					3
136	Do you usually try to find a workaround to temporary solve the problem?					2
137	After the problem identification, do you usually develop a suitable workaround?					2
	In cases where a workaround is found,					2
138	1. The problem record remains open?					2
139	2. The workaround details are documented within the Problem Record?					2
140	3. Others _____					2
141	The implemented actions are effective for working group?					2
142	If yes, do you usually submit a process improvement proposal?					3
143	Is there a database of known and suspected error (KEDB) defined?					3
	If yes,					3
144	1. The database includes known errors communicated by external vendors?					3
145	2. Do you usually try to identify the problem that may be a known error by comparing incident data with KEDB?					3
146	3. When the problem is already available in KEDB, do you usually classify it as a known error?					3
147	4. Do you usually associate the affected configuration items to the established/known error?					3
148	5. The Known Error contains details of workarounds or resolution activities?					3
	Do you usually produce reports to communicate the progress					4
149	1. In resolving problems?					4
150	2. To monitor the continuing impact of problems not solved?					4
151	3. Others _____					4

152	Is the status of problem-handling process being monitored?					4
	If yes,					4
153	1. Throughout its life cycle including input from change and configuration management?					4
154	2. Other _____					4
155	When the diagnosis is complete and a workaround is found, is a Known Error Record Raised?					3
	If yes,					3
156	1. Is placed in the KEDB?					3
157	2. Other _____					3
158	The Know Error Database (KEDB) is used as part of problem resolution to help resolve quickly any further occurrences of the incidents/problems that occurred?					3
159	The problem is processed via change management, based on a cost-benefit business case and business impact and urgency?					4
160	Do you usually try to find a solution to the problem?					3
161	As soon as a solution is found, it is immediately applied?					3
162	Is the business case for resolution capable to be justified?					3
163	If no, any decision is taken to leave the problem record open and use the workaround described on KEDB?					3
164	Do you usually close the problem record?					3
	If yes,					3
165	1. Is any related incident record is still open?					3
166	2. Have confirmed successful elimination of the known error?					3
167	3. Agreement with the business on how to alternatively handle the problem?					3
168	The record contains full historical description of all events?					3
169	After resolution applied, the status of any related Known Error Record is updated?					3
170	After problem closure, a review is conducted?					3
	Do you usually inform the Service Desk (SD) about:					3
171	1. The schedule of problem closure?					3
172	2. The schedule for fixing the known errors?					3
173	3. The possible workaround or the fact that the problem will remain until the change is implemented					3

174	4. The consequences of the approach taken?					3
175	5. Other _____					3
	Do you usually keep informed					4
176	1. The affected users?					4
177	2. The affected customers?					4
178	3. Other _____					4
179	Throughout the resolution process, do you usually obtain regular reports from change management on progress in resolving problems and errors?					4
180	The impact of problems and known errors on services is continuing monitored?					4
181	Are there major problems?					3
182	If yes, the success of resolutions of major problems is usually reviewed and confirmed?					3
183	In a service review meeting with the business customer, do you usually share the knowledge learned from review?					3
184	Do you usually analyse the action proposal(s)?					3
185	After proposal(s) analysis, priorities are determined?					3
	If yes, what includes the criteria for prioritizing action proposals?					3
186	1. Implications of not addressing the defect or problem					3
187	2. Cost to implement process improvements to prevent the defect or problem					3
188	3. Expected impact on quality					3
189	4. Other _____					3
190	Do you always select the action proposal(s) to be implemented?					3
191	The action plan to implement the selected action proposals is created?					3
	If yes, the action plan includes the following:					3
192	1. Person responsible for implementation					3
193	2. Detailed description of the improvement					3
194	3. Description of the affected areas					3
195	4. People who are to be kept informed of status					3
196	5. Schedule Cost expended					3
197	6. Next date that status will be reviewed					3
198	7. Rationale for key decisions					3
199	8. Description of implementation actions					3
200	9. Other _____					3
201	The action plan is implemented?					3
	If yes, are the following tasks performed?					3

202	1. Make assignments?					3
203	2. Coordinate the people doing the work					3
204	3. Review the results					3
205	4. Track action items to closure					3
206	5. Other _____					3
207	Experiments are conducted for particularly complex changes?					3
	If yes, the experiments include:					3
208	1. Using a temporary modified process?					3
209	2. Using a new tool?					3
210	3. Other _____					3
211	Do you usually look for similar causes in other processes and work products?					3
212	If you find similar causes in other processes and work products, do you usually take actions?					3
213	Do you usually review the problem?					5
	If yes, during the review do you:					5
214	1. Examine tasks done correctly?					5
215	2. Examine tasks done wrong?					5
216	3. Examine what could be done better in future?					5
217	4. Examine how to prevent recurrence?					5
218	5. Examine is there any 3rd party responsibility involved?					5
219	6. Examine is any follow up action needed?					5
220	7. Communicate information to key stakeholders?					5
	If the information is communicated to key stakeholders, how is the information communicated?					4
221	a. Reports?					4
222	b. Periodic meetings?					4
223	c. Other _____					4
224	Is there a problem manager?					4
225	According previous review points identified, are they part of any training and awareness activities for support staff, provided by the Problem Manager?					4
	The customer is aware of:					3
226	1. The actions taken?					3
227	2. The plans to prevent future major problems from occurring?					3
228	The process owners and managers meet regularly to discuss known problems?					3
	If yes, the managers are from which area?					3

