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A Method for COBIT 2019 Process Selection

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Abstract

COBIT (Control Objectives for Information and Related Technologies) provides a framework that supports enterprises in achieving their objectives in the governance and management of enterprise IT. The current method for the selection and prioritisation of Management Objectives in COBIT 2019 does not provide enterprises with the flexibility to customise their Design Factors, which means that it is not possible to adapt the framework to their context. In this research, we propose an alternative method to the current one provided by COBIT 2019, which aims to solve this problem. We use a multicriteria decision-making method called the Analytic Hierarchy Process (AHP) in combination with the COBIT 2019 Design Factors to help organisations establish their priorities for a better implementation of COBIT 2019. In the evaluation step, we conduct a simulation and compare the results from both the current method and our proposed method against the decision of domain experts.

Keywords: Enterprise Governance of IT, COBIT 2019, Goals Cascade, AHP, Design Factors.

Resumo

COBIT (Control Objectives for Information and Related Technologies) é uma framework que apoia as empresas na concretização dos seus objectivos de governação e gestão das TI. O método actual para a selecção e prioritização dos Objectivos de Gestão (Management Objectives) no COBIT 2019 não proporciona às organizações a flexibilidade necessária para personalizar os seus Factores de Design, o que significa que não é possível adaptar a framework ao seu contexto. Nesta investigação, propomos um método alternativo ao actual fornecido pelo COBIT 2019, que visa resolver este problema. Utilizamos um método de decisão multicritério chamado Analytic Hierarchy Process (AHP) em combinação com os Design Factors do COBIT 2019 para ajudar as organizações a estabelecer as suas prioridades para uma melhor implementação do COBIT 2019. Na etapa de avaliação, realizamos uma simulação e comparamos os resultados tanto do método atual (COBIT 2019) como do método proposto em relação à decisão dos especialistas do setor.

Keywords: Enterprise Governance of IT, COBIT 2019, Goals Cascade, AHP, Design Factors.

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Chapter 1

Introduction

The issues, opportunities, and challenges of effectively managing and governing an organisation's Information Technology (IT) investments, resources, and significant initiatives have become a major concern of enterprises on a global basis [1]. Long-term success in organisations requires a secure connection between business and IT, to maximise benefits and reduce the uncertainties of IT projects [2].

However, due to the focus on "IT" in the naming of the concept, the IT Governance discussion mainly stayed a discussion within the IT area [3]. This situation initiated a shift in the naming of the concept from "IT Governance" to "Enterprise Governance of IT" [4].

Enterprise Governance of IT (EGIT) can be defined as "an integral part of corporate governance and addresses the definition and implementation of processes, structures and relational mechanisms in the organisation that enable both business and Information Technology (IT) people to execute their responsibilities in support of business/IT alignment and the creation of business value from IT-enabled business investments" [5]. EGIT can be deployed using a mixture of structure, processes and relational mechanisms [6] that encourage behaviours consistent with the organisation's mission, strategy, values, norms, and culture [7].

Enterprises are increasingly making tangible and intangible investments in improving their EGIT [4]. In support of this, enterprises are drawing upon the practical relevance of generally accepted good-practice frameworks such as COBIT, ITIL and ISO 27000 [4]. In this thesis, we decided to analyse COBIT since researchers have agreed that it is among the most popular, valuable frameworks and frameworks/standards currently being adopted [15,21]. Several researches have also shown that COBIT is widely adopted by organisations in practice [6, 8, 9].

COBIT presents a framework to support enterprises in accomplishing their goals in the governance and management of enterprise IT [10]. According to ISACA, 'COBIT 5 provides a comprehensive framework that assists enterprises to achieve their objectives for the governance and management of enterprise IT. COBIT 5 enables IT to be governed and managed holistically for the whole enterprise, taking in the full end-to-end business and IT functional areas of responsibility, considering the IT-related interests of internal and external stakeholders' [11].

COBIT 5 introduces a valuable tool, the Goals Cascade, which translates stakeholder needs into an organisation's actionable strategy [10]. This method constitutes the core entry point for the COBIT 5 process improvement [12]. In COBIT 5 there is an explicit assumption that organisations should start by analysing their business/IT alignment state through the definition of enterprise goals, linking those goals to IT-related goals, and subsequently to the IT processes [13, 14].

In 2018, ISACA released COBIT 2019, the first update of COBIT after almost seven years. One of the major differences between COBIT 5 and COBIT 2019 is related to the Goals Cascade mechanism. In the new version, the Goals Cascade is not the core entry point, but just part of a broader mechanism.

In COBIT 2019, different Design Factors were introduced, namely Enterprise Strategy, Enterprise Goals, Risk Profile, Enterprise Size, Threat Landscape, Compliance Requirements, Role of IT, Sourcing Model for IT, IT Implementation Methods and Technology Adoption Strategy.

These Design Factors influence the design of an enterprise's governance system, representing what an enterprise must consider in tailoring governance systems to realise their most IT value[15].

A tailored governance system based on COBIT is a system that has taken the generic contents of COBIT and has assigned specific priorities and target capability levels to the governance and management components based on the enterprise's context and design factor values [15].

Taking an evolutionary analysis of COBIT, while in COBIT 5 the Goals Cascade was the sole mechanism for selecting processes (currently called Management Objectives), in COBIT 2019, it is only one out of ten combined "factors" in making that selection. Therefore, in order to have an ordered list of Management Objectives, each organisation must make an individual analysis of each Design Factor. For this purpose, ISACA provides a toolkit with an evaluation model to be completed by the organisation. At the end of the assessment, a prioritised list of Management Objectives is suggested to the user.

In this research, the method suggested by ISACA to choose Management Objectives was studied. This method has a toolkit, also provided by ISACA, which is the practical implementation of the method in question. To better understand this method, different scenarios were simulated during this research. The authors concluded that the suggested method has some flaws that may influence the choice of Management Objectives, such as lack of customisation and rigidity in the pre-defined criteria. As a result, instead of having a method that adapts to the organisation, this new method requires the organisation to adjust the tool.

In this research, we propose an alternative method to help organisations achieve better results when selecting the Management Objectives. Multi-Criteria Decision Making (MCDM) methods support decision making in the presence of multiple, usually conflicting, criteria [16]. Based on the literature review carried out by Velasquez and Hester [17] we concluded that the Analytical Hierarchy Process (AHP) and Multi-Attribute Utility Theory (MAUT) are the most popular MCDMs.

AHP is a powerful and flexible multi-criteria decision-making tool for dealing with complex problems where both qualitative and quantitative aspects need to be considered [18]. MAUT is "a more rigorous methodology for how to incorporate risk preferences and uncertainty into multi-criteria decision support methods" [19], but Velasquez and Hester also recognise that MAUT needs a lot of input and preferences to be precise [17].

AHP has some advantages and disadvantages to consider. The ease of use of the AHP is a recognisable strength. The AHP takes as its premise the idea that it is our concept of reality that is crucial and not our conventional representations of that reality by means such as statistics. With the AHP, practitioners can assign numerical values to what are essentially abstract concepts and then deduce from these values decisions to apply in the global framework. [20, 21]. This simplicity is crucial, as more complex methods require a more significant learning effort, something that does not fit in with this problem.

Therefore, in this research, we propose to use the AHP to help organisations establish the priorities for the COBIT 2019 process implementation. AHP was developed in the 1970s by Saaty and has since been extensively studied, and is currently used in decision making for complex scenarios, where people work together to make decisions when human perceptions, judgments, and consequences have long-term repercussions [22].

The results of this research are demonstrated using Design Factor (DF) 2 (COBIT 5 Goals Cascade) since the transition from the old Goals Cascade to the new DF2 is minimal. It also makes it considerably more accessible to find experts in the field willing to collaborate. However, this method can be applied to any of the Design Factors without losing any of the advantages that will be referenced throughout this document.

To evaluate the proposed method, a series of interviews were conducted with experts. During these interviews, each specialist compared their answers with those obtained using the method proposed by COBIT 2019 and the method proposed in this research.

1.1 Research Challenge

COBIT 2019 introduced a new method that attempts to solve the problems of COBIT 5 discussed in the literature [20, 23, 24]. During our research, however, we discovered that this method exhibits some major flaws which limit its adaptability and usability. These problems are summarised in this chapter.

COBIT 5 Goals Cascade is a method to translate the enterprise goals into specific processes. However, this method had several problems that were identified by different authors such as Lee et al., Almeida et al. and Steuperaert [20, 23, 24].These publications are detailed in Chapter 4 (Related Work).

COBIT 2019 defines ten different Design Factors to be selected, which are factors that can influence the design of an enterprise's governance system and position it for success in the use of Information & Technology [15].

In COBIT 2019, a new method is proposed to select and prioritise specific design factors to be considered for an enterprise's customised governance program [15]. This new method aims to mitigate the problems of the COBIT 5 Goals Cascade.

COBIT 2019 claims that it is a tailored governance solution that every enterprise should adopt as its "governance system for enterprise I&T", or "governance system" for short [15]. However, this claim is not entirely fulfilled due to the following problems with the method:

- The addition or removal of Design Factors is not possible in this method, which limits the set of possible Design Factors that can be selected by an organisation. These Design Factors are por-

trayed in the literature as Contingency Factors, which are covered in the Theoretical Background and Related Work chapters. In these chapters, it is demonstrated that a limited and non-modifiable set can be a limitation for the method.

- Each Design Factor has its own set of evaluation parameters that are impossible to be modified, added or deleted. Therefore, customisation in the evaluation methods of the Design Factors is not possible.
- Due to the absence of customisation possibilities, this process cannot be adapted to the particular context of an organisation or improved based on the experiences and knowledge of experts. Therefore, its potential is limited.
- There is a lack of theoretical evidence to support this method, as no concrete mathematical formulas are presented in the Design Guide Research book [15] to explain its underlying mechanisms.

There is limited scientific literature that supports the problems identified by the authors, given that this new version of COBIT was published very recently and thus the number of publications on the topic is limited. Some researchers [25] have shown that there are several factors (Contingency Factors) that influence the correct implementation of EGIT (e.g. Industry and Maturity). However, in the method presented by COBIT, it is not possible to add or remove any of these factors, which makes this method not adaptable to different organisations, thus limiting its performance.

To summarise, we may conclude that COBIT 2019 method is inflexible and lacks theoretical evidence for the selection and prioritisation of Management Objectives. Therefore, its utility in practice is limited and is prone to misleading results.

1.2 Outline of this document

This work is organised as follows. In Chapter 2, the research methodology used is described. In Chapter 3, some background information related to the topics of this thesis is laid out. In Chapter 4, works by other researchers are stated. In Chapter 5, the proposed solution is explained, and the demonstration is made in Chapter 6. In Chapter 7, a series of simulations were conducted to compare the experts' answers against the results of COBIT 2019 and that of the proposed method. In Chapter 7, a description is made on how we intend to communicate our research. Finally, a concluding remark is made in Chapter 9, which summarises the research, highlighting what was achieved in this research as well as its limitations

Chapter 2

Research Methodology

Design Science Research Methodology (DSRM) is the research methodology adopted in this research. Design science creates and evaluates IT artifacts intended to solve identified organisational problems [26]. It requires a rigorous process to design artifacts to solve problems, to make research contributions, to evaluate the designs, and to communicate the results to suitable audiences [27]. The goal of design science is to create and evaluate IT artifacts intended to solve identified organisational problems [26]. IT artifacts can be constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) or instantiations (implemented and prototype systems) [26]:

- Constructs provide the language in which problems and solutions are defined and communicated [27].
- Models use constructs to represent a real-world situation - the design problem and its solution space [28]
- Methods define processes. They guide how to solve problems, that is, how to search the solution space [26].
- Instantiations show that constructs, models, or methods can be implemented in a working system. They demonstrate feasibility, enabling accurate assessment of an artifact's suitability to its intended purpose [26].

The DSRM process is based on a six steps approach, summarized in Figure 2.1 [26]:

1. **Problem identification and motivation:** The primary goal is to come up with a well-defined problem that can justify the value of the solution and motivate the investigator to conduct the research to look for a possible solution.
2. **Defining the objectives for a solution:** Identification of the quantitative or qualitative objectives of a solution from the problem definition and knowledge of the state of the problem and possible solutions

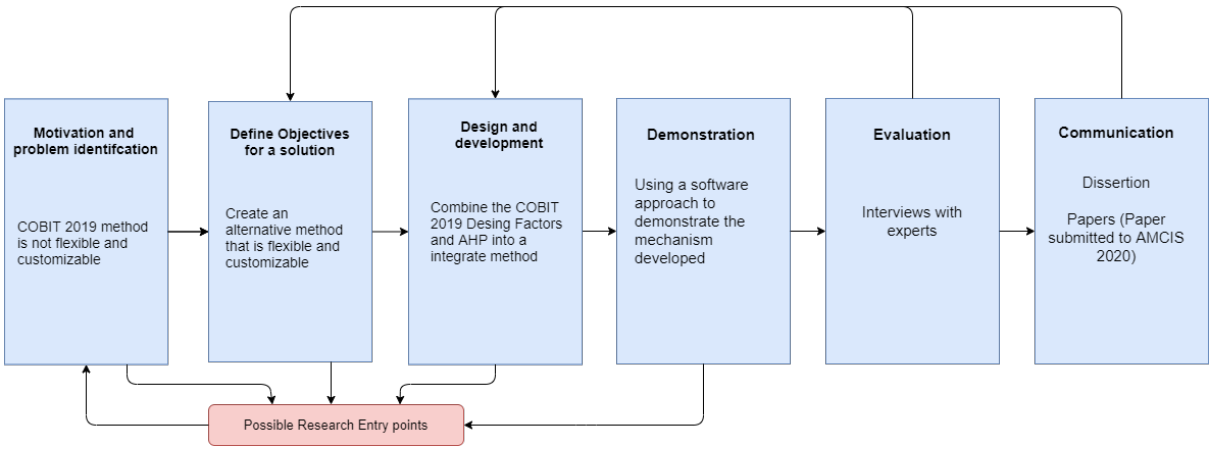


Figure 2.1: DSRM process with the research context adapted from [29]

3. **Design and development:** Decision on the artifact's desired functionality and architecture followed by its construction. A design research artifact can be any created object embedded with research contributions.

4. **Demonstration:** Demonstrate the application of the artifact to solve one or more cases of the problem. cases of the problem.

5. **Evaluation:** Observation and measurement of how well an artifact supports a solution. to the problem in order to compare the results observed from of the artifact in the demonstration.

6. **Communication:** Communication of the problem and its importance, the artifact, its utility and novelty, the rigour of its design and its effectiveness to researchers and other relevant audiences.

In summary, the guiding principles, practice rules, and a process of DSR for artifact development and artifact evaluation are used to conduct this research.

Chapter 3

Theoretical Background

In this chapter, we present a theoretical background on the topics related to our research.

3.1 Enterprise Governance of IT

In this section we provide a context to Enterprise Governance of IT

3.1.1 From ITG to EGIT

The modern concepts of EGIT are a legacy from the late nineties' concepts on IT Governance (ITG), where the first mentions started to appear both in academic and professional literature [30]. These origins led to some definitions of ITG, such as: "IT governance is the organisational capacity exercised by the board, executive management and IT management to control the formulation and implementation of IT strategy and in this way ensure the fusion of business and IT" [31]. Even though some concepts that stand now may have emerged only in the late nineties, it should, however, be noted that many of the underlying elements, such as business/IT alignment, has attracted attention many years before that [30]. Due to the focus on "IT" in the naming of the concept, the ITG debate mostly remained a discussion within the IT area [32]. However, it is clear that business value from IT investments cannot be achieved solely by IT, but will always be produced on the business side. This situation raised the issue that the involvement of business is critical for ITG and initiated a shift in the definition of ITG towards Enterprise Governance of IT (EGIT) [32].

3.1.2 Enterprise Governance of IT Definition

It is widely accepted that organizations depend more and more on IT [33]. However, IT projects still suffer from recurring costs, time overruns and failure to fully deliver the expected benefits to the users or the organization [34]. Because of this dependence and the constant lack of proper management in IT projects, EGIT appeared as a possible solution to solve these problems.

In this research, the following reference is used to describe EGIT: “EGIT is defined as an integral part of enterprise governance addressing the definition and implementation of processes, structures, and relational mechanisms in the organization that enable both business and IT people to execute their responsibilities in support of business/IT alignment and the creation of business value” [32]. Some studies have shown that companies with good EGIT models gain far higher returns on their IT investments than their competitors, mainly because they make better IT decisions [7]. EGIT goes beyond the IT-related responsibilities and extends towards (IT-related) business processes needed for business value creation [32].

3.1.3 Contingency factors

Factors that, depending on organizations context, may influence the EGIT implementation but that are not likely or intended, are a possibility that must be prepared for [25]. These factors are called EGIT contingency factors [25]. Pereira and Mira da Silva [25] further listed diverse contingency factors influencing enterprise governance. This information is synthesized in Figure 3.1.

