Developing a prescriptive IT architecture maturity model (ITA-MM)

Master Thesis

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Preface

This research, conducted as part of my Master Thesis, marks the end of my study Industrial Engineering & Management at the University of Twente and my time as a student. I am very thankful for the opportunity to perform my final internship at Ahold Delhaize. Even though my internship has taken a completely different turn due to the pandemic, I am still very grateful for the way in which I was included online in the team and as a result was able to successfully complete this research.

I would like to express my gratitude to Maria Iacob and Engine Topan, my supervisors from the University of Twente, for providing me with insights, advice, and feedback to enhance the quality of my research. Next, I would like to thank Sebastian for his continuous support, answering my questions and providing me with new insights.

I am thankful for having the opportunity to get to know Ahold Delhaize and more specifically the Inbound Logistics department and especially Pieter for his confidence in me to do my graduation internships at the department. Thank you for being such involved along the way in these digital times and for all your support and guidance during my graduation. Although we only met a few times in person, you gave me a unique insight into the work activities of the Inbound Logistics department.

In addition, I would like to express my gratitude to all other colleagues in the department for showing me their working activities, assignments, projects and all other resources and information which were necessary to complete my thesis. I want to thank them for their openness and honesty and the feeling that I have become part of the team. Furthermore, I wish to thank all the interview and case study participants for their input. Without their cooperation, I would not have been able to perform this research.

Finally, I would like to thank my family and friends for their support during my time as a student. I especially want to thank Tom and Femke for the UB sessions, their support, and feedback on my thesis when needed.

During my time as a student, I have had the pleasure of acquiring many new skills, joining several committees, and getting to meet many new people for which I am very grateful. It was a challenging but very educational experience. The pandemic made for an even more challenging period, testing my discipline and motivation as never before. In the end, the result is what matters.

Job van der Tas

Enschede, July 2021

Executive Summary

Problem Identification
The rise of new digital technologies allows organisations to radically change their business model. This transformation is often referred to as Digital Transformation. It involves changing critical business operations and incorporates all kinds of implementations and changes of digital technologies that significantly impact an organisation's IT architecture. However, organisations are often unaware of the current state of their business activities, applications, technologies and, especially, IT architecture. As a result, organisations find it hard to determine where and how to start with Digital Transformation.

To cope with these challenges, organisations look for a framework to navigate their Digital Transformation journey, resulting in the development of many maturity models in recent years. However, current models tend to be too general in their coverage, making practical implementation for organisations difficult. In addition to this, several studies show that current digital maturity models are often complex, time-consuming, and often need to be performed by external assessors. Furthermore, there is a lack of models that identify and recommend improvement opportunities to organisations, also known as prescriptive maturity models. Lastly, current models often do not implement a scientific profound development approach. Subsequently, the goal of this research is to develop an IT architecture maturity model (ITA-MM), which overcomes the aforementioned shortcomings, leading to the following research objective:

"To design a clear and concise IT architecture maturity model with a business-process point of view, that offers a prescriptive approach for organisations during their Digital Transformation journey."

Define objectives for a solution
The systematic literature review (SLR) performed in this research resulted in the identification of 14 digital maturity models. These models form the foundation for the ITA-MM. The review investigated how these models measure the digital maturity of organisations and especially what concepts the models find important regarding the IT architecture of an organisation. Furthermore, the review identified a common problem among organisations which is not covered by current digital maturity models, the development and use of shadow IT solutions. These solutions are developed to overcome the deficiencies of enterprise systems, but without the knowledge of the central IT department, which poses several risks for organisations. Lastly, the review investigated which are successful methodologies used during Digital Transformation journeys. The Bimodal IT development strategy is a commonly used strategy that balances the maintenance of the organisation's core systems and the agile development of innovative solutions and applications.

Design & Development
The ITA-MM incorporates four dimensions from current digital maturity models that influence the organisation's IT architecture: operations & processes, technology, data, and integration. In addition, the ITA-MM includes shadow IT as a fifth dimension. The ITA-MM presents a set of capabilities for each dimension and six maturity levels. These capabilities indicate whether the organisation meets one of the following maturity levels; non-existent, initiating, enabling, integrating, optimising, and continuous improvement. Furthermore, these capabilities indicate improvement opportunities for the organisation, which ensures the prescriptiveness of the ITA-MM. In addition to the maturity model, this research also developed a roadmap, which offers organisations a guideline to follow during a Digital Transformation journey.