229	1. Incident Management?					3
230	2. Problem Management?					3
231	3. Change Management?					3
232	4. Configuration Management?					3
233	5. Other _____					3
234	The process owners and managers meet regularly to discuss future planned changes and corrective actions?					3
	If yes, the managers from which area?					3
235	1. Incident Management?					3
236	2. Problem Management?					3
237	3. Change Management?					3
238	4. Configuration Management?					3
239	5. Other _____					3
240	Do you document all your lessons learned?					3
	If yes, what do you document?					3
241	1. Appropriate procedures					3
242	2. Work instructions					3
243	3. Diagnostic scripts					3
244	4. Known Error Records					3
245	The knowledge learned from the review is incorporated into a service review meeting with the customer?					4
	If yes, which customer?					4
246	1. Business Customer					4
247	2. Other _____					4
	The resolution to apply into production environment includes:					3
248	1. Extracted and registered Known-Errors?					3
249	2. Ad-hoc errors					3
	If yes,					3
250	1. A Known Error is logged in the KEDB?					3
251	2. Is there any formal step in the testing sign-off that ensures that this handover always takes place?					3
	In your organization the Problem Records are triggered in reaction to:					2
252	1. Incidents?					2
253	2. Service Desk staff?					2
254	3. IT staff?					2
255	4. Stages of testing such User Acceptance Testing (UAT)?					2
256	5. Supplier's notification?					2
257	6. Other _____					2

	The majority of Problem Records are triggered in reaction to:					2
258	1. Incidents?					2
259	2. Service Desk staff?					2
260	3. IT staff?					2
261	4. Stages of testing such User Acceptance Testing (UAT)?					2
262	5. Supplier's notification?					2
263	6. Other _____					2
264	Do you usually analyse the change in process performance of the affected processes or sub processes?					5
	If yes, do you measure it?					5
265	The selected change has positively influenced process performance?					5
266	The impact of the change/solution applied is determined?					4
	If yes, it achieves:					4
267	1. Quality?					4
268	2. Process Performance objectives?					4
269	3. Other _____					4
	If the process or sub process improvements did not result in expected benefits, do you usually:					5
270	1. Determine the appropriate actions?					5
271	2. Document the appropriate actions?					5
272	3. Other _____					5
273	The total costs of problems are monitored?					5
274	The change efforts resulting from problem management process activities are captured?					5
	If yes,					5
275	1. Are made reports about those change efforts?					5
276	2. Other _____					3
277	Is any report produced to monitor the problem resolution against the business requirements and SLAs?					4
278	Is any process available for escalation of problems, e.g. escalation to a higher management?					3
	If yes,					3
279	1. Is the escalation of problem according to agreed-on criteria?					3
280	2. The escalation includes contacting external vendors?					3
281	3. The escalation includes referring to the change advisory board to increase the priority of an urgent					3

	request for change (RFC) to implement a temporary workaround?					
282	Can you track the problem trends?					5
283	Have been identified and initiated sustainable solutions (permanent fix) addressing the root cause, and raise change requests via the established change management processes?					5
284	Do you measure your effectiveness and efficiency of PM process or its operation?					3
	If yes, what metrics do you use?					4
285	1. Is the total number of problems recorded in the period?					4
286	2. Is the percentage of problems resolved within SLA targets?					4
287	3. Is the percentage of problems unsolved within SLA targets?					4
288	4. Is the number and percentage of problems that exceeded their target resolution times?					4
289	5. Is the backlog of outstanding problems and the trend analysed? (static, reducing or increasing)					4
290	6. Is the average cost of handling a problem calculated?					4
291	7. Is the number of major open problems registered?					4
292	8. Is the number of major closed problems registered?					4
293	9. Is the number of major backlog problems registered?					4
294	10. Is the percentage of Major Problem Reviews successfully performed?					4
295	11. Is the number of Known Errors added to the KEDB calculated?					4
296	12. Is the percentage accuracy of the KEDB (from audits of the database) measured?					4
297	13. Is the percentage of Major Problem Reviews completed successfully measured? and on time.					4
298	14. Is the percentage of Major Problem Reviews on time successfully measured?					4
	In cases where a metric is used, the metrics are broken down by:					4
299	1. Category					4
300	2. Impact					4

301	3.	Severity					4
302	4.	Urgency					4
303	5.	Priority Level					4
304	6.	Other _____					4

C. FEEDBACK for Problem Management Maturity Model

Your feedback is important to me as I continue to improve and enhance the model offered through this thesis. Please take a few moments to provide input on your most recent experience. The information you submit will help me provide more efficient, effective and pertinent model.

1. Do you consider the maturity model concept useful somehow for any organization?
   Yes / No / Others: _____
2. Do you consider the choice of the three framework (ITIL, COBIT and CMMI) was the right choice'
   Yes / No / Others: _____
3. Have you used any maturity model before?
   Yes / No / Others: _____
4. Do you know any of used frameworks in this maturity model? If so, which one?
   Yes / No / Others: _____

5. Do you consider this questionnaire to be complete enough?
   Yes / No / Others: _____

6. If not, what's missing?
   _____

7. Do you consider this model useful?
   Yes / No / Others: _____

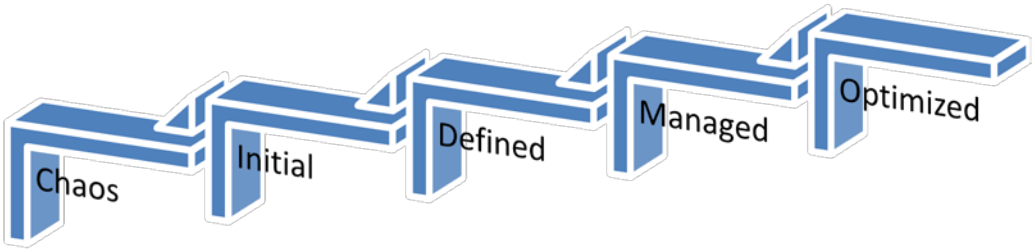
8. Have you considered recommending this questionnaire to a friend?
   Yes / No / Others: _____

Appendix E

Instituto Universitário de Lisboa

IT Problem Management

INDIVIDUAL REPORT



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Overall Analysis

After analysing the answers given by each of the interviewees to the 303 questions available in the provided questionnaire, it was possible to collect relevant information in order to carry out a more qualitative analysis on the maturity of the problem process.