Pereira and Mira da Silva [25] states that the factors that influence the EGIT implementation are: Culture, Structure, Size, Industry, Regional Differences, Maturity, Strategy, Ethical and Trust. Weill [7] claims that EGIT is influenced by these factors: Strategic and performance goals, Structure, Governance experience, Size and Diversity and Industry and Regional differences. Sambamurthy and Zmud [35] states that EGIT is influenced by Overall Governance mode, Firm size, Diversification mode, Diversification breadth, Exploitation strategy for scope economies and Line IT knowledge.

In conclusion, there is no consensus in the literature on which factors influence the correct implementation of EGIT. It is, therefore, challenging to define a set of Contingency Factors on which all organisations should rely. In the method developed in this research, the organisation is free to choose or eliminate any factor, thus making it more customised than the method presented by COBIT.

3.2 COBIT

A historical overview of the different versions of COBIT is shown in Figure 3.2.

3.2.1 COBIT 5

COBIT, developed by ISACA [11], is a governance framework. It enables IT to be governed and managed holistically for the whole enterprise, taking in the full end-to-end business and IT functional areas of responsibility, considering the IT-related interests of internal and external stakeholders [11]. COBIT 5 identifies five basic principles, seven categories of enablers and thirty-seven governance processes [36]. The five major principles that form the backbone of COBIT 5 philosophy are [37]:

- Meeting Stakeholder Needs
- Covering the Enterprise End-to-End

Contingency Factors	Literature
Organizational Culture	(Brown and Grant, 2005) (Fink and Ploder, 2008) (Gerard, 2009) (Hosseinbeig et al., 2011) (Jiandong and Hongjun, 2010) (Maidin and Arshad, 2010) (Symons, 2005) (Weisinger and Trauth, 2003)
Organizational Structure	(Adams et al., 2008) (Aagesen et al., 2011) (Cochran, 2010) (De Haes and Grembergen, 2008) (Gallagher and Worrel, 2008) (Gao et al., 2009) (Guney and Cresswell, 2010) (Hosseinbeig et al., 2011) (Lunardi et al., 2009) (Park et al., 2006) (Shpilberg et al., 2007) (Symons, 2005) (Web et al., 2006)
Size	(Brown and Grant, 2005) (Cochran, 2010) (De Haes and Grembergen, 2008) (Jacobson, 2009) (Lunardi et al., 2009)
Industry	(Brown and Grant, 2005) (De Haes and Grembergen, 2008) (Gerard, 2009) (Jacobson, 2009) (Jiandong and Hongjun, 2010) (Simonsson et al., 2008) (Tanriverdi, 2006)
Regional Differences	(Aagesen et al., 2011) (Fink and Ploder, 2008) (Gallagher and Worrel, 2008) (Shpilberg et al., 2007) (Weisinger and Trauth, 2003)
Maturity	(Cochran, 2010) (Dahlberg and Lahdelma, 2007) (De Haes and Grembergen, 2008) (Park et al., 2006) (Simonsson and Johnson, 2008) (Simonsson et al., 2008)
Strategy	(Brown and Grant, 2005) (Dahlberg and Lahdelma, 2007) (De Haes and Grembergen, 2008) (Jacobson, 2009) (Park et al., 2006) (Silva, and Chaix, 2008) (Symons, 2005)
Ethical	(Maidin and Arshad, 2010) (Memiyanty and Putera, 2010)
Trust	(Memiyanty and Putera, 2010)

Figure 3.1: Contingency factors [25]

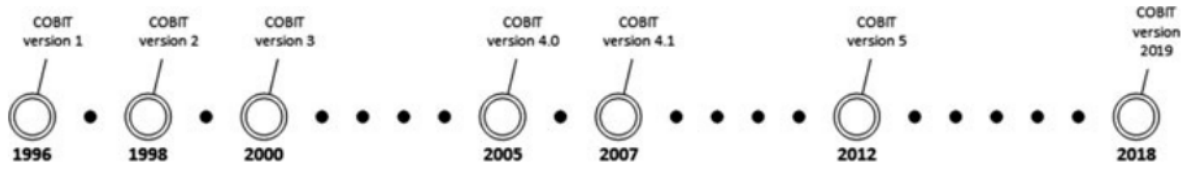


Figure 3.2: COBIT historical timeline [38]

- Applying a Single, Integrated Framework
- Enabling a Holistic Approach
- Separating Governance from Management

To satisfy the first principle in an organization, COBIT 5 introduces the Goals Cascade, which shows how stakeholder drivers create stakeholder needs, which define the enterprise's goals. The enterprise goals, in turn, generate IT-related goals, which define the enabler goals (process goals) [4]. This cascade now constitutes the core entry point for the COBIT 5 process improvement.

3.2.2 Goals Cascade

The COBIT 5 Goals Cascade is a mechanism that convert the stakeholders needs into organization goals. Specifically, the steps of the COBIT 5 Goals Cascade proposed in COBIT 5 are as follows [23]:

- **Step 1. Stakeholder Drivers Influence Stakeholder Needs.**

  Stakeholder needs are influenced by some drivers, e.g., strategy fluctuations, changing business and regulatory environment, and innovative technologies.

- **Step 2. Stakeholder Needs Cascade to Enterprise Goals.**

  Stakeholders can relate themselves to a set of generic enterprise goals. COBIT 5 has seventeen generic goals. These goals are represented in a Balanced Scored Board (BSC), that also defines the relationship between the main governance objectives and the generic goals. The relationship has three different levels ("P" stands for a primary relationship, "S" stands for a secondary relationship and if space is blank, stands for no relationship).

- **Step 3. Enterprise Goals Cascade to IT-related Goals.**

  Some IT-related goals are required for the achievement of enterprise goals. There are seventeen different IT-related goals, and they are represented ina mapping table. This table maps the Enterprise goals and the IT-related goals and uses the same levels of relationship mention of step 2 ("P", "S" and blank) (Figure 3.3).

- **Step 4. IT-related Goals Cascade to Enabler Goals.**

  To achieve the purpose of IT-related goals, it is necessary to have a successful application and use of some enablers. The concept of enablers is vast and include notions like include processes, organisational structures and information. In COBIT 5, there is a mapping between IT-related goals and COBIT 5 processes. In this mapping table, the relationship levels mention before are also used.

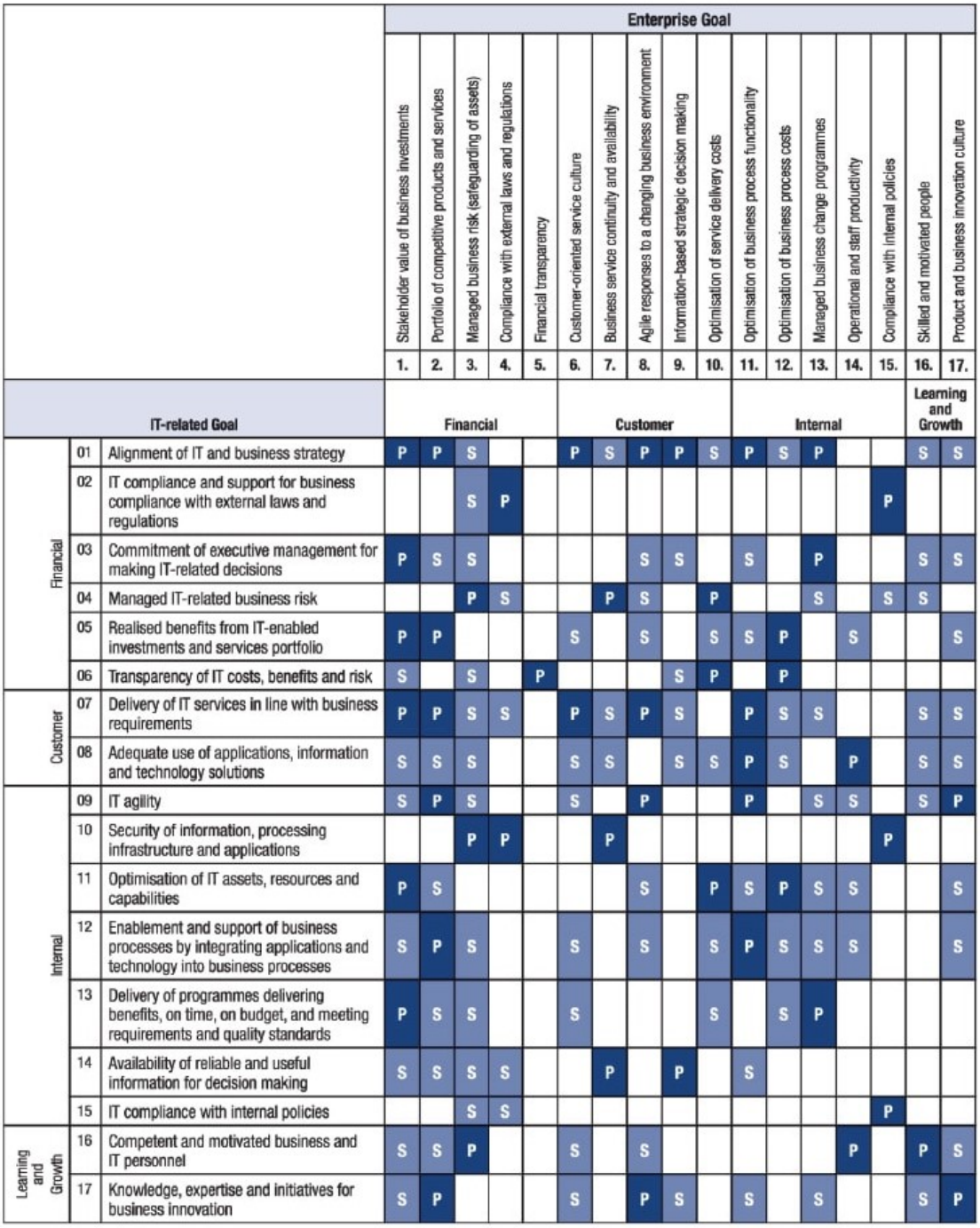
3.2.3 From COBIT 5 to COBIT 2019

COBIT 2019 is based mainly on COBIT 5. After almost seven years since the introduction of COBIT 5, it was natural to update and refresh several things, as technology, its role, and the way it is used in many organisations has significantly changed [38]. In COBIT 2019, three new objectives were introduced, namely APO14, BAI11 and MEA04. Among the new updates of COBIT 2019 include the identification of the components of an effective EGIT system, the identification of design factors, the introduction of an updated goals cascade and identification and the introduction of the concept of focus areas [39]. In November 2018, the successor of COBIT 5, i.e., COBIT 2019, was officially released. This most recent COBIT update is aimed at facilitating a more flexible, tailored implementation of effective "enterprise governance of information and technology (EGIT)" [38]. Figure 3.4 condenses the overall COBIT 2019 architecture and approach [39].

3.2.4 COBIT 2019

COBIT 2019 framework is organised into four main publications, De Haes et al. [40] provides a summary of each publication:

- **"COBIT 2019 Framework: Introduction and Methodology":** introduces the structure of the overall COBIT 2019 framework, explains its concepts and terminology [40].



			Enterprise Goal																
			1. Stakeholder value of business investments	2. Portfolio of competitive products and services	3. Managed business risk (safeguarding of assets)	4. Compliance with external laws and regulations	5. Financial transparency	6. Customer-oriented service culture	7. Business service continuity and availability	8. Agile responses to a changing business environment	9. Information-based strategic decision making	10. Optimisation of service delivery costs	11. Optimisation of business process functionality	12. Optimisation of business process costs	13. Managed business change programmes	14. Operational and staff productivity	15. Compliance with internal policies	16. Skilled and motivated people	17. Product and business innovation culture
			Financial					Customer					Internal					Learning and Growth	
		IT-related Goal																	
Financial	01	Alignment of IT and business strategy	P	P	S			P	S	P	P	S	P	S	P			S	S
	02	IT compliance and support for business compliance with external laws and regulations			S	P											P		
	03	Commitment of executive management for making IT-related decisions	P	S	S					S	S		S		P			S	S
	04	Managed IT-related business risk			P	S			P	S		P			S		S	S	
	05	Realised benefits from IT-enabled investments and services portfolio	P	P				S		S		S	S	P		S			S
	06	Transparency of IT costs, benefits and risk	S		S		P				S	P		P					
Customer	07	Delivery of IT services in line with business requirements	P	P	S	S		P	S	P	S		P	S	S			S	S
	08	Adequate use of applications, information and technology solutions	S	S	S			S	S		S	S	P	S		P		S	S
Internal	09	IT agility	S	P	S			S		P			P		S	S		S	P
	10	Security of information, processing infrastructure and applications			P	P			P								P		
	11	Optimisation of IT assets, resources and capabilities	P	S						S		P	S	P	S	S			S
	12	Enablement and support of business processes by integrating applications and technology into business processes	S	P	S			S		S		S	P	S	S	S			S
	13	Delivery of programmes delivering benefits, on time, on budget, and meeting requirements and quality standards	P	S	S			S				S		S	P				
	14	Availability of reliable and useful information for decision making	S	S	S	S			P		P		S						
	15	IT compliance with internal policies			S	S											P		
Learning and Growth	16	Competent and motivated business and IT personnel	S	S	P			S		S						P		P	S
	17	Knowledge, expertise and initiatives for business innovation	S	P				S		P	S		S		S			S	P

Figure 3.3: Relation between Enterprise Goals and IT-Related Goals [11] Appendix (A.1)

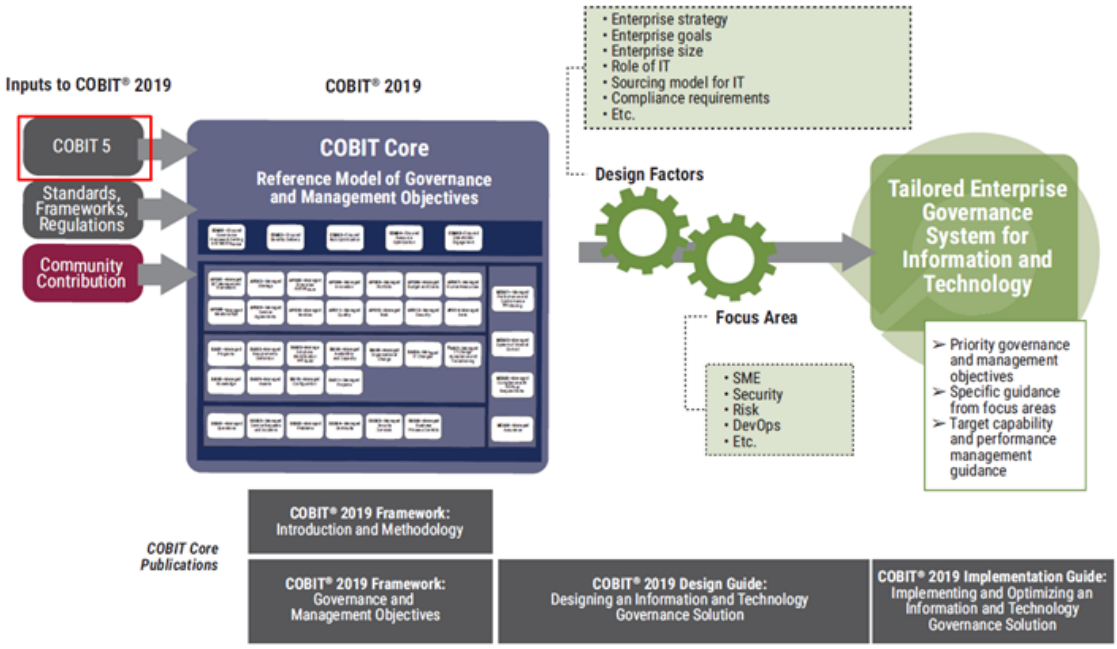


Figure 3.4: Design Guide COBIT 2019 [15]

- **"COBIT 2019 Framework: Governance and Management Objectives":** contains a detailed description of the COBIT 2019 core model and each of its 40 governance and management objectives [40].
- **"COBIT 2019 Design Guide: Designing an Information and Technology Governance Solution":** provides prescriptive how-to insights for COBIT users related to the design of an EGIT system. With the new concept of "design factors", COBIT 2019 provides hands-on insights on the factors that can influence an EGIT system [40].
- **"COBIT 2019 Implementation Guide: Implementing and Optimizing an Information and Technology Governance Solution"** provides a road map for continuous improvement of an EGIT system [40].

The main focus of this research is on "COBIT 2019 Design Guide: Designing an Information and Technology Governance Solution".

COBIT 2019 provides a generic list of Enterprise Goals (EG), Alignment Goals (AG), and their interrelationships (i.e., which alignment goals contribute in a "primary (P)" or a "secondary (S)" way to the achievement of the enterprise goals) [40] (represented in Figure 5.1).COBIT 2019 also provides Management Objectives, and the mapping between them and the Alignment Goals, as shown in Figure 5.2.