The initial version of the ITA-MM is validated with user and expert interviews. Participants rated statements and answered open questions to validate whether the ITA-MM meets the stated requirements and validation criteria. The validation results show, in general, high perceived usefulness and ease of

use, resulting in a high intention to use the ITA-MM. However, there were several points for improvement, which resulted in developing the ITA-MM tool, incorporating several refinements

Demonstration & Evaluation
A case study at the Ahold Delhaize Inbound Logistics department demonstrates the refined version of the ITA-MM in practice to evaluate the practical relevance. The department is involved in several improvement projects that are part of their Digital Transformation journey, which is the typical application scenario for the ITA-MM. The chosen project for the case study included several key points of interest of the ITA-MM, such as stakeholder involvement, standardisation and digitalisation of business activities and IT security improvements.

The participants in the case study indicate that the developed ITA-MM tool, which includes several refinements compared to the initial version, offers straightforward guidance during the execution of an improvement project. Furthermore, the roadmap and tool encourage the discussion between stakeholders about the current situation, the improvement opportunities, and the execution of the Digital Transformation journey and the opportunity to document the results, decisions, and information. The maturity model assesses the department's IT architecture, helps to identify improvement opportunities, and increases the knowledge on how to improve the IT architecture.

Conclusion
This research developed the ITA-MM in two iterations. The tool incorporates both the maturity model and roadmap. The practical application of the ITA-MM has become apparent in the validation and case study. However, the model is, like the roadmap, open to continuous improvement.

This scientific research contributes to research by introducing a unique maturity model, combining existing concepts into a new model and has a different focus than current digital maturity models. The ITA-MM incorporates a self-assessment targeted towards employees rather than management. Furthermore, the model has a specific focus on IT architecture and has a prescriptive approach. This research can be used as a starting point by other researchers.

The practical contribution of this research is twofold. First, the research provides the ITA-MM, which can be used to assess the IT architecture of an organisation and identify improvement opportunities. Second, this research proposes a roadmap for organisations that guide them during a Digital Transformation.

Recommendations
Organisations engaged in a Digital Transformation journey would benefit from using the ITA-MM. When organisations start using the ITA-MM, it is important that they see the tool primarily as a way to start the discussion between stakeholders in determining and documenting the goals, current situation, and improvement opportunities.

Specific to the Ahold Delhaize Inbound Logistics department, the recommendation is to continue the positive trend of starting improvement projects, learn from the results of the case study and implement the ITA-MM tool as a guide during their Digital Transformation journey.

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List of Abbreviations

ADIL	Ahold Delhaize Inbound Logistics
AI	Artificial Intelligence
BPMN	Business Process Modelling Notation
DC	Distribution Centre
DPO	Daily Performance Overview
DSRM	Design Science Research Methodology
EA	Enterprise Architecture
ILM	Inbound Logistics Manager
ILS	Inbound Logistics Specialist
IT	Information Technology
ITA-MM	IT Architecture Maturity Model
I4.0	Industry 4.0
PBL	Problem Based Learning
PIT	Product Input Template
SLR	Systematic Literature Review
SSD	Supplier Source Document
TAM	Technology Acceptance Model

1 Introduction

Section 1.1 introduces the organisations involved in this research. After which, Section 1.2 provides background information on which the research is based. Lastly, Section 1.3 discusses the research design, containing the problem identification, research objective and the research questions.

1.1 Organisational Context

This section discusses each organisation referred to in this research.

1.1.1 Ahold Delhaize

Ahold Delhaize is established in 2016 by a merger of Ahold and Delhaize Group. Ahold was a Dutch international retailer, which originated from the Dutch supermarket chain Albert Heijn. Albert Heijn started with a small grocery store in the Oostzaan that opened in 1887. Delhaize Group started twenty years before, in 1867, when the Delhaize brothers opened their first wholesale grocery business in Belgium. Both companies expanded to one of the biggest supermarket chains in the Netherlands and Belgium. The two chains combined their forces to become a world-leading food retail group. Their goal is to help customers shop anytime, anywhere and in any manner (in-store and online) (Ahold Delhaize, 2020a).

Ahold Delhaize has nearly 7,000 stores worldwide and a rapidly increasing number of pick-up points. The company operates across the United States, Europe and has a joint venture in Indonesia (Ahold Delhaize, 2020c). In the Netherlands, Ahold Delhaize serves millions of customers each week in more than 2,100 stores. Well-known Dutch companies that operate under Ahold Delhaize are Albert Heijn, Bol.com, drugstore Etos and wine and liquor shop Gall & Gall (Ahold Delhaize, 2020b).

1.1.2 Inbound Logistics Department

The Ahold Delhaize Inbound Logistics (ADIL) department, established in 2008, is an internal wholesaler within Ahold Delhaize. The department imports goods from suppliers worldwide and stores them in three warehouses throughout the Netherlands. The products are delivered to the daughter organisations in the Netherlands, Belgium, and the Czech Republic from these warehouses. Business activities like observing lead times, price negotiations, inventory management, handling custom authorities and managing a very diverse portfolio of suppliers are centralised in this way.