In the questionnaire, the most prevalent level of maturity is the level 2 and by consequence is where.

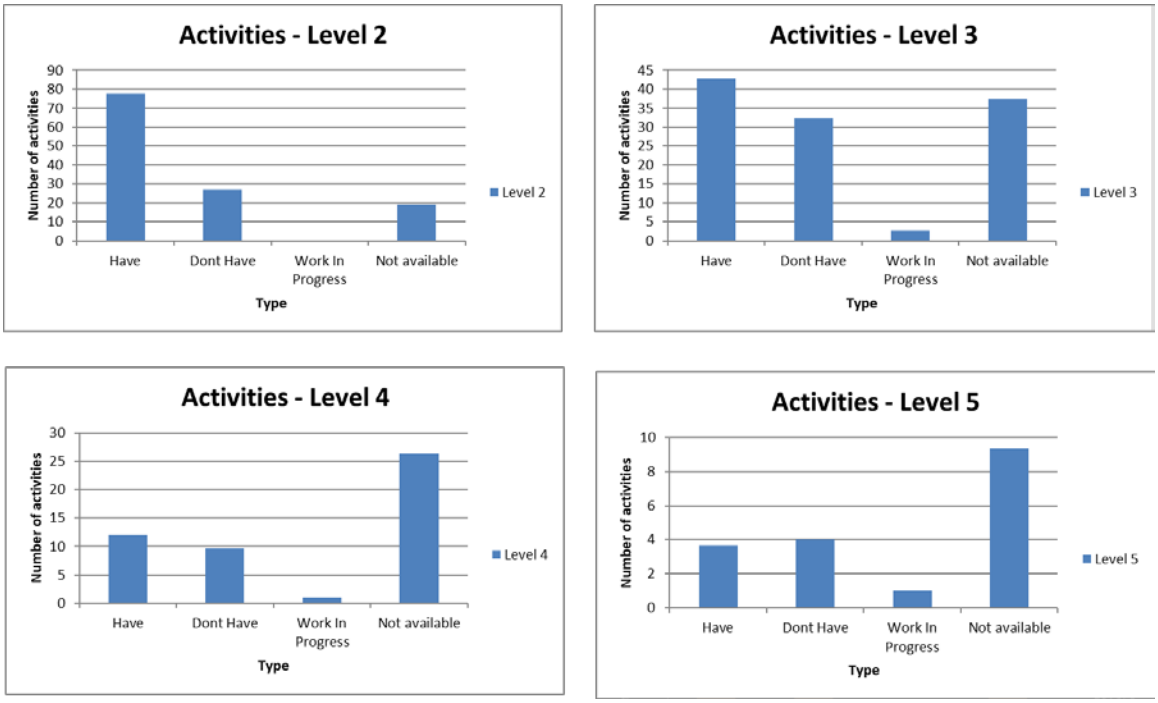


Figure 11 - Individual level achievement analysis on your organization

As illustrated on Figure 11, for level 2, the questionnaire offers 124 activities. The result says that of these 124, only 78 are implemented, 0 are in progress, 19 is not available and the rest is not relevant or unanswered. For level 3, the questionnaire offers 115 activities. The result says that of these 115, only 43 are implemented, 3 are in progress, 38 is not available and the rest is not relevant or unanswered. For level 4, the questionnaire offers 49 activities. The result says that of these 49, only 12 are implemented, 1 are in progress, 10 is not available and the rest is not relevant or unanswered. For level 5, the questionnaire offers 18 activities. The result says that of these 18, only 4 are implemented, 1 are in

progress, 4 is not available and the rest is not relevant or unanswered. The Figure 12 illustrates the average of achievement level on your organization.