According to ISACA, an EGIT system needs to be tailored to the specific context of the enterprise. COBIT 2019 allows enterprises to design, operate, and improve a governance system tailored to their needs [39]. This specific context is shaped by several external and internal factors: the so-called design factors (Figure 3.7). These design factors can influence the prioritisation of governance and manage-

		EG01	EG02	EG03	EG04	EG05	EG06	EG07	EG08	EG09	EG10	EG11	EG12	EG13
		Portfolio of competitive products and services	Managed business risk	Compliance with external laws and regulations	Quality of financial information	Customer-oriented service culture	Business service continuity and availability	Quality of management information	Optimization of internal business process functionality	Optimization of business process costs	Staff skills, motivation and productivity	Compliance with internal policies	Managed digital transformation programs	Product and business innovation
AG01	I&T compliance and support for business compliance with external laws and regulations		S	P								S		
AG02	Managed I&T-related risk		P				S							
AG03	Realized benefits from I&T-enabled investments and services portfolio	S				S			S	S			P	
AG04	Quality of technology-related financial information				P			P		P				
AG05	Delivery of I&T services in line with business requirements	P				S	S		S				S	
AG06	Agility to turn business requirements into operational solutions	P				S			S				S	S
AG07	Security of information, processing infrastructure and applications, and privacy		P				P							
AG08	Enabling and supporting business processes by integrating applications and technology	P				P			S		S		P	S
AG09	Delivering programs on time, on budget and meeting requirements and quality standards	P				S			S	S			P	S
AG10	Quality of I&T management information				P			P		S				
AG11	I&T compliance with internal policies		S	P								P		
AG12	Competent and motivated staff with mutual understanding of technology and business					S					P			
AG13	Knowledge, expertise and initiatives for business innovation	P		S									S	P

Figure 3.5: Relation between Enterprise Goals and Alignment Goals [15]

ment objectives that are to be met by the enterprise [40].

However, as identified in the Introduction Section (1.1), the potential of these design factors to achieve their goals is highly limited, due to their lack of flexibility to be tailored to the specific needs of enterprises.

3.3 Multi-Criteria Decision Making

In this section, we provide a context to Multi-Criteria Decision Making algorithms.

MCDM has been one of the fastest growing problem areas in many disciplines [41]. MCDM methods can be applied into diverse real-world decisions. The progression of technology over the past couple of decades has allowed for more complex decision analysis methods to be developed [17].

The role of MCDMs in different application areas has increased significantly, especially as new methods are developed and as old methods are improved [17]. In our literature research, we identified the research of Velasquez and Hester [17] as a good resume of the advantages and disadvantages of the most well-known MCDMs. After analysing this literature review, we decided to use AHP as a possible solution to this research. In Table 3.1, we can analyse a comparison made by Velasquez and Hester [17] between the most well-known MCDMs.

3.3.1 Analytic hierarchy process

AHP is a multi-criteria decision-making algorithm proposed by Saaty in 1977 [42]. AHP is a method for

		AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
		I&T compliance and support for business compliance with external laws and regulations	Managed I&T-related risk	Realized benefits from I&T-enabled investments and services portfolio	Quality of technology-related financial information	Delivery of I&T services in line with business requirements	Agility to turn business requirements into operational solutions	Security of information, processing infrastructure and applications, and privacy	Enabling and supporting business processes by integrating applications and technology	Delivering programs on time, on budget and meeting requirements and quality standards	Quality of I&T management information	I&T compliance with internal policies	Competent and motivated staff with mutual understanding of technology and business	Knowledge, expertise and initiatives for business innovation
EDM01	Ensured governance framework setting and maintenance	P	S	P					S			S		
EDM02	Ensured benefits delivery			P		S	S		S					S
EDM03	Ensured risk optimization	S	P					P				S		
EDM04	Ensured resource optimization			S		S	S		S	P			S	
EDM05	Ensured stakeholder engagement				S						P	S		
APO01	Managed I&T management framework	S	S	P		S		S	S	S	S	P		
APO02	Managed strategy			S		S	S		P				S	S
APO03	Managed enterprise architecture			S		S	P	S	P					
APO04	Managed innovation			S			P		S				S	P
APO05	Managed portfolio			P		P	S		S	S				
APO06	Managed budget and costs			S	P					P	S			
APO07	Managed human resources			S		S				S			P	P
APO08	Managed relationships			S		P	P		S	S			P	P
APO09	Managed service agreements					P			S					
APO10	Managed vendors					P	S			S				
APO11	Managed quality			S	S	S				P	P			
APO12	Managed risk		P					P						
APO13	Managed security	S	S					P						
APO14	Managed data	S	S		S			S			P			
BAI01	Managed programs			P			S		S	P				
BAI02	Managed requirements definition			S		P	P		S	P			S	
BAI03	Managed solutions identification and build			S		P	P		S	P				
BAI04	Managed availability and capacity					P		S		S				
BAI05	Managed organizational changes			P		S	S		P	P			S	
BAI06	Managed IT changes		S			S	P		S					
BAI07	Managed IT change acceptance and transitioning		S				P			S				
BAI08	Managed knowledge			S			S		S	S			P	P
BAI09	Managed assets				P						S			
BAI10	Managed configuration					S		P						
BAI11	Managed projects			P		S	P			P				
DSS01	Managed operations					P			S					
DSS02	Managed service requests and incidents		S			P		S						
DSS03	Managed problems		S			P		S						
DSS04	Managed continuity		S			P		P						
DSS05	Managed security services	S	P			S		P				S		
DSS06	Managed business process controls		S			S		S	P			S		
MEA01	Managed performance and conformance monitoring	S		S		P				S	P	S		
MEA02	Managed system of internal control	S	S		S	S		S		S	S	P		
MEA03	Managed compliance with external requirements	P										S		
MEA04	Managed assurance	S	S		S	S		S			S	P		

Figure 3.6: Relation between Alignment Goals and Management Objectives [15] (Appendix A.2)

Figure 3.7: Design Factors [15]

Table 3.1: Comparison between different MCDMs [17]

Method	**Advantages**	**Disadvantages**	**Areas of Application**
Multi-Attribute Utility Theory (MAUT)	Takes uncertainty into account; can incorporate preferences.	Needs a lot of input; preferences need to be precise.	Economics, finance, actuarial, water management, energy management, agriculture
Analytic Hierarchy Process (AHP)	Easy to use; scalable; hierarchy structure can easily adjust to fit many sized problems; not data intensive.	Problems due to interdependence between criteria and alternatives; can lead to inconsistencies between judgment and ranking criteria; rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
Case-Based Reasoning (CBR)	Not data intensive; requires little maintenance; can improve over time; can adapt to changes in environment.	Sensitive to inconsistent data; requires many cases.	Businesses, vehicle insurance, medicine, and engineering design.
Data Envelopment Analysis (DEA)	Capable of handling multiple inputs and outputs; efficiency can be analyzed and quantified.	Does not deal with imprecise data; assumes that all input and output are exactly known.	Economics, medicine, utilities, road safety, agriculture, retail, and business problems.
Fuzzy Set Theory	Allows for imprecise input; takes into account insufficient information.	Difficult to develop; can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
Simple Multi-Attribute Rating Technique (SMART)	Simple; allows for any type of weight assignment technique; less effort by decision makers.	Procedure may not be convenient considering the framework.	Environmental, construction, transportation and logistics, military, manufacturing and assembly problems
Goal Programming (GP)	Capable of handling large-scale problems; can produce infinite alternatives.	It's ability to weight coefficients; typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.
ELECTRE	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman's terms; outranking causes the strengths and weaknesses of the alternatives to not be directly identified.	Energy, economics, environmental, water management, and transportation problems.

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Figure 3.8: The fundamental table of Saaty scale [46]

ranking decision alternatives and selecting the best one when the decision maker has multiple criteria [43].

AHP tries to answer which one of the different options should be chosen. This decision will be achieved by making pairwise comparisons between the alternatives. The decision-maker examines two choices by considering one criterion and indicating a preference. These comparisons are made using a preference scale, which assigns numerical values to different levels of preference [44]. The standard scale used to make these comparisons is 1-9, as described in Figure 3.8. In the pairwise comparison matrix, the value 9 indicates that one factor is significantly more important than the other, and the value 1/9 suggests that one factor is remarkably less important than the other, whereas the value 1 indicates equal importance [45].

From now on, “Saaty scale” will be the term used to refer to this scale.

An important aspect of the AHP is the idea of consistency. The consistency ratio (C.R.) is obtained by comparing the consistency index with the appropriate one of the following set of numbers each of which is an average random consistency index derived from a sample of size 500 of randomly generated (Figure 3.9) [47]. If it is about 0.10 (10%) or less the results are consistent. If it is not less than 0.10 study the problem and revise the judgments [47].

The objectives of using this method are to identify the preferred alternative and to determine a ranking of the alternatives when all the decision criteria are considered simultaneously [46]. The preference towards AHP, instead of another multi-criteria technique, is due to the following reasons, as mention by

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	.52	.89	1.11	1.25	1.35	1.40	1.45	1.49

Figure 3.9: The Random Index

Mahmoodzadeh et al [48]:

- Quantitative and qualitative criteria can be included in the decision making
- A large number of criteria can be considered
- A flexible hierarchy can be constructed according to the problem

Saaty [49] claims that to make a decision it is necessary to decompose the process into four distinct and well-defined steps:

1. Define the problem and determine the kind of knowledge to be sought.
2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare with the elements in the level immediately below it.
4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom-most level are obtained.

The process of decomposition is the core of AHP. A complex problem is subdivided into smaller ones, wherein the top of the hierarchy is the Goal. Next, is the criteria and sub-criteria, and at this level, it is necessary to perform the pairwise comparison, between the criteria or sub-criteria. The alternatives (solutions) are at the bottom level. It is also necessary to perform a pairwise comparison between the alternatives and the sub-criteria. A simple illustration of the AHP idea can be found in Figure 3.10.

3.3.2 Summary

In short, to solve the problems mentioned before, or at least mitigate them, MCDMs was chosen as the basis for an alternative method to the current one. After an analysis of different MCDMs and checking whether there were similar problems in the literature, we found that AHP has appropriate characteristics for this type of problems and that it had been used in similar problems by several authors (Related work chapter). The next step would be to try to figure out how to connect the AHP to COBIT 2019. In this step, we decided that each criterion of the different Design Factors would be the AHP criterion and that each

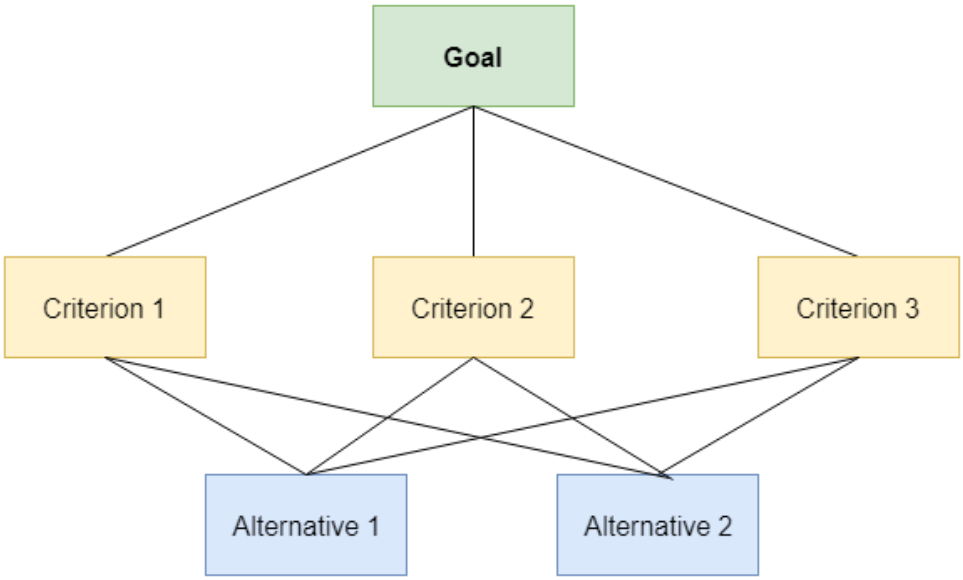


Figure 3.10: AHP simple example

Management Objective would be the AHP alternatives. However, as explained before, this research only focuses on Design Factor 2. For this Design Factor, it was decided that each of the Enterprise Goals would constitute the different criteria of the AHP, that each of the Alignment Goals would be the Sub-Criteria of the AHP and that the Management Objectives would be the alternatives of the AHP. This method is explained in more detail in the Proposal chapter.

Chapter 4

Related Work

In this chapter, we present some research that, despite not solving the aforementioned problem, contributed to the development of our proposal.

4.1 Enterprise Governance of IT

From this book ”Enterprise Governance of Information Technology” we would like to highlight Chapter 1. In this chapter, a high-level description of what Enterprise Governance of IT is about is provided [5] through the presentation of a brief context of Enterprise Governance of IT in Digitized Organizations.

EGIT addresses the definition and implementation of processes, structures, and a relational mechanism that allow both business and IT individuals to perform their responsibilities in support of business/IT alignment and the conception of value from IT-enabled business investments [4]. Accomplishing a high degree of business/IT alignment, in turn, enables the achievement of business value from IT. IT, by itself, will not produce value for the business. Value will only be achieved with the involvement and alignment of both IT and the business [4].

4.1.1 Impact of Enterprise Governance

In many organisations, information technology (IT) has become critical in the support, sustainability and growth of the business. This persistent use of technology has generated a crucial dependency on IT that demands a specific focus on enterprise governance of IT (EGIT) [30].

De Haes and Grembergen’s research [30] starts by briefly documenting the transition from IT Governance to EGIT. The definition of IT Governance made by the IT Governance Institute is used: ”IT governance is the responsibility of executives and the board of directors and consists of the leadership, organisational structures and processes that ensure that the enterprise’s IT sustains and extends the organisation’s strategy and objectives” [50]. However, it is concluded that this definition does not represent the reality since ”business value will only be created when new and adequate business processes are designed and executed enabling the salespeople of the organisation to increase turnover and profit. However, it is concluded that this definition does not represent the reality since ”business value will

only be created when new and adequate business processes are designed and executed enabling the salespeople of the organisation to increase turnover and profit [30].

This discussion raised the issue of the necessity of the involvement of business and initiated a shift in the definition of IT Governance towards “Enterprise Governance of IT” [30]. Thus, the definition of EGIT used in this paper is the same as that used in this research, which defines EGIT as ”an integral part of enterprise governance and addresses the definition and implementation of processes, structures and relational mechanisms in the organisation that enable both business and IT people to execute their responsibilities in support of business/IT alignment and the creation of business value from IT-enabled business investments”.

The study revealed a strong relationship between the implementation status of COBIT and Val IT processes and the achievement of IT goals, and a strong relationship between the achievement of IT goals and the achievement of business goals [30]. However, no strong correlations could be found directly between the implementation of COBIT and Val IT processes and the achievement of business goals [30]. A set of COBIT and Val IT processes was found that impact the IT goals the most, and IT goals were highlighted that impact the business goals the most [30].

4.2 COBIT 5 Prioritization Problem

The COBIT 5 goals cascade is a mechanism that converts the stakeholder’s needs into organisation goals [23]. In our research, we found some literature to improve the Goals Cascade (Design Factor 2) [20, 23, 24].

In the paper of Steuperaert [24], the quality of the Goals Cascade was assessed by looking at the accuracy of the published mapping tables, the dependencies between goals in the same goal set and the sensitivity of the Goals Cascade towards input variations [24].The questions that identify the scope of this research are the following [24]:

1. Is the Goals Cascade accurate?
2. Does the Goals Cascade allow easy prioritisation at the input side?
3. Does the Goals Cascade demonstrate sufficient sensitivity for process prioritisation?
4. Is it possible to complement the current Goals Cascade with a new artefact?

In Research Question 1, the author analyse the effect of two sets of mapping tables - one based on the original research made by a research group at Antwerp University, and another published by COBIT 5 - on the outcome of the goals cascade, as represented in Figure 4.1 [24]. This is done by running a simulation where they feed the same input (a [1x17] matrix, representing the priorities of each of the generic enterprise goals as defined in COBIT 5, where each goal is deemed equally important) to both sets of mapping tables and compare the output of the Goals Cascade (a [1x34] matrix, containing the resulting weights of each COBIT 5 process, obtained through multiplication of the input matrices with both mapping tables) [24].

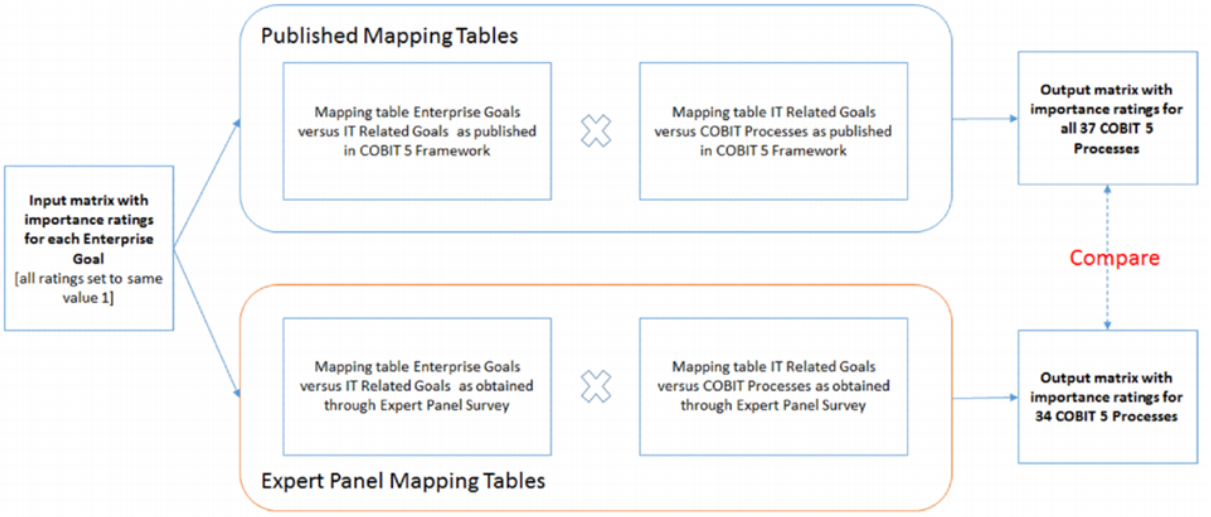


Figure 4.1: Comparison of the two sets of mapping tables [24]

The results are shown in Figure 4.2, a spider chart that contains two sets of values: (1) The process weights obtained through the application of the published COBIT 5 Goals Cascade, and (2) The process weights obtained through the application of the Goals Cascade with the original research data [24].