1.2 Background Research

This section discusses several topics that provide background information on the research topic of this thesis. Since these concepts are at the core of this research, they should be explained and defined clearly. Firstly, the section covers Digital Transformation and its benefits. After which, the background research discusses digital maturity models and how they relate to Digital Transformation. Lastly, the impact of Digital Transformation on the IT architecture of organisations is covered. By discussing the subjects mentioned above, this section answers the first research question:

RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?

1.2.1 Digital Transformation

The rise of new digital technologies allows organisations to radically change and improve their business models (Ziyadin et al., 2020). This transformation involves changing critical business operations like products, processes, and organisational structures (Matt et al., 2015). In literature and practice, they refer to this change as Digital Transformation. However, there is no commonly accepted definition for this trend (Schallmo et al., 2017). To complicate matters, many different concepts are adopted to address and describe elements of this trend, including digitisation and digitalisation.

Digitisation is the change of an analogue process to a digital form without any changes or value-adding activities to the process itself (Gartner, 2020b). Digitalisation, on the other hand, provides new revenue and value-adding opportunities (Gartner, 2020a). In practice, digitalisation is a more fundamental change than just digitising existing processes or artefacts (Parviainen et al., 2017). To give a practical example for both definitions, converting a paper document to a digital document is seen as digitisation. It becomes digitalisation when extra functionalities are added to this digital solution that were not available with the paper document.

Reis et al. (2018) define Digital Transformation as "*the use of new digital technologies that enable major business improvements and influences all aspects of customers' life"*. According to Stolterman and Fors (2004), Digital Transformation refers to *"the changes associated with the application of digital technology in all aspects of human society"*. This research refers to Digital Transformation as a fundamental transformation process enabled by digital innovations, which impacts an organisation's IT, business, and organisational aspects.

Since Digital Transformation impacts an organisation on all fronts, the benefits achieved with successful implementations are numerous. A typical start for organisations is digitising certain work activities, also known as going 'paperless'. More operational changes eliminate manual steps from (business) processes, resulting in improved efficiency and consistency. With the replacement of paper and manual processes with digital alternatives, data becomes less error-prone (Parviainen et al., 2017). Furthermore, they discuss that many additional opportunities arise for organisations to collect data to better understand and analyse their performances, cost drivers and causes of risks. This real-time data can be visualised and monitored in reports and dashboards, allowing organisations to address problems before becoming critical (Markovitch & Willmot, 2014). The benefits mentioned above often result in financial advantages too. More error-prone processes and data result in less rework, while faster processes result in less time needed. Both events result in fewer expenses for organisations (Pramanik et al., 2019).

Social benefits are another main driver for organisations to digitally transform, resulting from customers spoiled by new digital innovations (Teichert, 2019). They keep demanding companies to meet their needs and increasing demands (Markovitch & Willmot, 2014). Organisations answer this with innovations that address ease of use and convenience for customers (Parviainen et al., 2017). Another essential social aspect mentioned by these authors is increased employee satisfaction by automating routine work and thus lowering the workload. Resulting in more time available for employees for other important work, customer, or personal related activities.

Lastly, there are scalability benefits associated with Digital Transformation. Organisations use social networks and the internet to reach more potential customers (Pramanik et al., 2019). In addition to this, having data and services digital and automated makes scaling more easily.

1.2.2 IT Architecture

Digital Transformation is interrelated with implementing and improving digital solutions. In combination with the organisation-wide impact of Digital Transformation, it heavily impacts the IT architecture organisations. IT architecture is the overall design of computing systems, the logical and physical interrelationships between them, and the principles and guidelines governing their design and evolution over time (The Open Group, 2020). Components incorporated in the IT architecture are the hardware, software, access methods and protocols used throughout the organisation.

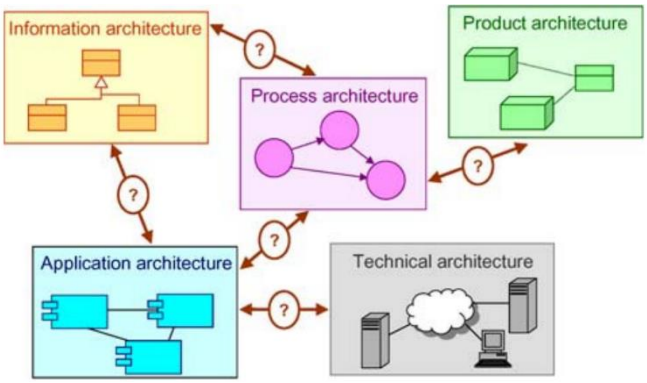

Figure 1: Visualisation of the Enterprise Architecture domains (Jonkers et al., 2006)

IT architecture is frequently referred to as Enterprise Architecture (EA). A commonly accepted definition of Enterprise Architecture (EA), as is also visualised in Figure 1, was introduced by Jonkers et al. (2006), and states *"A coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business, processes, information systems, and infrastructure"*.