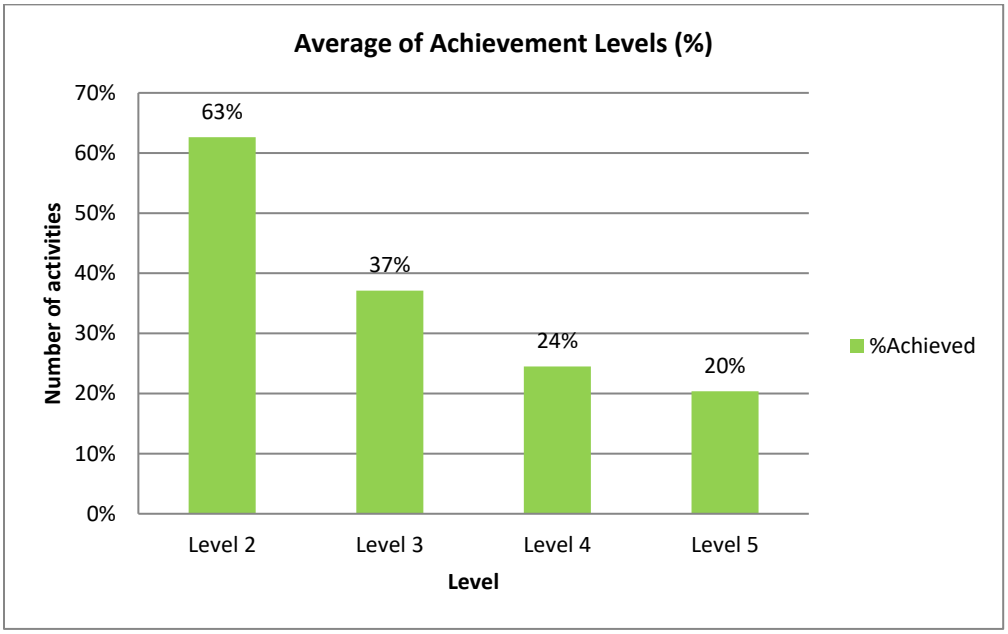


Figure 12 - Percentage of average of Achievement Level

Framework Analysis

Another topic that is also relevant to the research is the distribution of activities according to the different IT frameworks. In the following chart, it's possible to verify the distribution of activities per IT framework.

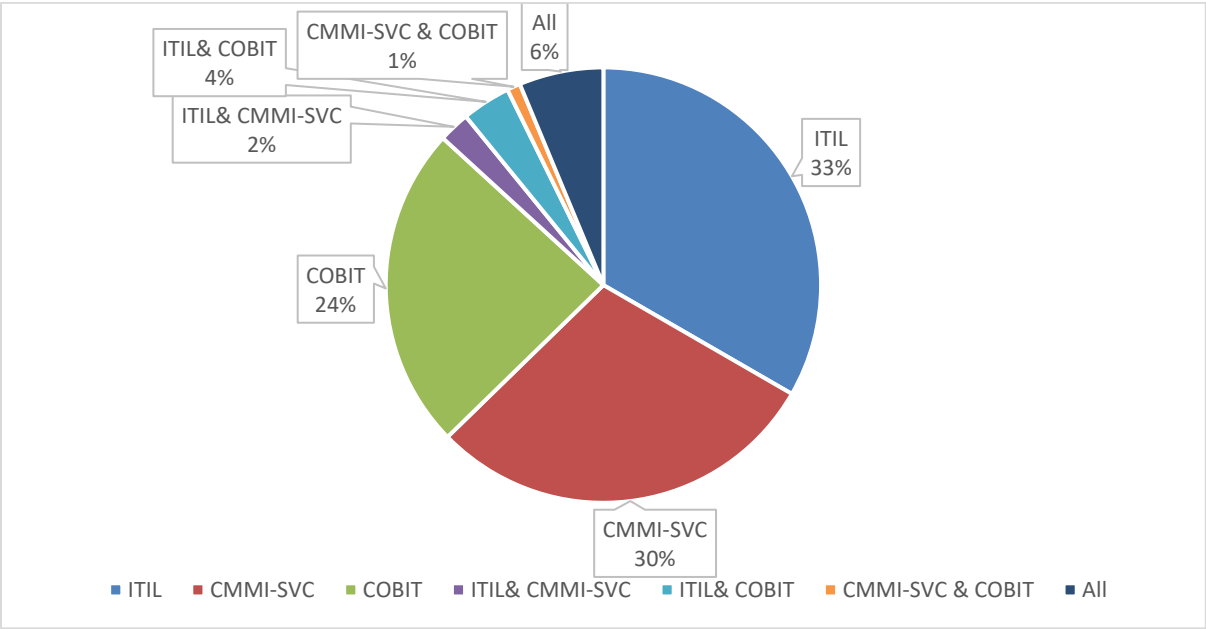


Figure 13 - Distribution of activities per framework on your organization

In the Figure 13, it's possible to verify the distribution of activities and their weight in the construction of the questionnaire for the process PM. Based on the values presented, we highlight the activities overlaps that make up the 19 of the total activities.

Final considerations and proposals for improvement

The defined rationale for achieving a certain level of maturity is 75% of activities performed at the corresponding level. After the statistical analysis of the questionnaire obtained, it is considered that the organization has a maturity level 2 in the problem management process. At this level, 75% of activities are carried out.

To achieve maturity level 3 it is advisable to implement at least 6 of the missing activities in Table 29.

Table 29 - Missing activities in order to achieve the maturity level 3

The customer is aware of:
1. The actions taken?
2. The plans to prevent future major problems from occurring?
The process owners and managers meet regularly to discuss known problems?
If yes, the managers are from which area?
1. Incident Management?
2. Problem Management?
3. Change Management?
4. Configuration Management?
5. Other _____
The process owners and managers meet regularly to discuss future planned changes and corrective actions?
If yes, the managers from which area?
1. Incident Management?
2. Problem Management?
3. Change Management?
4. Configuration Management?
5. Other _____
Do you document all your lessons learned?

If yes, what do you document?
1. Appropriate procedures
2. Work instructions
3. Diagnostic scripts
4. Known Error Records

At maturity level 4 it is where the process has the lowest level of maturity with the total of activities not performed being higher than the level of activities performed. Special attention is recommended at this level and that:

- Establishment of qualitative / quantitative objectives of one or more sub processes in order to determine the capacity of the process.
- Statistical management of the performance of one or more sub processes of the Problem Management process.
- Establishing quantitative goals based on customer needs and business objectives.

Other factors to achieve maturity level 4 are suggested to analyse metrics as well as produce and distribute reports. With these recommendations it is possible to do a predictive analysis optimizing the process and saving time and resources.

Thank you very much for your prompt and courteous attention to this matter.