In Research Question 2, the author used analytical review and peer review on a subset of enterprise goals and assess whether there exist dependencies between these enterprise goals [24].To validate this assumption, the author took a subset of the Enterprise Goals [11] and had four researchers from his research group independently assess their interdependencies. The result is shown in Figure 4.3, highlighting a substantial number of interdependencies [24].

In Research Question 3, the author performed a simulation of the Goals Cascade and observed two dependent variables of the Goals Cascade: (a) The resulting process weight, normalised on a scale of 10, and (b) the relative process ranking in the ranked list of all 37 COBIT 5 processes [24]. The results of the simulations are shown in Figure 4.4 and in Figure 4.5, where the authors show the outcome of both dependent variables – process weight and process ranking - for the large simulation.

In Research Question 4, the author took a design-science based approach. An expert panel has performed a first validation of the new artefact (Improving the Quality of the [24]. The result was a new artefact, the “Enterprise Strategies”. The author defined the following set of four potential enterprise strategies that any organisation could pursue. Then, in order to validate the concept of the proposed solution, and in order to initially populate the new mapping table, the author worked with a limited expert panel who were given a questionnaire to map each of the four enterprise strategies to the COBIT 5 processes. The results from the expert panel were analysed, and the findings were as follows: the panel did not report any significant difficulty in completing the survey, thus indicating that the direct mapping between enterprise strategies and processes is viable and does not create any conceptual difficulties [24].

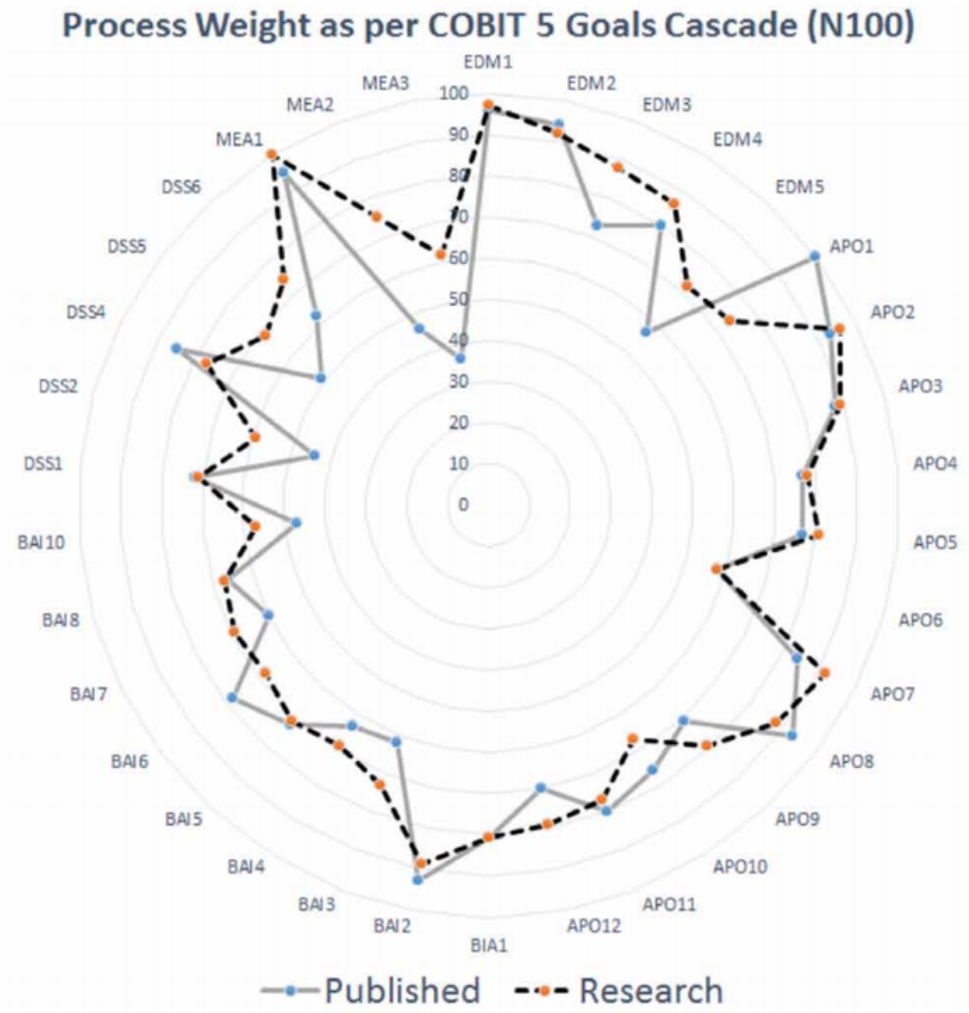


Figure 4.2: Results of Research Question 1 [24]

Goals Interdependencies	EG02	EG03	EG04	EG05	EG06	EG07	EG08	EG09	EG10
EG01	H	H	?	H	H	H	H		?
EG02				H	H	H	H	H	H
EG03			H	?		H	H	?	
EG04				H		?	?	?	?
EG05								H	?
EG06						H	H	H	H
EG07							?	?	
EG08								H	
EG09									

Figure 4.3: Results of Research Question 2 [24]

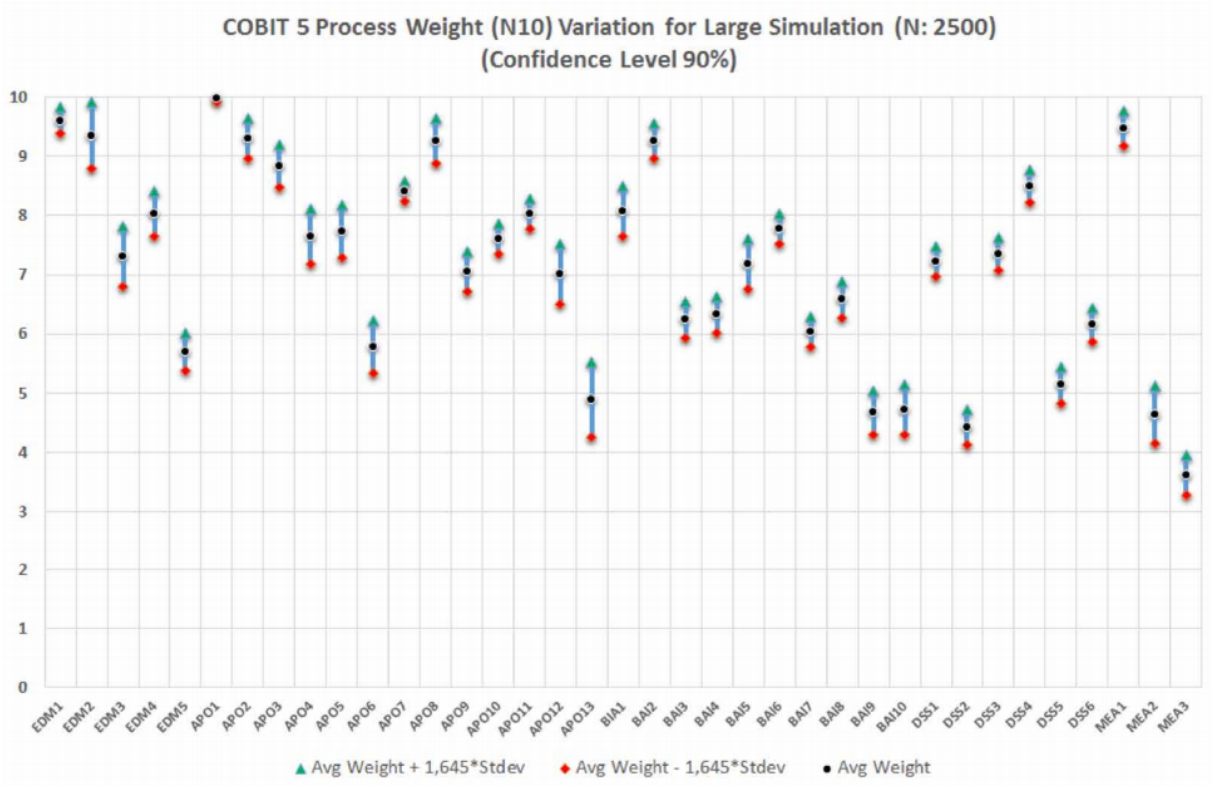


Figure 4.4: COBIT 5 process weight range after goals cascade application (N=2500) [24]

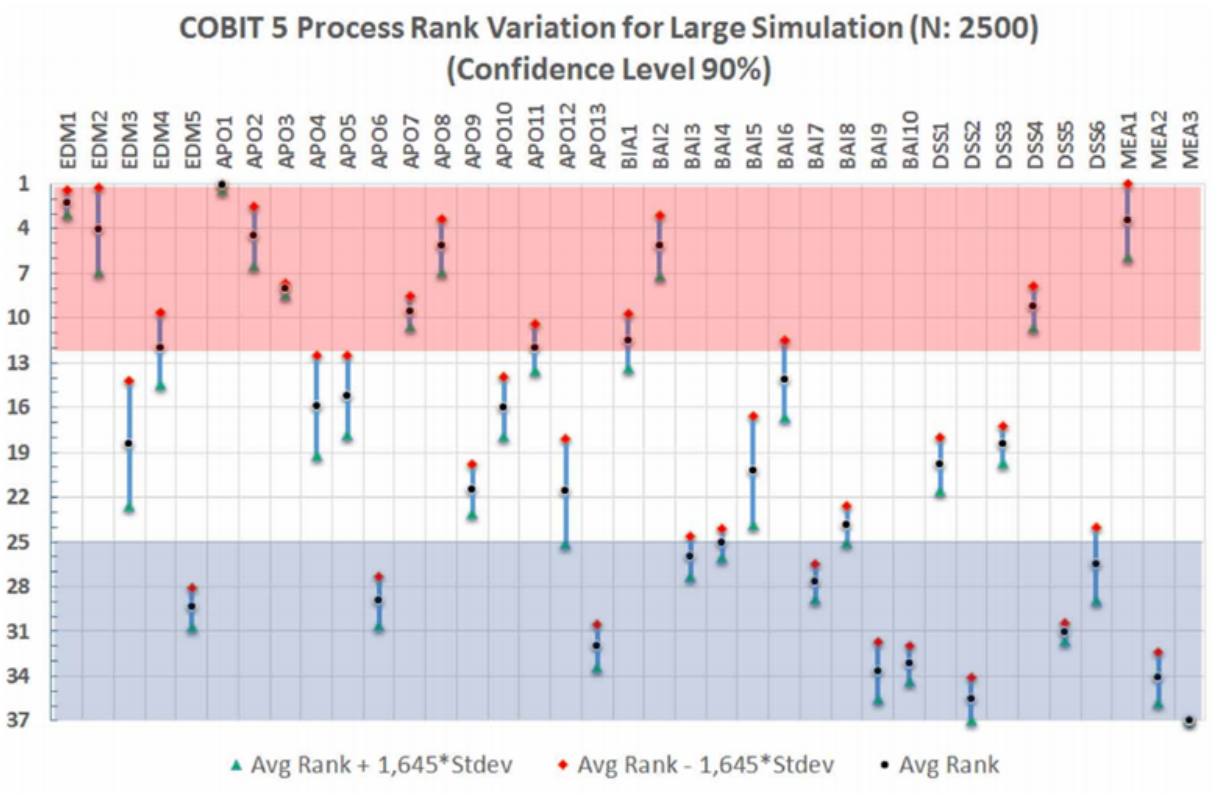


Figure 4.5: COBIT 5 process ranking range after goals cascade application (N=2500)[24]

BSC Dimension	Enterprise Goal	Relation to Governance Objectives		
		Benefits Realisation	Risk Optimisation	Resource Optimisation
Financial	1. Stakeholder value of business investments	P		S
	2. Portfolio of competitive products and services	P	P	S
	3. Managed business risk (safeguarding of assets)		P	S
	4. Compliance with external laws and regulations		P	
	5. Financial transparency	P	S	S
Customer	6. Customer-oriented service culture	P		S
	7. Business service continuity and availability		P	
	8. Agile responses to a changing business environment	P		S
	9. Information-based strategic decision making	P	P	P
	10. Optimisation of service delivery costs	P		P
Internal	11. Optimisation of business process functionality	P		P
	12. Optimisation of business process costs	P		P
	13. Managed business change programmes	P	P	S
	14. Operational and staff productivity	P		P
	15. Compliance with internal policies		P	
Learning and Growth	16. Skilled and motivated people	S	P	P
	17. Product and business innovation culture	P		

Figure 4.6: BSC used by Lee et al. [23] from COBIT 5 [37]

4.2.1 AHP with Balanced Scorecard (BSC)

In the research conducted by Lee et al. [23], the authors, in section four (4), identified a number of IT-related goals according to the Enterprise goals. However, the priorities required to achieve these goals are not provided [23]. This paper aims to give priority to the IT-related goals according to the Enterprise goals. The method created by the authors to achieve this is based in a AHP approach [23].

First, the authors use the table provided by COBIT 5 [23] that relates the stakeholders needs with the Enterprise Goals. Then they compare the different criteria presented in the COBIT 5 table (Financial, Customer, Internal and Learning and Growth) with the three main governance objectives (Benefits Realisation, Risk Optimisation and Resource Optimisation), as shown in Figure 4.6. With the help of a Balanced Scored Board (BSC), they relate each criterion to the IT-related goal. By doing this, the authors proposed a BSC showing the relative weight of each criterion with regard to each of the IT-related goals [23].

A practical example is presented in section six (6), where the authors apply the method to a Slovenian e-health project. The goal of this project was to establish a communication network for exchanging information [23]. In the case of this project, 'Benefits Realization' was the selected goal [23]. The IT-related goals that are mapped to the previous enterprise goals are as follows:

- 03. Commitment of executive management for making IT-related decisions.
- 04. Managed IT-related business risk.
- 05. Realised benefits from IT-enabled investments and services portfolio.
- 07. Delivery of IT services in line with business requirements.

Table 4.1: Each Measure and mean of the BSC attribute [23]

Measure of the BSC attribute			
Financial	**Customer**	**Internal**	**Learning and Growth**
3	4	4	1.5
Mean of the weight			
3/5	4/5	4/5	1.5/2

Table 4.2: The matrix of pairwise comparisons and the sum of the columns [23]

	Financial	**Customer**	**Internal**	**Learning and Growth**
Financial	1	3/4	3/4	4/5
Customer	4/3	1	1	32/15
Internal	4/3	1	1	15/32
Learning and Growth	5/4	15/32	15/32	1
Sum of columns	8.9167	3.2188	3.2188	6.0667

- 09. IT agility.
- 11. Optimization of IT assets, resources and capabilities
- 12. Enablement and support of business processes by integrating applications and technology into business processes.
- 14. Availability of reliable and useful information for decision making.
- 17. Knowledge, expertise and initiatives for business innovation.

In Figure 4.6, there are three P's in relation to financial and benefits realization, four P's in relation to customer and benefits realization, four P's in relation to internal and benefits realisation, and one P and one S in relation to learning and growth and benefits realisation [23]. The measures and mean are shown in Table 4.1 [23].

Comparing Financial and Customer as an example, since the score for Financial is 3/5 and the score for Customer is 4/5, Financial is therefore (3/5)/(4/5) = 3/4 times more important than Customer. In this way, the matrix of pairwise comparisons can be obtained by the following Table 4.2 [23].

This result is the weight of each BSC attribute. The matrices that have undergone this process are shown in Table 4.3 [23].

The weight of Financial is 0.1775, the weight of Customer is 0.2806, the weight of Internal is 0.2806, and the weight of Learning and Growth is 0.1490. The BSC attribute with the highest weight is the first alternative to consider. Applying this priority to IT goals results in two outcomes because Internal and Customer priorities are the same [23]. Priorities are shown in Figure 4.7.

Table 4.3: The weight of each BSC attribute [23]

	Financial	**Customer**	**Internal**	**Learning and Growth**	**Sum of rows**	**Weight**
Financial	0.1121	0.2330	0.2330	0.1319	0.7100	0.1775
Customer	0.1495	0.3107	0.3107	0.3516	1.1225	0.2806
Internal	0.1495	0.3107	0.3107	0.3516	1.1225	0.2806
Learning and Growth	0.1402	0.1456	0.1456	0.1648	0.5962	0.1490

Priority	BSC attribute	IT-related Goals
1	Internal	• 9. IT agility • 11. Optimization of IT assets, resources and capabilities • 12. Enablement and support of business processes by integrating applications and technology into business processes • 14. Availability of reliable and useful information for decision making
	Customer	• 7. Delivery of IT services in line with business requirements
2	Financial	• 3. Commitment of executive management for making IT-related decisions • 4. Managed IT-related business risk • 5. Realized benefits from IT-enabled investments and services portfolio
3	Learning &Growth	• 17. Knowledge, expertise and initiatives for business innovation

Figure 4.7: Priority of IT objectives obtained by applying the paper methodology [23]

The authors conclude that “this study presented a way for companies to use COBIT 5 in a more quantitative way to create a business or IT value. In the COBIT 5 method, your financial and customer will always have priority, even if your organisation’s goals change” [23].

From our perspective, this paper is of great value because it not only identifies an obvious problem of COBIT 5 which is the lack of prioritisation but also offers a possible solution - the use of AHP. The use of this type of solution serves as a basis for the method developed in this thesis.

4.3 AHP to prioritise COBIT 5 processes.

Almeida et al. [20] research identified that the COBIT 5 process prioritisation is an essential part of the COBIT 5 process improvement selection [20]. Their research goals are as follows [20]:

- Literature review to pinpoint published solutions to the problem at hand and identify the research gap;
- Evaluation of the MCDM found in the literature;
- Combination of the COBIT 5 Goals Cascade with the chosen MCDM (AHP);
- Demonstration of the proposal.

Based on their research, the authors have chosen the following criteria to prioritise the COBIT 5 processes selected in the Goals Cascade run: Allocate fewer resources (related to the reserved resources factor), Short development time (related to the scheduled time factor), Higher Improvement Impact (related to the quality factor), and Higher Business Value of IT/IS projects (also related to the quality factor) [20].

The authors used the scientific article by Velasquez and Hester [17] to choose the MCDM and, as in this thesis, the choice fell on the AHP [20]. Their proposal consists of the following steps [20], as summarised in Figure 4.8 [20]:

The authors demonstrated their proposal with the following example [20]:

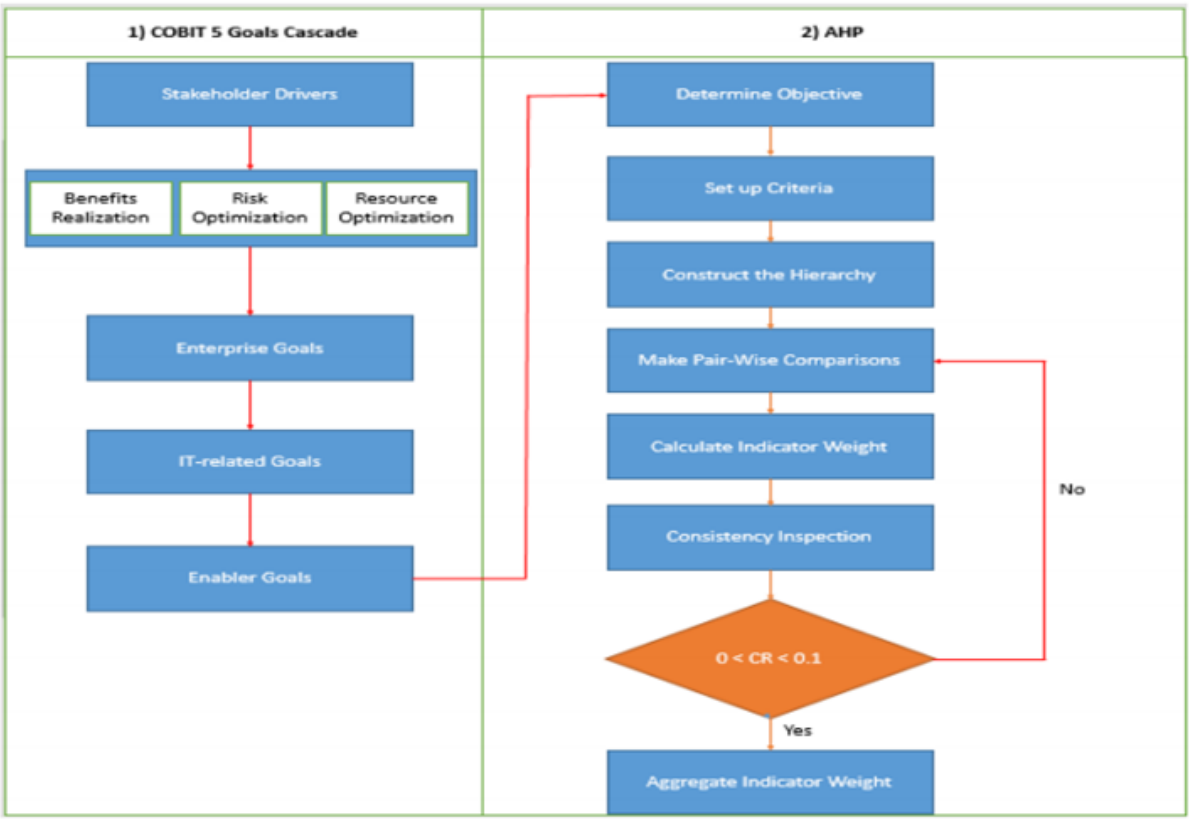


Figure 4.8: Method presented in Almeida et al. research [20]

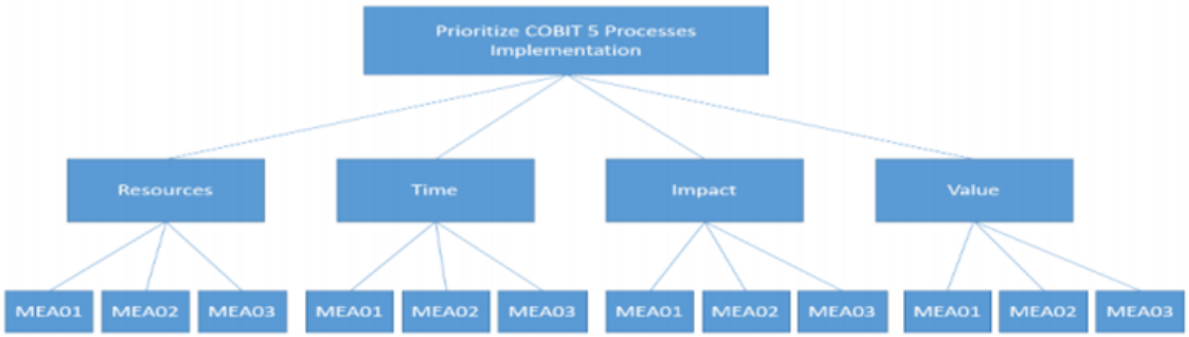


Figure 4.9: AHP structure [20]

Table 4.4: The rank of each Criteria [20]

Criteria	Priority	Rank
Resources	0.08	4
Time	0.51	1
Impact	0.24	2
Value	0.17	3

Table 4.5: Final rank of each Process

Processes	Resoruces	Time	Impact	Value
MEA01	0.73	0.71	0.19	0.27
MEA02	0.19	0.22	00.72	0.12
MEA03	0.08	0.07	0.09	0.61

The weights given by the experts can be seen in Table 4.4 and the final results in Table 4.5.

- **Step 1. Stakeholders' Needs Cascade to Enterprise Goals:** The following two stakeholders' needs were chosen to run the goals cascade: "How do I get Assurance over IT?" and "Does IT support the enterprise in complying with regulations and service levels?". These needs were translated into Enterprise Goals "Compliance with External Laws and Regulations" and "Compliance with Internal Policies" [20].

- **Step 2. Enterprise Goals Cascade to IT-related Goals:** The enterprise goals "Compliance with External Laws and Regulations" and "Compliance with Internal Policies" are translated into the IT-Goals "IT Compliance and Support for Business Compliance with External Laws and Regulations", "Security of Information, Processing Infrastructure, and Applications" and "IT Compliance with Internal Policies" [20].

- **Step 3. IT-related Goals Cascade to Enabler Goals:** "In this scenario, we translated the IT-related goals into the process enabler, which resulted in the following selection APO01, APO12, APO13, BAI10, DSS05, MEA01, MEA02, and MEA03" [20].

- **Step 4. AHP for Process Prioritization:** The AHP structure illustrated in Figure 4.9 was presented and analysed by three IT management experts with vast experience in COBIT 5. These three experts made the pairwise comparison of the criteria (first layer) and the pairwise comparison of the alternatives (second layer) [20].

This research [20] was of great value to this thesis. As with Lee et al. [23], they used the AHP to solve the existing prioritisation problem in COBIT 5. This research tries to prioritise Processes (currently called Management Objectives), similar to the method developed in this thesis. Thus, we can state that there are data in the literature that support the use of AHP as a basis to a method like the one developed in this thesis.

Chapter 5

Proposal

This chapter describes how we intend to solve the research problem listed in Section 1.1.

5.1 Objectives

The main objectives of this research are:

- Getting a list of processes prioritised by their importance, which takes into consideration internal and external factors that affect the organisation.
- Developing a fully-customizable method

5.2 Proposal Description

Considering the macro objectives of this proposal, we can infer that in general terms, the proposed method tries to include all the real benefits in the current ISACA method, and on top of that, also attempts to solve or mitigate the previously identified errors: lack of flexibility, customizability and adaptability to the organisation (Section 1.1). More explicitly, we have divided the macro criteria into more specific criteria, intending to solve the problems encountered while retaining the benefits of the current method. Therefore, we will later evaluate this proposed method not only on its ability to achieve the current objectives but also on the quality of its results.

The more specific objectives are:

- **Universality:** The method should be applicable to all Design Factors.
- **Customisable Criteria:** The method should allow the organisation to determine the weight of each of the criteria.
- **Flexibility:** The method should allow the addition or removal of criteria as intended by the organisation.

		EG01	EG02	EG03	EG04	EG05	EG06	EG07	EG08	EG09	EG10	EG11	EG12	EG13
		Portfolio of competitive products and services	Managed business risk	Compliance with external laws and regulations	Quality of financial information	Customer-oriented service culture	Business service continuity and availability	Quality of management information	Optimization of internal business process functionality	Optimization of business process costs	Staff skills, motivation and productivity	Compliance with internal policies	Managed digital transformation programs	Product and business innovation
AG01	I&T compliance and support for business compliance with external laws and regulations		S	P								S		
AG02	Managed I&T-related risk		P				S							
AG03	Realized benefits from I&T-enabled investments and services portfolio	S				S			S	S			P	
AG04	Quality of technology-related financial information				P			P		P				
AG05	Delivery of I&T services in line with business requirements	P				S	S		S				S	
AG06	Agility to turn business requirements into operational solutions	P				S			S				S	S
AG07	Security of information, processing infrastructure and applications, and privacy		P				P							
AG08	Enabling and supporting business processes by integrating applications and technology	P				P			S		S		P	S
AG09	Delivering programs on time, on budget and meeting requirements and quality standards	P				S			S	S			P	S
AG10	Quality of I&T management information				P			P		S				
AG11	I&T compliance with internal policies		S	P								P		
AG12	Competent and motivated staff with mutual understanding of technology and business					S					P			
AG13	Knowledge, expertise and initiatives for business innovation	P		S									S	P

Figure 5.1: Relation between Enterprise Goals and Alignment Goals [15]

- **Automatic:** Part of the process should be completely automated. The level of automation should be similar to that presented by the COBIT 2019 Toolkit.

To solve the previously mentioned problems and achieve the above requirements, the AHP algorithm is adopted. To integrate AHP with the problem context, the following questions need to be answered:

1. What should the criteria and sub-criteria be, and how are they related?
2. What should the alternatives be, and how are they related to the sub-criteria?
3. Who evaluates the different criteria?
4. How should different criteria and sub-criteria be evaluated?

The criteria and sub-criteria are the Enterprise Goals and Alignment Goals, respectively. They are related according to the table of relations provided by ISACA, an example of which is given in Figure 5.1. The alternatives are the Management Objectives, which are related to the sub-criteria based on the relationships between the Alignment Goals and Management Objectives provided by ISACA. It should be noted that this set of relations are only a basis, which can be customised if desired.

The evaluation of the criteria, which is the only part of the process involving human interaction, is done by the user. The criteria and sub-criteria are evaluated using a method created by the authors, where the previously mentioned relationships (Figure 5.2) are converted into numerical values on the Saaty scale.

The evaluations are done based on the relations between the Enterprise Goals and Alignment Goals as defined in COBIT 2019 (Figure 5.2), which are described in Table 7.1. The assessment is done

Table 5.1: Conversion table of relationships to the Saaty scale

First Alignment Goal	Second Alignment Goal	Evaluation First to Second	Evaluation Second to First
“P”	“P”	1	1
“P”	“S”	3	1/3
“P”	””	9	1/9
“S”	“S”	1	1
“S”	””	5	1/5
””	””	1	1

Table 5.2: Comparison between Alignment Goal 04 and Alignment Goal 05

	AG04	**AG05**
AG04	1	1/9
AG05	9	1

by comparing the Alignment Goals against the selected Enterprise Goal. The following example is a simulation of the proposed method: If the user chooses Enterprise Goal 1, the evaluation between Alignment Goal 04 and Alignment Goal 05 is made based on the relations that these two Alignment Goals have with Enterprise Goal 1, and the result is represented in Table 5.2. This matrix is filled in this way because Alignment Goal 05 has a ”P” relationship with Enterprise Goal 1 while Alignment Goal 04 has an ”empty” relationship. This method has been tested to meet consistency levels that the algorithm requires to execute correctly. It is important to note that these matrices can be filled in automatically as soon as the user has chosen the Enterprise Goals.

To fulfil our purposes, it is necessary to determine whether this method can be extended to all other Design Factors. This method can be extended to any existing Design Factor by converting the evaluation parameters into criteria. Taking into consideration Design Factor 1 (Enterprise Strategy), the different parameters (Growth/Acquisition, Innovation/Differentiation, Cost Leadership, Client Service/Stability) are the different criteria. Then, as was done for Enterprise Goals in the previous example, it is only necessary to create a matrix with all the parameters and evaluate them using the Saaty scale (respecting consistency, explained in Theoretical Background Chapter). After that, the organisation has to map the Management Objectives to the criteria.

This reasoning can be applied to any existing or created Design Factors. One of the advantages of this method is that it gives the organisation complete control over the mapping between Management Objectives and criteria and enables any addition or removal of Design Factors. It also makes it possible to test hypotheses and theories of how this map should work, no matter for scientific or business purposes. As mentioned, any parameter can be added or removed without affecting the normal working of the method. When a new parameter is added, it is only necessary to remap the Management Objectives to the new parameter.

In Figure 5.3, the two perspectives to solve the Design Factor 2 problem are presented: using COBIT 2019 (left) and using our method (right).