Sincerely,

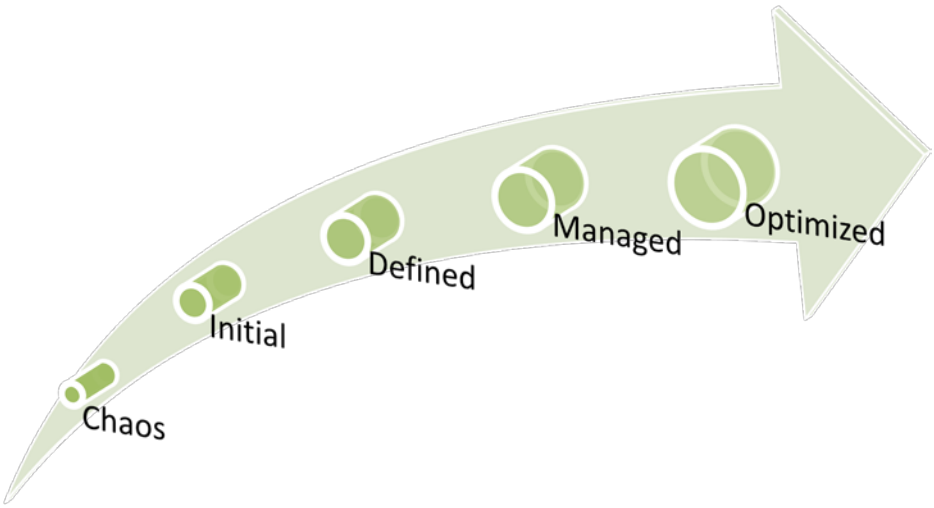
Rafael

Appendix F

Instituto Universitário de Lisboa

IT Problem Management

GENERAL REPORT



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Global Analysis

In pursuance of demonstrate the artefact, the author has searched for companies that have the process management process in place (up and running), unfortunately the PM is a process that is not yet present in many companies. Five companies accepted the invitation to proceed to evaluate the proposed artefact where the method used for data collection was through semi-structured interviews with respective organization experts. These organizations differ in a set of contingency factors such as: industry, size, strategy, structure and processes. Although the size of organizations varies significantly, all organizations are of considerable size and useful for research (Table 30)

Table 30 - Factors analysis and details about interviewer's organization

Industry	Size	Employees	Market	Strategy	Structure	Culture
Telecommunication	*2100*	*400*	*Worldwide*	*Flexibility*	*Decentralized*	*Pyramidal*
Energy, Automation and Telecommunication	*1.400*	*28*	*Worldwide*	*Flexibility*	*Decentralized*	*Pyramidal*
Pharmaceutical	*42.000*	*1300*	*Worldwide*	*Efficiency*	*Federal*	*Contest*
Software	*13.000*	-	*Worldwide*	-	-	-
Banking	-	-	*Wordwide*	*Flexibility*	*Federal*	*Pyramidal*

Additional insights can be obtained regarding the IT frameworks adopted within each organization. Most of interviewed organizations pointed ITIL to be the most adopted IT framework (Figure 14).

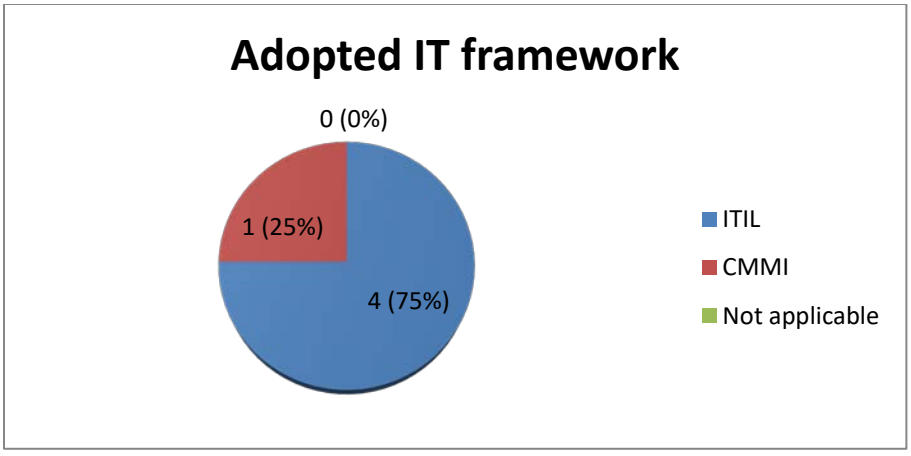

Figure 14 - Adoption or implementation of an IT framework within the organization

In order to achieve a determined maturity level organization had to implement at least 75% activities of that corresponding level. Based on Figure 15 and Figure 16, it's notorious level 2 is the most mature, followed by level 3, level 4 and level 5 respectively. Overall, organizations are more focused on definition and management activities but neglect metrics and measures to promote continuous improvement and predictive analysis.