The following practical example helps to understand the proposed method:

		AG01 I&T compliance and support for business compliance with external laws and regulations	AG02 Managed I&T-related risk	AG03 Realized benefits from I&T-enabled investments and services portfolio	AG04 Quality of technology-related financial information	AG05 Delivery of I&T services in line with business requirements	AG06 Agility to turn business requirements into operational solutions	AG07 Security of information, processing infrastructure and applications, and privacy	AG08 Enabling and supporting business processes by integrating applications and technology	AG09 Delivering programs on time, on budget and meeting requirements and quality standards	AG10 Quality of I&T management information	AG11 I&T compliance with internal policies	AG12 Competent and motivated staff with mutual understanding of technology and business	AG13 Knowledge, expertise and initiatives for business innovation
EDM01	Ensured governance framework setting and maintenance	P	S	P					S			S		
EDM02	Ensured benefits delivery			P		S	S		S					S
EDM03	Ensured risk optimization	S	P					P				S		
EDM04	Ensured resource optimization			S		S	S		S	P			S	
EDM05	Ensured stakeholder engagement				S						P	S		
APO01	Managed I&T management framework	S	S	P		S		S	S	S	S	P		
APO02	Managed strategy			S		S	S		P				S	S
APO03	Managed enterprise architecture			S		S	P	S	P					
APO04	Managed innovation			S			P		S				S	P
APO05	Managed portfolio			P		P	S		S	S				
APO06	Managed budget and costs			S	P					P	S			
APO07	Managed human resources			S		S				S			P	P
APO08	Managed relationships			S		P	P		S	S			P	P
APO09	Managed service agreements					P			S					
APO10	Managed vendors					P	S			S				
APO11	Managed quality			S	S	S				P	P			
APO12	Managed risk		P					P						
APO13	Managed security	S	S					P						
APO14	Managed data	S	S		S			S			P			
BAI01	Managed programs			P			S		S	P				
BAI02	Managed requirements definition			S		P	P		S	P			S	
BAI03	Managed solutions identification and build			S		P	P		S	P				
BAI04	Managed availability and capacity					P		S		S				
BAI05	Managed organizational changes			P		S	S		P	P			S	
BAI06	Managed IT changes		S			S	P		S					
BAI07	Managed IT change acceptance and transitioning		S				P			S				
BAI08	Managed knowledge			S			S		S	S			P	P
BAI09	Managed assets				P						S			
BAI10	Managed configuration					S		P						
BAI11	Managed projects			P		S	P			P				
DSS01	Managed operations					P			S					
DSS02	Managed service requests and incidents		S			P		S						
DSS03	Managed problems		S			P		S						
DSS04	Managed continuity		S			P		P						
DSS05	Managed security services	S	P			S		P				S		
DSS06	Managed business process controls		S			S		S	P			S		
MEA01	Managed performance and conformance monitoring	S		S		P				S	P	S		
MEA02	Managed system of internal control	S	S		S	S		S		S	S	P		
MEA03	Managed compliance with external requirements	P										S		
MEA04	Managed assurance	S	S		S	S		S			S	P		

Figure 5.2: Relation between Alignment Goals and Management Objectives [15] (Appendix A.2)

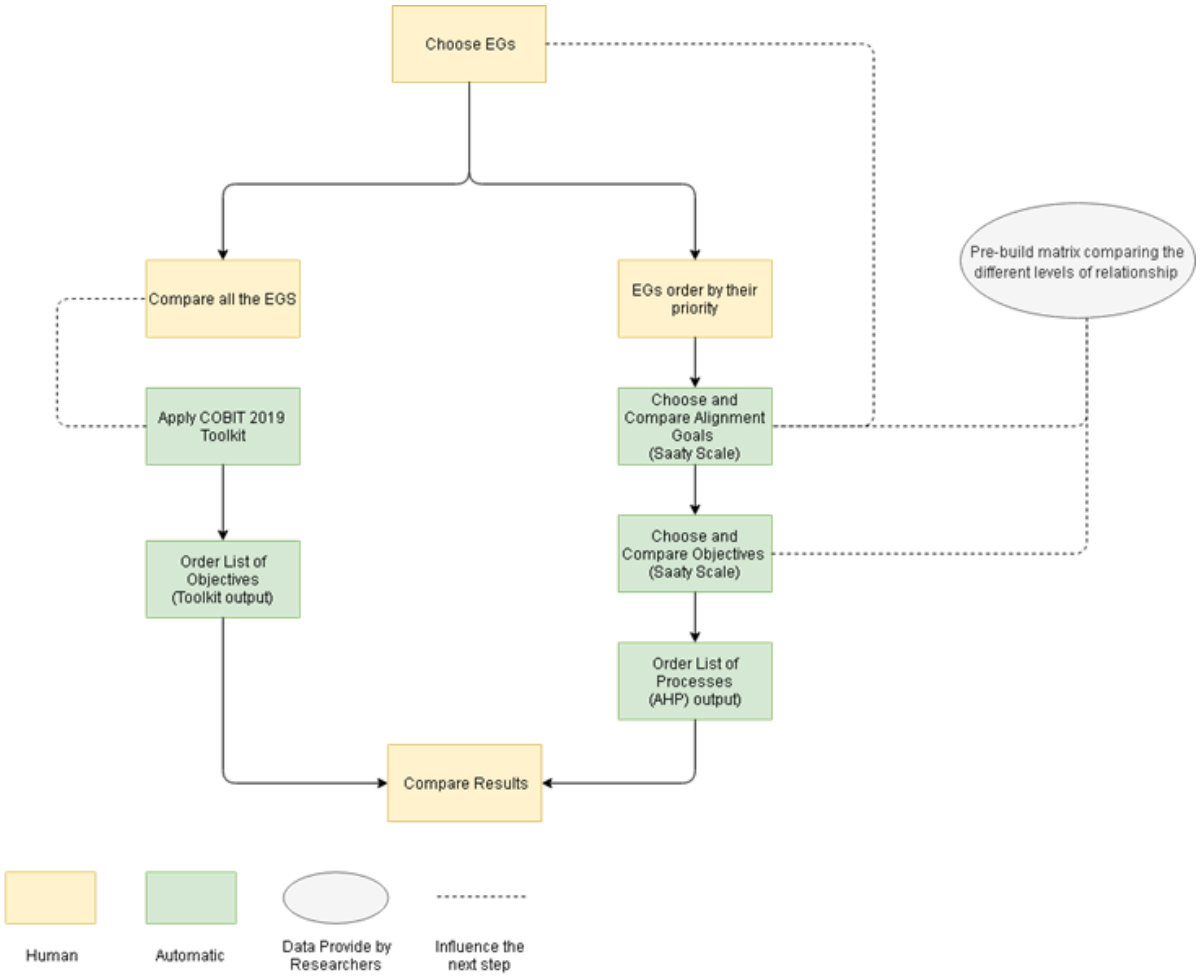


Figure 5.3: Representation of COBIT 2019 method and AHP method

Table 5.3: Comparison between Enterprise Goal 04 and Enterprise Goal 07

	EG04	**EG07**
EG04	1	1
EG07	1	1

Table 5.4: Comparison between Alignment Goal 04 and Alignment Goal 10

	AG04	**AG10**
AG04	1	1
AG10	1	1

5.2.1 Step 1: Stakeholders' Needs Cascade to Enterprise Goals (manual step).

In this step, the stakeholder will choose the Enterprise Goals that translate to the organisation's vision. In this example, the Enterprise Goals chosen are Enterprise Goal 4 and Enterprise Goal 7.

5.2.2 Step 2: Enterprise Goals prioritisation (manual step).

At this point, an evaluation should be made among all the chosen Enterprise Goals using the Saaty scale. In this example, we assume that both Enterprise Goal 4 and Enterprise Goal 7 are equally important. Table 5.3 represents this evaluation.

5.2.3 Step 3: Enterprise Goals Cascade to Alignment Goals (automatic step).

At this stage, the process is automatic, Alignment Goals that do not have a ”P” relationship with any of the previously selected Enterprise Goals are eliminated (Figure 5.1). In this example, the chosen Alignment Goals are Alignment Goal 4 and Alignment Goal 10.

5.2.4 Step 4: Alignment Goals prioritization (automatic step).

As was done in step 2, all Alignment Goals are evaluated among themselves. The assessment is made by taking into account the relationships that each pair of Alignment Goal has with the Enterprise Goal. However, in this step, this evaluation is repeated n times, with n being the number of Enterprise Goals. In the example, there are two Enterprise Goals. Therefore two matrices are created and after step 3, the number of the remaining Alignment Goals is two, so each square matrix has size two. In Figure 5.1, we can see that both Alignment Goals have a ”P” relationship with both Enterprise Goal 4 and Enterprise Goal 7, so the matrices will be equal, as represented in Table 5.4.

5.2.5 Step 5: Alignment Goals Cascade to Management Objectives (automatic step).

At this stage, Management Objectives that do not have a ”P” relationship with any of the previously selected Alignment Goals are eliminated. In this example, the chosen Management Objectives are EDM05, APO06, APO11, APO14 and MEA01.

	EDM05	APO01	MEA01	MEA02	MEA04	APO06	APO11	APO14	BAI09
EDM05	1,0	5,0	5,0	1,0	1,0	0,333	1,0	1,0	0,333
APO01	0,2	1,0	1,0	0,2	0,2	0,111	0,2	0,2	0,111
MEA01	0,2	1,0	1,0	0,2	0,2	0,111	0,2	0,2	0,111
MEA02	1,0	5,0	5,0	1,0	1,0	0,333	1,0	1,0	0,333
MEA04	1,0	5,0	5,0	1,0	1,0	0,333	1,0	1,0	0,333
APO06	3,0	9,0	9,0	3,0	3,0	1,0	3,0	3,0	1,0
APO11	1,0	5,0	5,0	1,0	1,0	0,333	1,0	1,0	0,333
APO14	1,0	5,0	5,0	1,0	1,0	0,333	1,0	1,0	0,333
BAI09	3,0	9,0	9,0	3,0	3,0	1,0	3,0	3,0	1,0

Figure 5.4: Comparison between all the Management Objectives

APO06	0,15330483
BAI09	0,15330483
APO11	0,13447125
APO14	0,13447125
EDM05	0,13447125
MEA01	0,09875233
MEA02	0,07564772
MEA04	0,07564772
APO01	0,03992880
SUM	1,0

Figure 5.5: Result of the example presented

Step 6: Evaluate the Management Objectives (automatic step).

As it was done in step 4, all Management Objectives are evaluated among themselves. The assessment is made by taking into account the relationships that each pair of Management Objective has with the Alignment Goal. The evaluation is repeated n times, with n being the number of Alignment Goals. In the example, there are two Alignment Goals, therefore two matrices are created and after step 5, the number of the remaining Management Objective is five, so each square matrix has size five. In Figure 5.1, we can see that both Alignment Goals have at least an ”S” relationship with both Alignment Goal 4 and Alignment Goal 10, so the matrices will be equal, as represented in Figure 5.4.

5.2.6 Step 7: Run AHP (automatic step).

In this last step, all the data needed to run the algorithm is collected and processed. In this example, the result of the proposed method can be seen in Figure 5.5.

In the previous example, in Step 2, we used values of 1 to simplify the example. However, the user can always choose any value on the Saaty scale if the C.R. is below 10%. We developed a method capable of achieving the requirements that we established.

Chapter 6

Demonstration

This chapter links to the DSRM demonstration phase and demonstrates how the research proposal can be used to solve the research problem described in Section 1.1. To demonstrate that the proposal can be used to solve the research problem, we conducted an example of the COBIT 2019 Goals Cascade run. To do that, a prototype that is able to run the COBIT 2019 Goals Cascade and the AHP method was developed. It is important to note that all the translations are based on the translation maps provided by ISACA [11]:

1. Stakeholders' Needs Cascade to Enterprise Goals
2. Enterprise Goals prioritisation
3. Enterprise Goals Cascade to Alignment Goals
4. Alignment Goals prioritisation
5. Alignment Goals Cascade to Management Objectives
6. Management Objectives prioritisation
7. Run AHP

To run the seventh step (Run AHP), a software was developed and is available at the following link: `https://drive.google.com/open?id=14E3X2cw2DPSyAg0WsQN9W5PIG4Ce2U6U`

We will exemplify a possible scenario, following the steps of the method developed in this thesis algorithm:

6.1 Step 1: Stakeholders' Needs Cascade to Enterprise Goals.

To demonstrate the proposal, the following two stakeholders' needs were chosen to run the goals cascade: "How do I get Assurance over IT?" and "Does IT support the enterprise in complying with regulations and service levels?". These needs were translated into Enterprise Goal "Compliance with External Laws and Regulations" and "Compliance with Internal Policies", exemplified in Figure 6.1.

EG01	EG02	EG03	EG04	EG05	EG06	EG07	EG08	EG09	EG10	EG11	EG12	EG13
Portfolio of competitive products and services	Managed business risk	Compliance with external laws and regulations	Quality of financial information	Customer-oriented service culture	Business service continuity and availability	Quality of management information	Optimization of internal business process functionality	Optimization of business process costs	Staff skills, motivation and productivity	Compliance with internal policies	Managed digital transformation programs	Product and business innovation

Figure 6.1: List of Enterprise Goals

	EG03	EG11
EG03	1	1
EG11	1	1

Figure 6.2: Comparison of Enterprise Goals

6.2 Step 2: Enterprise Goals prioritisation.

In this step, we compare the Enterprise Goal using the Saaty table mentioned before. In this example, both EGs have the same importance for the stakeholders, represented in Figure 6.2.

6.3 Step 3. Enterprise Goals Cascade to Alignment Goals.

The chosen Enterprise Goals (Enterprise Goal 3 and Enterprise Goal 11) originated the following list of Alignment Goals: Alignment Goal 1 ”I&T compliance and support for business compliance with external laws and regulations” and Alignment Goal 11 ”I&T compliance with internal policies”. All the Alignment Goals that do not have a ”P” relationship with any of the previously selected Enterprise Goals are eliminated, as demonstrated on Figure 6.3, where the selected Alignment Goals are highlighted with red colour.

6.4 Step 4: Alignment Goals prioritisation.

In this step, an automatic comparison is made, based on the rationale explained in the proposal, all Alignment Goals are evaluated among themselves. The assessment is made taking into account the relationship that each pair of Alignment Goal has with the Enterprise Goal.

6.5 Step5: Alignment Goals Cascade to Management Objectives.

The chosen Alignment Goals (Alignment Goal 1 and Alignment Goal 11) originated the following list of Management Objectives: EDM01, EDM03, EDM05, APO01, APO13, APO14, DSS05, DSS06, MEA01, MEA02, MEA03 and MEA04. This list is generated by deleting all the Management Objectives that do not have a relation with any Alignment Goal, as demonstrated on Figure 6.4, where the selected Management Objectives are highlighted with red colour.

		EG01	EG02	EG03	EG04	EG05	EG06	EG07	EG08	EG09	EG10	EG11	EG12	EG13
		Portfolio of competitive products and services	Managed business risk	Compliance with external laws and regulations	Quality of financial information	Customer-oriented service culture	Business service continuity and availability	Quality of management information	Optimization of internal business process functionality	Optimization of business process costs	Staff skills, motivation and productivity	Compliance with internal policies	Managed digital transformation programs	Product and business innovation
AG01	I&T compliance and support for business compliance with external laws and regulations		S	P								S		
AG02	Managed I&T-related risk		P				S							
AG03	Realized benefits from I&T-enabled investments and services portfolio	S				S			S	S			P	
AG04	Quality of technology-related financial information				P			P		P				
AG05	Delivery of I&T services in line with business requirements	P				S	S		S				S	
AG06	Agility to turn business requirements into operational solutions	P				S			S				S	S
AG07	Security of information, processing infrastructure and applications, and privacy		P				P							
AG08	Enabling and supporting business processes by integrating applications and technology	P				P			S		S		P	S
AG09	Delivering programs on time, on budget and meeting requirements and quality standards	P				S			S	S			P	S
AG10	Quality of I&T management information				P			P		S				
AG11	I&T compliance with internal policies		S	P								P		
AG12	Competent and motivated staff with mutual understanding of technology and business					S					P			
AG13	Knowledge, expertise and initiatives for business innovation	P		S									S	P

Figure 6.3: Mapping Table between Enterprise Goals and Alignment Goals

6.6 Step 6: Comparison of Processes

In this step, an automatic comparison is made, based on the rationale explained in the proposal. All Management Objectives are evaluated among themselves. The assessment is made taking into account the relationship that each pair of Management Objective has with the Alignment Goal. Figure 6.5 gives the comparison result between all the Management Objectives based on Alignment Goal 11. Figure 6.6, represents the other quadratic matrix. This matrix gives the comparison result between all the Management Objectives based on Alignment Goal 1.

6.7 Step 7: Run AHP

After these steps, we could obtain the results by running the AHP. We have performed a run on the given an example, and the results are displayed in the Figure 6.7.

6.8 Summary

As we can see, the demonstration includes a software prototype capable of simulating the rationale of the proposal, producing a list of Management Objectives, as can be seen in the Figure 6.7. It should be noted that, as mentioned above, the prototype was only developed for this specific problem. However, the authors reiterate the possibility of extending this reasoning to each of the existing Design Factors.

		AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
		I&T compliance and support for business compliance with external laws and regulations	Managed I&T-related risk	Realized benefits from I&T-enabled investments and services portfolio	Quality of technology-related financial information	Delivery of I&T services in line with business requirements	Agility to turn business requirements into operational solutions	Security of information, processing infrastructure and applications, and privacy	Enabling and supporting business processes by integrating applications and technology	Delivering programs on time, on budget and meeting requirements and quality standards	Quality of I&T management information	I&T compliance with internal policies	Competent and motivated staff with mutual understanding of technology and business	Knowledge, expertise and initiatives for business innovation
EDM01	Ensured governance framework setting and maintenance	P	S	P					S			S		
EDM02	Ensured benefits delivery			P		S	S		S					S
EDM03	Ensured risk optimization	S	P					P				S		
EDM04	Ensured resource optimization			S		S	S		S	P			S	
EDM05	Ensured stakeholder engagement				S						P	S		
APO01	Managed I&T management framework	S	S	P		S		S	S	S	S	P		
APO02	Managed strategy			S		S	S		P				S	S
APO03	Managed enterprise architecture			S		S	P	S	P					
APO04	Managed innovation			S			P		S				S	P
APO05	Managed portfolio			P		P	S		S	S				
APO06	Managed budget and costs			S	P					P	S			
APO07	Managed human resources			S		S				S			P	P
APO08	Managed relationships			S		P	P		S	S			P	P
APO09	Managed service agreements					P			S					
APO10	Managed vendors					P	S			S				
APO11	Managed quality			S	S	S				P	P			
APO12	Managed risk		P					P						
APO13	Managed security	S	S					P						
APO14	Managed data	S	S		S			S			P			
BAI01	Managed programs			P			S		S	P				
BAI02	Managed requirements definition			S		P	P		S	P			S	
BAI03	Managed solutions identification and build			S		P	P		S	P				
BAI04	Managed availability and capacity					P		S		S				
BAI05	Managed organizational changes			P		S	S		P	P			S	
BAI06	Managed IT changes		S			S	P		S					
BAI07	Managed IT change acceptance and transitioning		S				P			S				
BAI08	Managed knowledge			S			S		S	S			P	P
BAI09	Managed assets				P						S			
BAI10	Managed configuration					S		P						
BAI11	Managed projects			P		S	P			P				
DSS01	Managed operations					P			S					
DSS02	Managed service requests and incidents		S			P		S						
DSS03	Managed problems		S			P		S						
DSS04	Managed continuity		S			P		P						
DSS05	Managed security services	S	P			S		P				S		
DSS06	Managed business process controls		S			S		S	P			S		
MEA01	Managed performance and conformance monitoring	S		S		P				S	P	S		
MEA02	Managed system of internal control	S	S		S	S		S		S	S	P		
MEA03	Managed compliance with external requirements	P										S		
MEA04	Managed assurance	S	S		S	S		S			S	P		

Figure 6.4: Mapping Table between Alignment Goals and Management Objectives [15] (Appendix A.3)

	EDM01	EDM03	DSS05	MEA01	APO01	MEA02	MEA03	MEA04	EDM05	MEA01	APO13	APO14
EDM01	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
EDM03	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
DSS05	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
MEA01	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
APO01	3,0	3,0	3,0	3,0	1,0	1,0	3,0	1,0	3,0	3,0	9,0	9,0
MEA02	3,0	3,0	3,0	3,0	1,0	1,0	3,0	1,0	3,0	3,0	9,0	9,0
MEA03	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
MEA04	3,0	3,0	3,0	3,0	1,0	1,0	3,0	1,0	3,0	3,0	9,0	9,0
EDM05	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
MEA01	1,0	1,0	1,0	1,0	0,333	0,333	1,0	0,333	1,0	1,0	5,0	5,0
APO13	0,2	0,2	0,2	0,2	0,111	0,111	0,2	0,111	0,2	0,2	1,0	1,0
APO14	0,2	0,2	0,2	0,2	0,111	0,111	0,2	0,111	0,2	0,2	1,0	1,0

Figure 6.5: Comparison of Management Objectives (AG11)

	EDM01	EDM03	DSS05	MEA01	APO01	MEA02	MEA03	MEA04	EDM05	MEA01	APO13	APO14
EDM01	1,0	3,0	3,0	3,0	3,0	3,0	1,0	3,0	9,0	9,0	3,0	3,0
EDM03	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
DSS05	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
MEA01	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
APO01	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
MEA02	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
MEA03	1,0	3,0	3,0	3,0	3,0	3,0	1,0	3,0	9,0	9,0	3,0	3,0
MEA04	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
EDM05	0,111	0,2	0,2	0,2	0,2	0,2	0,111	0,2	1,0	1,0	0,2	0,2
MEA01	0,111	0,2	0,2	0,2	0,2	0,2	0,111	0,2	1,0	1,0	0,2	0,2
APO13	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0
APO14	0,333	1,0	1,0	1,0	1,0	1,0	0,333	1,0	5,0	5,0	1,0	1,0

Figure 6.6: Comparison of Management Objectives (AG01)

MEA03	0,1307848685
EDM01	0,1307848685
APO01	0,1233468193
MEA02	0,1233468193
MEA04	0,1233468193
EDM03	0,06756938029
DSS05	0,06756938029
MEA01	0,06756938029
APO13	0,04313340468
APO14	0,04313340468
EDM05	0,03970742742
MEA01	0,03970742742
SUM	1

Figure 6.7: Results of the practical example

Chapter 7

Evaluation

Part of the evaluation of the results of this research was carried out with the aid of specialists. To this end, two rounds of interviews were conducted with managers linked to the EGIT field. The objective of the first round was to collect information on the profile of the interviewee, present the toolkit of COBIT 2019, and introduce the concepts of AHP. In the second round of interviews, some candidates were eliminated from the process. This round aimed to evaluate the quality of our proposed method by creating a scenario in which the interviewee has to perform the Design Factor 2 (Goals Cascade) manually and simulate the same choices using both the COBIT 2019 toolkit and our proposal. In the end, the two results were presented to the interviewee without identifying the methods behind them. Then a discussion was conducted to analyse the results of the algorithms against the Management Objectives chosen by the expert.

7.1 First round of interviews

Twenty (20) IT managers and COBIT specialists from different backgrounds were invited via email and LinkedIn. Among these, only fourteen (14) were willing to participate in this research for a semi-structured interview. All candidates were classified according to the scale present below:

1. Fundamental Awareness (basic knowledge)
2. Novice (limited experience)
3. Intermediate (pratical applicattion)
4. Advanced (applied theory)
5. Expert (recognized authority)

In order to be classified as Level 5 (Expert), an interviewee must hold a certification of COBIT 2019 or COBIT 5. For Level 4 (Advanced), a manager should have already worked with COBIT and have a certification in any EGIT framework. Level 3 (Intermediate) represents someone who has worked with COBIT but does not have a solid basis of understanding about it. We consider anyone who has worked

Table 7.1: Comparison between Alignment Goal 04 and Alignment Goal 10

Country	Experience	COBIT Certification	Level	Other Certifications
Portugal	5-10 years	No	4	ISO/IEC 20000; PMP
Brazil	+ 30 years	Yes	5	SAS member; PMI-RMP; ITIL
Portugal	20-30 years	No	4	ISO/IEC 90001:2008; CISA; ITIL
Portugal	5-10 years	Yes	5	ITIL/Bridge
Portugal	5-10 years	No	4	CISA

with any framework in the area of EGIT, other than COBIT, at Level 2 (Novice). Finally, a person who holds a management position in the field of EGIT but has no experience with any framework is classified as Level 1 (Fundamental Awareness).

After conducting the first round of interviews and ranking our interviewees, only managers with Levels 4 and 5 are suitable to proceed to the next round of interviews. The profiles of these experts are shown in Table 7.1.

7.2 Second round of interviews

In the second round, we proceeded with semi-structured interviews. All interviews were conducted in the following steps:

1. **Review:** During this phase, a review of the concepts and summary of the first interview was made.

2. **Choice of Enterprise Goals:** At this stage, the interaction with the interviewee was made as follows: ”Of all the Enterprise Goals, you should choose the ones that you consider most important, and the number of chosen Enterprise Goals should be between three and five. You can imagine a scenario for a company if it makes it easier for you to choose”.

3. **Prioritisation of Enterprise Goals:** At this point, the interviewee would have to prioritise the Enterprise Goals using the Saaty scale and then using the COBIT 2019 toolkit. It should be noted that during this process, the interviewee did not have access to any results.

4. **Choice of Management Objectives:** During this phase, the interviewee was challenged to choose five Management Objectives that he considered crucial to achieving the previously selected Enterprise Goals. It should be noted that some managers showed difficulty in reducing his choices down to five Management Objectives. Thus, they were asked to make the best reduction possible instead.

5. **Discussion of the results:** During this phase, the COBIT 2019 and AHP algorithms were executed to obtaining two lists of prioritised Management Objectives. However, the expert did not have access to these results. A file with three columns was then prepared, as shown in Figure 7.1. The first one was well identified, and it was the column that contained the processes chosen by the interviewee. The second and third columns contained the result of the COBIT 2019 method and AHP, respectively. It should be noted that the fact that the expert was unable to identify the column

Interviewee	Algoritmo X	Algoritmo Y
EDM01—Ensured Governance Framework Setting & Maintenance	APO12—Managed Risk	APO02—Managed Strategy
APO03—Managed Enterprise Architecture	APO13—Managed Security	APO08—Managed Relationships
APO04—Managed Innovation	MEA03—Managed Compliance with External Requirements	APO04—Managed Innovation
MEA01—Managed Performance and Conformance Monitoring	EDM03—Ensured Risk Optimization	DSS06—Managed Business Process Controls
APO08—Managed Relationships	DSS05—Managed Security Services	APO07—Managed Human Resources

Figure 7.1: List of the interviewee and the two list produced by the proposed method and COBIT 2019 method

of each method was deliberately made to avoid a biased opinion, thereby obtaining a completely impartial discussion. It should be noted that all the interviews in the second round were recorded (with the permission of the interviewees) for analysis of the results and the considerations made by the experts.

7.3 Analysis of interviews

A summary of each interview is present below (all discussions were made using fictitious names for the COBIT and AHP methods):

1. In the first interview, after analysing the results as demonstrated in Figure 7.2, the expert criticised the fact hat both algorithms do not suggest the Management Objective EMD02 in their list. He stated that the proposed method in this research had more similarities with his vision. He also stated that the suggestions of both algorithms were coherent and that all the Management Objectives presented were consistent with the chosen Enterprise Goals. When he was asked to choose between the two methods, the choice fell on the AHP method.

2. In the following discussion, the AHP method showed again higher similarity with the expert's view, while the COBIT method had no process in common with the choices of the interviewee. He stated that all the Management Objectives chosen by the AHP were consistent with the Enterprise Goals chosen and that for this reason, he considered that method more coherent than the one proposed by COBIT 2019. The specialist also criticised the scale presented in the COBIT toolkit, stating that it makes the process of choice difficult with such a short scale. In Figure 7.3 all the Management

	COBIT2019	AHP
EDM02—Ensured Benefits Delivery	EDM05—Ensured Stakeholder Engagement	BAI09—Managed Assets
EDM04—Ensured Resource Optimization	BAI09—Managed Assets	APO06—Managed Budget & Costs
APO06—Managed Budget & Costs	APO14—Managed Data	APO14—Managed Data
APO11—Managed Quality	APO02—Managed Strategy	APO11—Managed Quality
APO14—Managed Data	APO03—Managed Enterprise Architecture	EDM05—Ensured Stakeholder Engagement

EG04—Quality of financial information
EG05—Customer-oriented service culture
EG07—Quality of management information

Figure 7.2: Summary of the first interview

Interviewee	Algoritmo X	Algoritmo Y
EDM01—Ensured Governance Framework Setting & Maintenance	APO12—Managed Risk	APO02—Managed Strategy
APO03—Managed Enterprise Architecture	APO13—Managed Security	APO08—Managed Relationships
APO04—Managed Innovation	MEA03—Managed Compliance with External Requirements	APO04—Managed Innovation
MEA01—Managed Performance and Conformance Monitoring	EDM03—Ensured Risk Optimization	DSS06—Managed Business Process Controls
APO08—Managed Relationships	DSS05—Managed Security Services	APO07—Managed Human Resources

EG03—Compliance with external laws and regulations
EG05—Customer-oriented service culture
EG13—Product and business innovation

Figure 7.3: Summary of the second interview

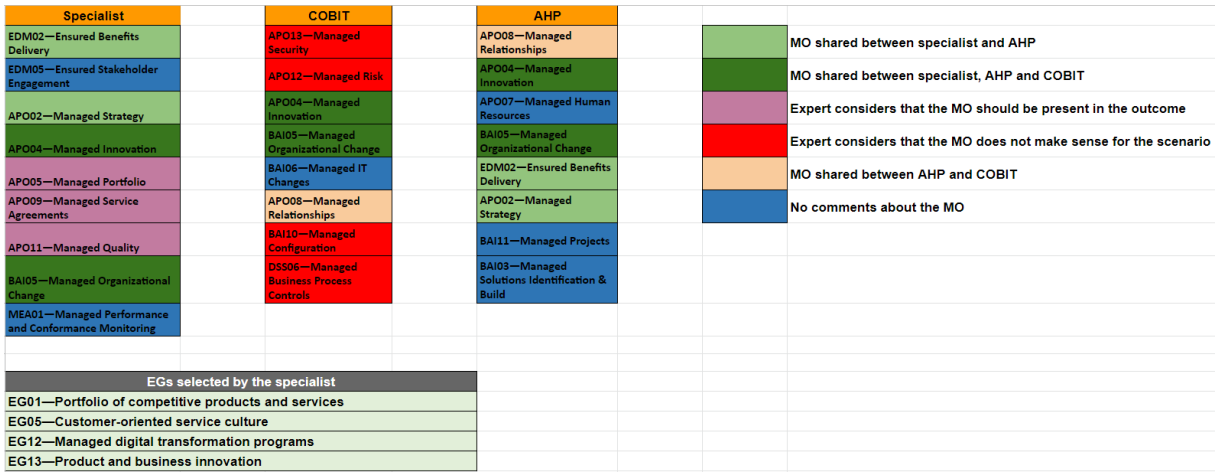


Figure 7.4: Summary of third interview (Appendix A.4)

Objectives selected are shown.

3. In this third interview, when analysing the COBIT method, the specialist criticised the fact that Management Objectives APO13, APO12, BAI10 and DSS06 were suggested by the method. In his analysis of the AHP method, he stated that all the suggested Management Objectives were important. Finally, he stated that he expected the Management Objectives APO05, APO09 and APO11 to be suggested. In Figure 7.4 we can see in detail the Management Objectives chosen and what the expert referred to during the assessment.

4. In the fourth interview, the specialist criticised the choice of all the processes suggested by the AHP. As for the COBIT method, the interviewee stated that he agreed with three and disagreed with the other two. It should be pointed out that the specialist left critics to both methods, mainly to the AHP method. In Figure 7.5 we can see in detail the Management Objectives chosen.

5. In the last interview, after analysing the similarities between the three tables, the specialist argues that all the Management Objectives suggested by the AHP method are coherent. On the other hand, although he believes that the set of Management Objectives suggested by COBIT to be corrected, states that, given the Enterprise Goals chosen, he believes that the suggestion made by the AHP method is superior. In the end, he praised both methods but ended up preferring the AHP method. In Figure 7.6 we can see in detail the Management Objectives selected.

7.4 Evaluation of requirements

In the Proposal Section, the following requirements were proposed:

- **Universality:** The method should be applicable to all Design Factors
- **Customisable Criteria:** The method should allow the organisation to determine the weight of each of the criteria.

	COBIT 2019	AHP
EDM03—Ensured Risk Optimization	EDM03—Ensured Risk Optimization	APO08—Managed Relationships
EDM04—Ensured Resource Optimization	APO12—Managed Risk	APO04—Managed Innovation
APO06—Managed Budget & Costs	APO13—Managed Security	MEA02—Managed System of Internal Control
APO12—Managed Risk	MEA03—Managed Compliance with External Requirements	BAI03—Managed Solutions Identification & Build
BAI09—Managed Assets	DSS05—Managed Security Services	BAI02—Managed Requirements Definition

EG01—Portfolio of competitive products and services
EG02—Managed business risk
EG03—Compliance with external laws and regulations
EG09—Optimization of business process costs

Figure 7.5: Summary of fourth interview

	COBIT	AHP
EDM02—Ensured Benefits Delivery	APO02—Managed Strategy	APO08—Managed Relationships
EDM04—Ensured Resource Optimization	APO04—Managed Innovation	APO04—Managed Innovation
APO02—Managed Strategy	APO08—Managed Relationships	APO07—Managed Human Resources
APO04—Managed Innovation	APO09—Managed Service Agreements	BAI05—Managed Organizational Change
APO05—Managed Portfolio	BAI08—Managed Knowledge	EDM02—Ensured Benefits Delivery
APO14—Managed Data	DSS01—Managed Operations	APO02—Managed Strategy

EG01—Portfolio of competitive products and services
EG05—Customer-oriented service culture
EG12—Managed digital transformation programs
EG13—Product and business innovation

Figure 7.6: Summary of fifth interview

DF1	Growth/Acquisition	Innovation/Differentiation	Cost Leadership	ClientService/Stability
EDM01	1.0	1.0	1.5	1.5
EDM02	1.5	1.0	2.0	3.5
EDM03	1.0	1.0	1.0	2.0
EDM04	1.5	1.0	4.0	1.0
EDM05	1.5	1.5	1.0	2.0
APO01	1.0	1.0	1.0	1.0
APO02	3.5	3.5	1.5	1.0
APO03	4.0	2.0	1.0	1.0
APO04	1.0	4.0	1.0	1.0
APO05	3.5	4.0	2.5	1.0
APO06	1.5	1.0	4.0	1.0
APO07	2.0	1.0	1.0	1.0
APO08	1.0	1.5	1.0	3.5
APO09	1.0	1.0	1.5	4.0
APO10	1.0	1.0	3.5	1.5
APO11	1.0	1.0	1.0	4.0
APO12	1.0	1.5	1.0	2.5
APO13	1.0	1.0	1.0	2.5
APO14	1.0	1.0	1.0	1.0
BAI01	4.0	2.0	1.5	1.5
BAI02	1.0	1.0	1.5	1.0
BAI03	1.0	1.0	1.5	1.0
BAI04	1.0	1.0	1.0	3.0
BAI05	4.0	2.0	1.0	1.5
BAI06	2.0	2.0	1.0	1.5
BAI07	1.5	2.0	1.0	1.5
BAI08	1.0	3.5	1.0	1.0
BAI09	1.0	1.0	1.0	1.0

Figure 7.7: Mapping between Management Objectives and Design Factor 1 criteria

- **Flexibility:** The method should allow the addition or removal of criteria as intended by the organisation

- **Automatic:** Part of the process should be completely automated. The level of automation should be similar to that presented by the COBIT 2019 Toolkit.