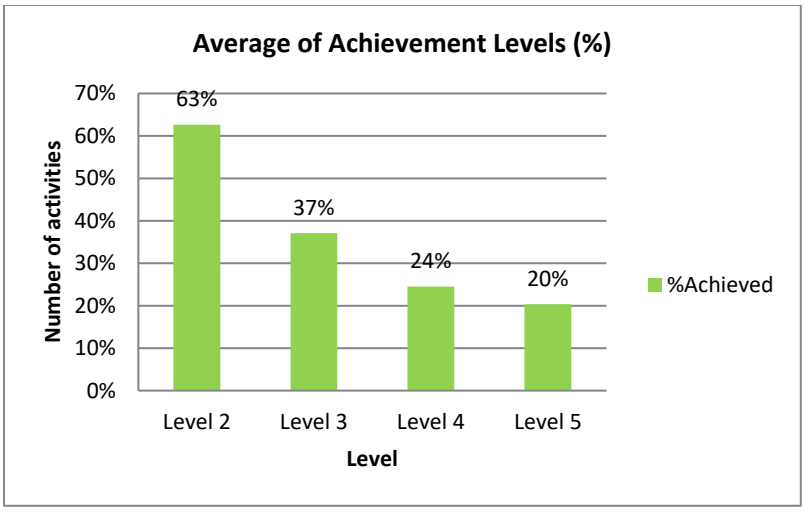

Figure 15 - Average of Achievement Levels on all organizations

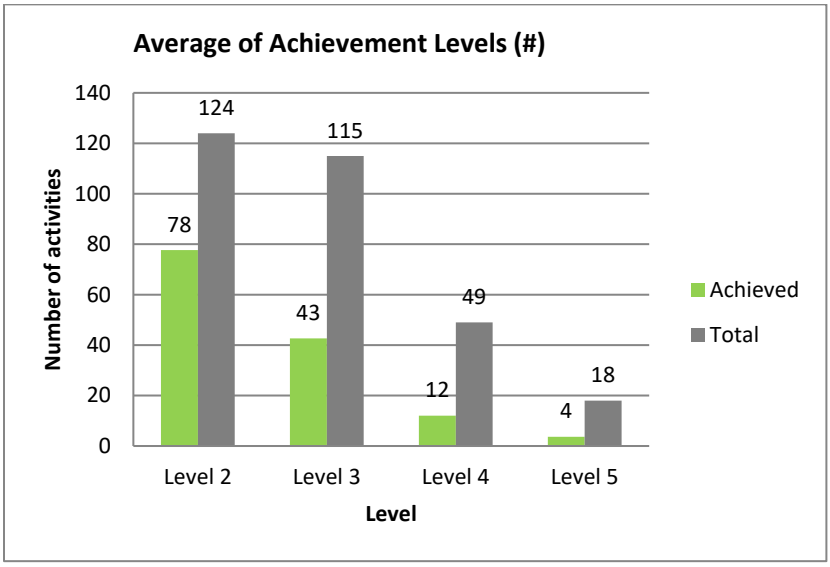

Figure 16 - Average of Achievement Levels on all organizations

As reported by Figure 17, all organizations are in a similar achievement for level 2 (Managed). The level 5 (optimizing) is still the lowest level, consequently level 4 (Quantitatively Managed) and finally level 3 (defined). Apparently, there is no visible disparity between the various types of organizations.

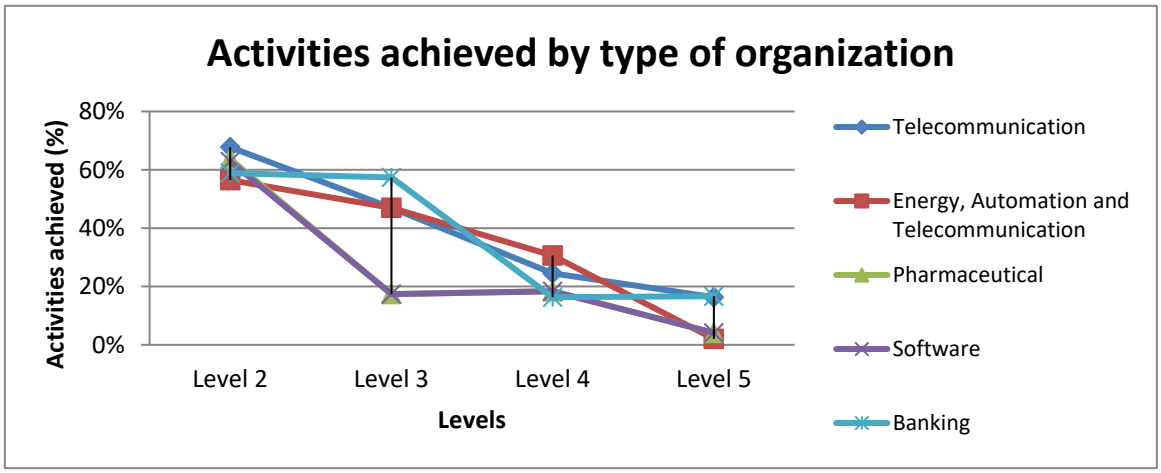

Figure 17 - Activities achieved by type of organization

To sum up, the author expected that some organizations were already at level 2 but none have fulfilled the requirements to reach that level. All the assessed organizations are at level 1 (initial). In average, organizations tend to focus their effort in the first two levels, level 2 and 3. To be considered a managed process (level 2) and reach level 3 (defined), most organizations only need to implement plus 12% or 37% of the remaining activities.

At maturity level 2, activities are appropriately planned, staffed, monitored and controlled. Is collected enough information to identify the practices which are more effective (they're producing expected results) and efficient (with less cost or effort). At level 3, the best practices are shared and managed across the organization, with measurements and lessons learned being collected to refine and improve them. Regarding the other levels, it’s quite normal level 4 higher than level 5 because level 4 is usually used as an input to identify improvements areas or points within organizations and departments (level 5). Level 4 places the key practices (those most critical for customer satisfaction) under statistical control, allowing projects to rapidly identify any deviations and generating

predictable results. Finally, at level 5, practices can be continuously improved based on a measured understanding of their cost and value and the possibility of predicting mathematically the probable impact of any proposed change to the process or the tools being employed.