Universality: In order to assess universality, it is necessary to realise that AHP can be used in several areas. In this case, it is only necessary to map the criteria and subcriteria with the different alternatives (Management Objectives). Using Design Factor 1 as an example, the COBIT 2019 already provides a mapping between the Management Objectives and the different criteria (Figure 7.7). To apply the AHP, it is only necessary to convert this table (Figure 7.7) into Saaty values, respecting consistency ratio, as it was done in Design Factor 2 (explained in Proposal Section).

Customisable: To determine if the method in question is customisable, let us take Design Factor 2 as an example. To add or remove any relationship, it is only required to change the existing relationship table, and the algorithm will automatically incorporate these changes the next time it is executed. Each relationship has a weight assigned by the authors, which can also be modified.

Flexibility: This method allows to add and remove criteria, subcriteria or alternative. Let us take Design Factor 2 as an example. To add a new Enterprise Goal is necessary to add it to the table with the relationships (Figure 5.2) and the algorithm will automatically take that new Enterprise Goal into account. The same applies to the Alignment Goals and Management Objectives. To remove any Enterprise Goal, Alignment Objective or Management Objective, delete this link from the corresponding table.

Automatic: This method needs a single interaction with the user: prioritise the criteria (in the case

of Design Factor 2, to prioritise the Enterprise Goals). The whole other process is automatic.

Chapter 8

Conclusion

The selection and prioritisation of management objectives are a critical feature in COBIT 2019 that tries to address some concerns raised regarding the Goals Cascade mechanism. However, this method does not conform to the statement by ISACA that EGIT systems should be tailored to the enterprise, thus posing a limitation to this framework. A method that allows the framework to adapt to each organisation should be provided, rather than one that uses a fixed set of closed method and parameters.

8.1 Achievements

In this research, we propose a method that allows organisations to select and prioritise Management Objectives using the Design Factors. In this method, users are given the flexibility to customise these Design Factors, as well as their parameters, according to their own judgements and needs, which is not possible with the current COBIT 2019 method. The results of our evaluation also allow us to assert that our method had better outcomes compared to the ones produced by the COBIT 2019 method. In summary, the method developed in this research allows organisations the autonomy to adapt the framework to their own context while producing better results than the one presented by ISACA. We conclude by highlighting the fact that every requirement we proposed was fulfilled: the method gives a prioritise method of Management Objectives, and is universal customisable, flexible and automatic.

Apart from providing an alternative method to this framework, this study also offers valuable insights into the choices of domain experts in different scenarios. It also demonstrates that there are no one-size-fits-all answers or algorithms to tackle this problem due to the complex differences between organisations and that the experience and knowledge of experts play a crucial role in understanding the context of an organisation and making an optimal judgment. Last but not least, this study also provides a means to verify if the relationships between the Enterprise, Alignment and Management Objectives are correct, thus providing new approaches to analyse this data.

8.2 Limitations

Despite the positive results obtained from the demonstration of this study, more empirical work is required to reveal more patterns in the experts' decision process that can, among other benefits, provide a better mapping from the relationships to the numerical Saaty scale values. This can be achieved through more interviews with experts or, instead of what has been done in this research, having each expert conducting more than one scenario per interview. Another limitation we would also like to highlight is human subjectivity, where under the same scenario experts can choose different solutions or even, the same expert can give different solutions to the same scenario if asked in different occasions. A further limitation is the fact that the specialists chosen are mainly from Portugal; greater geographical diversification is advisable. Apart from that, due to the recent publication of COBIT2019, there is a lack of literature related to this version of COBIT, which poses a limitation on our research process and also on the amount of support from prior works on our analyses. On the bright side, this also allows our work to be one of the pioneers in this field.

8.3 Future Work

Due to the limitations of AHP, we intend to test other approaches in our future work, such as Fuzzy AHP and the addition and/or removal of Design Factors that are not represented in the current version of COBIT 2019. We would also like to try techniques from data science, recommender systems and machine learning. These techniques have the potential to discover new patterns and connections that can increase the performance of the method. However, the implementation of such techniques would require a much larger quantity of data, which is the reason why we did not proceed with them.

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Appendix A

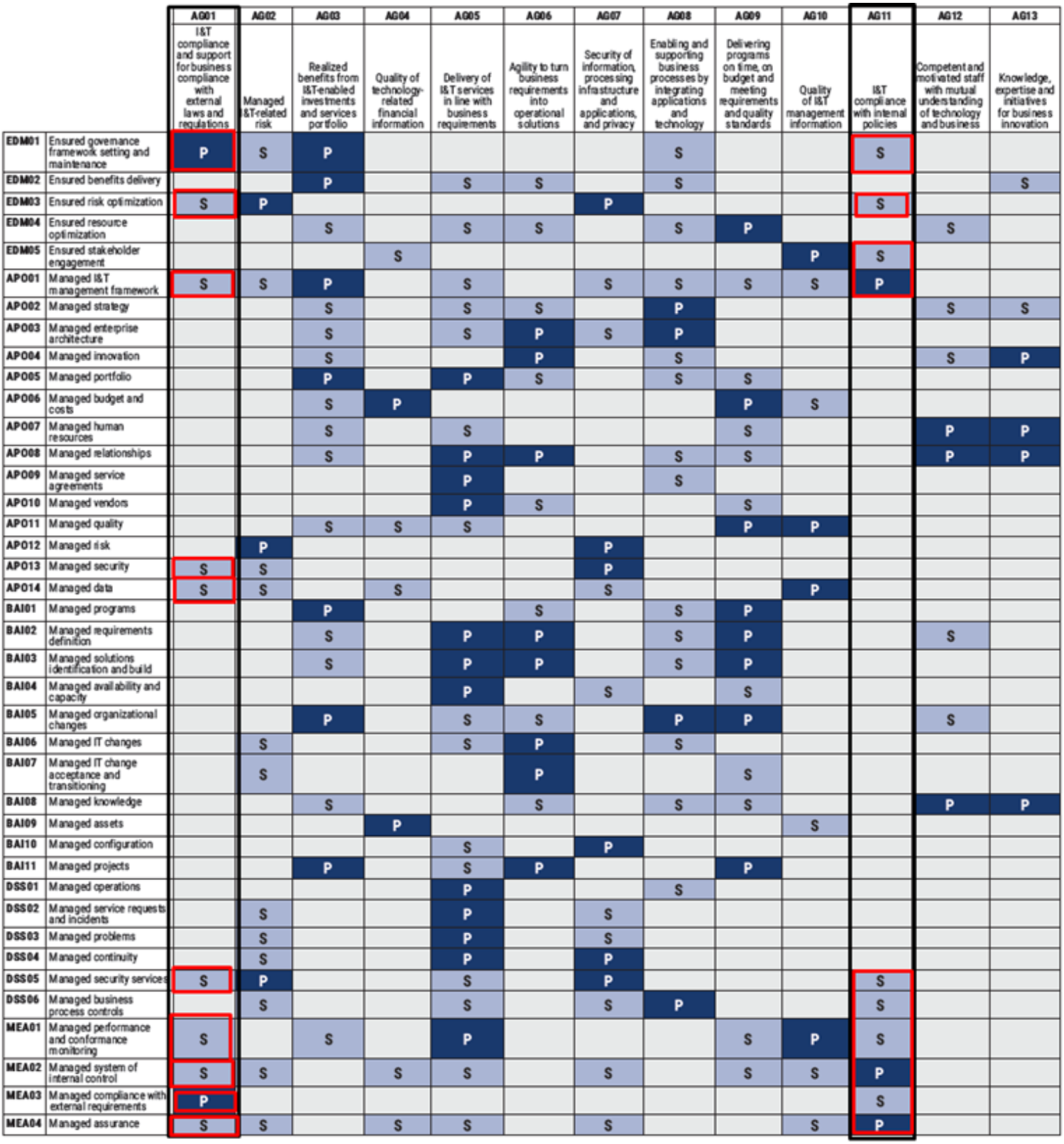
Figures

			Enterprise Goal																
			Stakeholder value of business investments	Portfolio of competitive products and services	Managed business risk (safeguarding of assets)	Compliance with external laws and regulations	Financial transparency	Customer-oriented service culture	Business service continuity and availability	Agile responses to a changing business environment	Information-based strategic decision making	Optimisation of service delivery costs	Optimisation of business process functionality	Optimisation of business process costs	Managed business change programmes	Operational and staff productivity	Compliance with internal policies	Skilled and motivated people	Product and business innovation culture
			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
		IT-related Goal	Financial					Customer					Internal					Learning and Growth	
Financial	01	Alignment of IT and business strategy	P	P	S			P	S	P	P	S	P	S	P			S	S
	02	IT compliance and support for business compliance with external laws and regulations			S	P											P		
	03	Commitment of executive management for making IT-related decisions	P	S	S					S	S		S		P			S	S
	04	Managed IT-related business risk			P	S			P	S		P			S		S	S	
	05	Realised benefits from IT-enabled investments and services portfolio	P	P				S		S		S	S	P		S			S
	06	Transparency of IT costs, benefits and risk	S		S		P				S	P		P					
Customer	07	Delivery of IT services in line with business requirements	P	P	S	S		P	S	P	S		P	S	S			S	S
	08	Adequate use of applications, information and technology solutions	S	S	S			S	S		S	S	P	S		P		S	S
Internal	09	IT agility	S	P	S			S		P			P		S	S		S	P
	10	Security of information, processing infrastructure and applications			P	P			P								P		
	11	Optimisation of IT assets, resources and capabilities	P	S						S		P	S	P	S	S			S
	12	Enablement and support of business processes by integrating applications and technology into business processes	S	P	S			S		S		S	P	S	S	S			S
	13	Delivery of programmes delivering benefits, on time, on budget, and meeting requirements and quality standards	P	S	S			S				S		S	P				
	14	Availability of reliable and useful information for decision making	S	S	S	S			P		P		S						
	15	IT compliance with internal policies			S	S											P		
Learning and Growth	16	Competent and motivated business and IT personnel	S	S	P			S		S						P		P	S
	17	Knowledge, expertise and initiatives for business innovation	S	P				S		P	S		S		S			S	P

Figure A.1: Relation between Enterprise Goals and IT-Related Goals [11]

		AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
		I&T compliance and support for business compliance with external laws and regulations	Managed I&T-related risk	Realized benefits from I&T-enabled investments and services portfolio	Quality of technology-related financial information	Delivery of I&T services in line with business requirements	Agility to turn business requirements into operational solutions	Security of information, processing infrastructure and applications, and privacy	Enabling and supporting business processes by integrating applications and technology	Delivering programs on time, on budget and meeting requirements and quality standards	Quality of I&T management information	I&T compliance with internal policies	Competent and motivated staff with mutual understanding of technology and business	Knowledge, expertise and initiatives for business innovation
EDM01	Ensured governance framework setting and maintenance	P	S	P					S			S		
EDM02	Ensured benefits delivery			P		S	S		S					S
EDM03	Ensured risk optimization	S	P					P				S		
EDM04	Ensured resource optimization			S		S	S		S	P			S	
EDM05	Ensured stakeholder engagement				S						P	S		
APO01	Managed I&T management framework	S	S	P		S		S	S	S	S	P		
APO02	Managed strategy			S		S	S		P				S	S
APO03	Managed enterprise architecture			S		S	P	S	P					
APO04	Managed innovation			S			P		S				S	P
APO05	Managed portfolio			P		P	S		S	S				
APO06	Managed budget and costs			S	P					P	S			
APO07	Managed human resources			S		S				S			P	P
APO08	Managed relationships			S		P	P		S	S			P	P
APO09	Managed service agreements					P			S					
APO10	Managed vendors					P	S			S				
APO11	Managed quality			S	S	S				P	P			
APO12	Managed risk		P					P						
APO13	Managed security	S	S					P						
APO14	Managed data	S	S		S			S			P			
BAI01	Managed programs			P			S		S	P				
BAI02	Managed requirements definition			S		P	P		S	P			S	
BAI03	Managed solutions identification and build			S		P	P		S	P				
BAI04	Managed availability and capacity					P		S		S				
BAI05	Managed organizational changes			P		S	S		P	P			S	
BAI06	Managed IT changes		S			S	P		S					
BAI07	Managed IT change acceptance and transitioning		S				P			S				
BAI08	Managed knowledge			S			S		S	S			P	P
BAI09	Managed assets				P						S			
BAI10	Managed configuration					S		P						
BAI11	Managed projects			P		S	P			P				
DSS01	Managed operations					P			S					
DSS02	Managed service requests and incidents		S			P		S						
DSS03	Managed problems		S			P		S						
DSS04	Managed continuity		S			P		P						
DSS05	Managed security services	S	P			S		P				S		
DSS06	Managed business process controls		S			S		S	P			S		
MEA01	Managed performance and conformance monitoring	S		S		P				S	P	S		
MEA02	Managed system of internal control	S	S		S	S		S		S	S	P		
MEA03	Managed compliance with external requirements	P										S		
MEA04	Managed assurance	S	S		S	S		S			S	P		

Figure A.2: Relation between Alignment Goals and Management Objectives [15]



		AG01	AG02	AG03	AG04	AG05	AG06	AG07	AG08	AG09	AG10	AG11	AG12	AG13
		I&T compliance and support for business compliance with external laws and regulations	Managed I&T-related risk	Realized benefits from I&T-enabled investments and services portfolio	Quality of technology-related financial information	Delivery of I&T services in line with business requirements	Agility to turn business requirements into operational solutions	Security of information, processing infrastructure and applications, and privacy	Enabling and supporting business processes by integrating applications and technology	Delivering programs on time, on budget and meeting requirements and quality standards	Quality of I&T management information	I&T compliance with internal policies	Competent and motivated staff with mutual understanding of technology and business	Knowledge, expertise and initiatives for business innovation
EDM01	Ensured governance framework setting and maintenance	P	S	P					S			S		
EDM02	Ensured benefits delivery			P		S	S		S					S
EDM03	Ensured risk optimization	S	P					P				S		
EDM04	Ensured resource optimization			S		S	S		S	P			S	
EDM05	Ensured stakeholder engagement				S						P	S		
APO01	Managed I&T management framework	S	S	P		S		S	S	S	S	P		
APO02	Managed strategy			S		S	S		P				S	S
APO03	Managed enterprise architecture			S		S	P	S	P					
APO04	Managed innovation			S			P		S				S	P
APO05	Managed portfolio			P		P	S		S	S				
APO06	Managed budget and costs			S	P					P	S			
APO07	Managed human resources			S		S				S			P	P
APO08	Managed relationships			S		P	P		S	S			P	P
APO09	Managed service agreements					P			S					
APO10	Managed vendors					P	S			S				
APO11	Managed quality			S	S	S				P	P			
APO12	Managed risk		P					P						
APO13	Managed security	S	S					P						
APO14	Managed data	S	S		S			S			P			
BAI01	Managed programs			P			S		S	P				
BAI02	Managed requirements definition			S		P	P		S	P			S	
BAI03	Managed solutions identification and build			S		P	P		S	P				
BAI04	Managed availability and capacity					P		S		S				
BAI05	Managed organizational changes			P		S	S		P	P			S	
BAI06	Managed IT changes		S			S	P		S					
BAI07	Managed IT change acceptance and transitioning		S				P			S				
BAI08	Managed knowledge			S			S		S	S			P	P
BAI09	Managed assets				P						S			
BAI10	Managed configuration					S		P						
BAI11	Managed projects			P		S	P			P				
DSS01	Managed operations					P			S					
DSS02	Managed service requests and incidents		S			P		S						
DSS03	Managed problems		S			P		S						
DSS04	Managed continuity		S			P		P						
DSS05	Managed security services	S	P			S		P				S		
DSS06	Managed business process controls		S			S		S	P			S		
MEA01	Managed performance and conformance monitoring	S		S		P				S	P	S		
MEA02	Managed system of internal control	S	S		S	S		S		S	S	P		
MEA03	Managed compliance with external requirements	P										S		
MEA04	Managed assurance	S	S		S	S		S			S	P		

Figure A.3: Mapping Table between Alignment Goals and Management Objectives

Specialist	COBIT	AHP
EDM02—Ensured Benefits Delivery	APO13—Managed Security	APO08—Managed Relationships
EDM05—Ensured Stakeholder Engagement	APO12—Managed Risk	APO04—Managed Innovation
APO02—Managed Strategy	APO04—Managed Innovation	APO07—Managed Human Resources
APO04—Managed Innovation	BAI05—Managed Organizational Change	BAI05—Managed Organizational Change
APO05—Managed Portfolio	BAI06—Managed IT Changes	EDM02—Ensured Benefits Delivery
APO09—Managed Service Agreements	APO08—Managed Relationships	APO02—Managed Strategy
APO11—Managed Quality	BAI10—Managed Configuration	BAI11—Managed Projects
BAI05—Managed Organizational Change	DSS06—Managed Business Process Controls	BAI03—Managed Solutions Identification & Build
MEA01—Managed Performance and Conformance Monitoring		

EGs selected by the specialist
EG01—Portfolio of competitive products and services
EG05—Customer-oriented service culture
EG12—Managed digital transformation programs
EG13—Product and business innovation

	MO shared between specialist and AHP
	MO shared between specialist, AHP and COBIT
	Expert considers that the MO should be present in the outcome
	Expert considers that the MO does not make sense for the scenario
	MO shared between AHP and COBIT
	No comments about the MO

Figure A.4: Summary of third interview