Framework Analysis

The source of most activities of the proposed model is the ITIL framework. Table 31 illustrates all insights obtained during assessment, view and adoption of each IT framework. One interesting insight was, one of the organizations indicated they use CMMI-SVC framework but it wasn't perceptible which I assume they ended to use the same activities CMMI have in common with the others frameworks.

Table 31 - Analysis of the adoption of each IT framework within the model

	ITIL	CMMI-SVC	COBIT	ITIL& CMMI-SVC	ITIL& COBIT	CMMI-SVC & COBIT	All	Total
Overall activities (nº)	*101*	*89*	*73*	*7*	*11*	*3*	*19*	*303*
Overall activities (%)	*33,33%*	*29,37%*	*24,09%*	*2,31%*	*3,63%*	*0,99%*	*6,27%*	*100%*
PM process overlap				***2,31%***	***3,63%***	***0,99%***	***6,27%***	***13%***
Average implemented activities (nº)	*90*	*72*	*65*	*4*	*9*	*2*	*15*	*257*
Average implemented activities (%)	*29.70%*	*23.76%*	*21.45%*	*1.32%*	*2.97%*	*0.66%*	*4.95%*	*12%*
Overall/average implemented (%)	*89.11%*	*80.90%*	*89.04%*	*57.14%*	*81.82%*	*66.67%*	*78.95%*	*77.66%*

Another topic that is also relevant to the research is the distribution of activities according to the different IT frameworks. In the following chart, it's possible to verify the distribution of activities per IT framework.

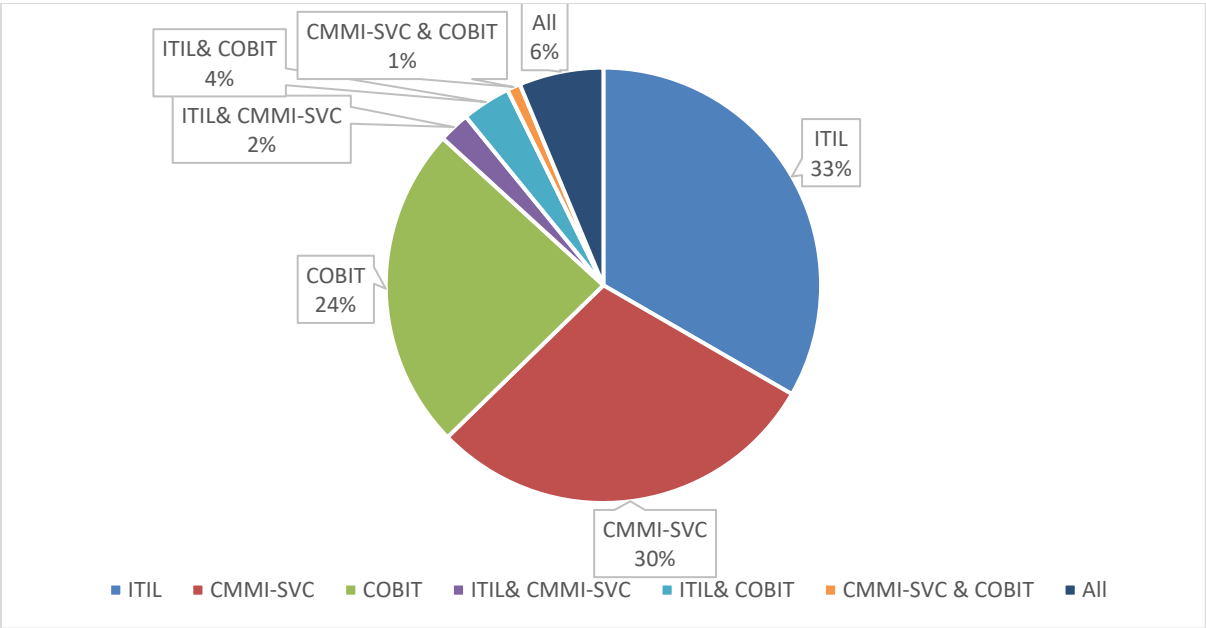

Figure 18 - Distribution of activities per framework

In Figure 18, it's possible to verify the distribution of activities and their weight in the construction of the questionnaire for the process PM. Based on the values presented, we highlight the activities overlaps that make up the 19 of the total activities.

Final considerations and proposals for improvement

For achieving a certain level of maturity is required 75% of activities performed at the corresponding level.

Several contributions could be withdrawn at the end of this research:

- They confirmed that implementing a IT framework is not straight forward and even multi-framework implementation is a different level.
- This research also reinforced that ITIL is the most widely used IT framework. Looking at the interviewed organizations, four of them pointed ITIL as the official IT framework (Figure 10), only one of them pointed CMMI as official IT framework.
- Regarding the research limitations, the author consider that the previous conclusions may not be the same for remaining IT processes and it is not possible to generalize our insights. Therefore, future research may pass by tune the maturity model with further IT frameworks and standards and develop the same maturity model approach for more IT processes. In a future, having a model able to cover the most used IT processes could be very useful and, at the same time, challenging which it's one more reason to continue this research.

Thank you very much for your prompt and courteous attention to this matter.

Sincerely,

Rafael

Appendix G

Proposed questionnaire to support semi-structured interview

During the semi-structured interviews, a questionnaire was provided. The questionnaire consisted in all post-overlap activities collected, arranged by order of process (problem identification, problem logging, etc.), in order to become rational and concise throughout its course. In the following Figure 19 is possible to identify a section of its activities therefore, a complete questionnaire could be found in the Appendix C.

	Activities	H	DH	W	NA	L
1	Are the problems identified?					2
	If yes, through which proper problem identification mechanisms?					
2	1. Service Desk					2
3	1.1 Defects reported by customers or end users?					2
4	1.2. Project management problem reports requiring corrective action?					2
5	1.3. Help desk calls, by time and incident category?					2
6	1.4. Inadequate availability of the service system?					2
7	1.5. Service fulfilment or service satisfaction problems?					2
8	1.6. Process capability problems?					2
9	1.7. Resource throughput, utilization, or response time measurements?					2
10	2. Incident Management					2
11	3. Event Management					2
12	4. Supplier and Contractor					2
	5. Proactive problem management					
13	5.1. Defects reported by service teams?					2
14	5.2. Defects found in service verification?					2
15	6.Others _____					2
16	Is gathered any information about the identified problem?					2

Figure 19 - Excerpt of questionnaire

Typically, the interviewee had the option to select the following scenarios

- If the option was available, option "Have".
- If the option was unavailable, option "Don’t Have.
- If he considers that is in progress, option “W” for Work In Progress.

- If he considers that is not applicable, the option "NA" for Not Applicable should cover when the activities were out of scope for the organization.

For example," Is the priority defined based on severity?". Some organization do not use severity in their processes, they focus on impact or urgency. Therefore, most of the ITSM software provides "severity" as a matrix between impact and priority. The questionnaire (appendix D.) starts with the header, where is requested generic information regarding company and interviewee. The questions available in the questionnaire are divided into three areas: interviewee information, company and their experience in the process and all have a reason for being. They were chosen with the purpose of trying to recognize some type of pattern during the analysis of the results. Some of the articles referenced throughout the thesis in this area mention this kind of information.

For questionnaire to support the semi-structured interviews, the author used the factors described on Table 32.

Table 32 - Analysis factors

Characteristic	**Description**
Industry	The industry environments can influence the adoption of IT frameworks.
Number of employees	The compliance increases with the company size. (Ow-Yong & Mallin, 2011) (Pereira & Silva, 2012) (Cochran, 2010). Hence, it's quite important to have this as a key factor in order to distinguish and find possible pattern during our test proposal.
International	This factor may have influence in some way. Being an international company, it is more exposed to a multicultural environment than a national company.
Maturity Level	This factor will be crucial in comparing expectations of their PM maturity versus reality.
Frameworks	There are several IT based frameworks and standards propounded by institutes, companies and organizations. This characteristic is to understand if the organization has already implemented some previous IT framework or intends to do it in the future. This information can be useful to compare with the activities they have implemented and using their framework. Therefore, it is also used to understand the process of more operational or management problems.
Culture	The culture defines the values, mission and vision of an organization. In organization development areas such health, safety or quality, a quick and coordinate response to problem is crucial for monitoring and managing IT infrastructure.
Strategy	The strategy impacts the performance of a business according to some research projects. Based on different IT strategies, we may find different approaches of the PM process providing some metrics for evaluation.
Structure	The success and achievement of business goals by organizations depends how organization is structured. This is one of the recurring issues found in the literature.

Appendix H

Table 33 - Levels using continuous representation for CMMI Maturity Model

Level	Description
Capability Level 0 - Incomplete	An incomplete process is a process that either is not performed or partially performed. One or more of the specific goals of the process area are not satisfied and no generic goals exist for this level since there is no reason to institutionalize a partially performed process.
Capability Level 1 - Performed	A capability level 1 process is characterized as a performed process. A performed process is a process that satisfies the specific goals of the process area. It supports and enables the work needed to provide services. Although capability level 1 results in important improvements, those improvements can be lost over time if they are not institutionalized. The application of institutionalization (the CMMI generic practices at capability levels 2 through 5) helps to ensure that improvements are maintained.
Capability Level 2 - Managed	A capability level 2 process is characterized as a managed process. A managed process is a performed (capability level 1) process that has the basic infrastructure in place to support the process. It is planned and executed in accordance with policy; employs skilled people who have adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description. The process discipline reflected by capability level 2 helps to ensure that existing practices are retained during times of stress.
Capability Level 3 - Defined	A capability level 3 process is characterized as a defined process. A defined process is a managed (capability level 2) process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines and contributes work products, measures, and other process improvement information to the organizational process assets. A critical distinction between capability levels 2 and 3 is the scope of standards, process descriptions, and procedures. At capability level 2, the standards, process descriptions, and procedures can be quite different in each specific instance of the process (e.g., on a particular project). At capability level 3, the standards, process descriptions, and procedures for a project are tailored from the organization's set of standard processes to

	suit a particular project or organizational unit and therefore are more consistent, except for the differences allowed by the tailoring guidelines. Another critical distinction is that at capability level 3 processes are typically described more rigorously than at capability level 2. A defined process clearly states the purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria. At capability level 3, processes are managed more proactively using an understanding of the interrelationships of the process activities and detailed measures of the process and its work products.
Capability Level 4 – Quantitatively Managed	A capability level 4 process is characterized as a quantitatively managed process. A quantitatively managed process is a defined (capability level 3) process that is controlled using statistical and other quantitative techniques. Quantitative objectives for quality and process performance are established and used as criteria in managing the process. Quality and process performance is understood in statistical terms and is managed throughout the life of the process.
Capability Level 5 – Optimizing	A capability level 5 process is characterized as an optimizing process. An optimizing process is a quantitatively managed (capability level 4) process that is improved based on an understanding of the common causes of variation inherent in the process. The focus of an optimizing process is on continually improving the range of process performance through both incremental and innovative improvements. Remember that capability levels 2 through 5 use the same terms as generic goals 2 through 5, and a detailed description of these terms appears in the Generic Goals and Generic Practices section in Part Two.