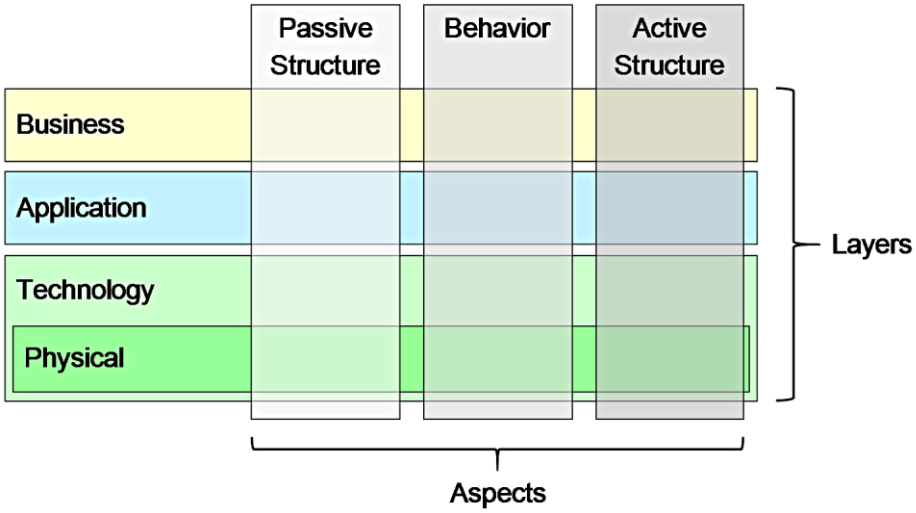

Figure 2: ArchiMate core framework (The Open Group, 2019)

ArchiMate is an open and independent Enterprise Architecture (EA) modelling language. Figure 2 shows the ArchiMate core framework, which defines a structure of generic elements and relationships and visualises these in three layers (The Open Group, 2019). The business layer incorporates the business activities performed by an organisation. The application layer covers the application services that realise the business activities. Lastly, the technology layer depicts the organisation's technology services needed to run the hard- and software. The active structure represents an actor who performs a certain behaviour on an object, represented by the passive structure.

1.2.3 Maturity Models

Along with the growing interest in Digital Transformation, there is also a growing demand for guidance during the transformation. Many maturity models were developed in recent years to answer this need. Maturity models are considered beneficial in Digital Transformation processes due to the generation of awareness regarding the addressed domain and the provision of a framework for systematically design improvement activities (van de Vrande et al., 2009).

An early definition of maturity, proposed by Philip Crosby (1979), is defined as "*the state of being complete, perfect or ready".* In an organisational context, maturity is seen as "*a measure to evaluate the capabilities of an organisation in regard to a certain discipline"* (Rosemann & De Bruin, 2005).

From a digital perspective, maturity reflects an organisation's Digital Transformation efforts (Chanias & Hess, 2016). The models use pre-defined dimensions to assess the current state of digital maturity (Teichert, 2019). Maturity models that only assess the current maturity level are called descriptive maturity models (de Bruin et al., 2005). Prescriptive models also recommend improvement activities to guide the organisation towards a higher maturity. Lastly, comparative models enable benchmarking across organisations or industries.

1.3 Research Design

This section describes the design of this research, starting with discussing the problem. After which, the section covers the objective, methodology, research questions and relevance of this study.

1.3.1 Problem Statement

From the previous section, it becomes clear that Digital Transformation offers many opportunities for organisations, e.g., optimisation of business processes, better organisational performance, increase in productivity and seamless and real-time information processing (Gollhardt et al., 2020). However, there are several barriers for organisations that keep them from successfully digitally transform their businesses.

To begin with, organisations lack awareness of their current digital maturity and strategic guidance during the transformation process. Organisations are not aware of the current state of their (business) processes, applications and technologies, making it hard to determine where and how to start with Digital Transformation (Cuylen et al., 2016; Leyh et al., 2017). In addition, organisations are not familiar with or aware of new technologies that could benefit them.

To cope with these challenges, organisations look for existing frameworks to navigate their Digital Transformation journey (Colli et al., 2019; Valdez-de-Leon, 2016). For this reason, many maturity models have been developed in recent years. Unfortunately, current maturity models tend to be descriptive, as they do not prescribe actions to overcome the identified weaknesses (Naskali et al., 2018; Tarhan et al., 2016; Thordsen et al., 2020; Zapata et al., 2020). In addition, the majority of existing digital maturity models address specifically the manufacturing domain (Teichert, 2019). Domains like service or retail-oriented organisations are clearly under-represented in the focus of digital maturity models.

On top of this, digital maturity models tend to be too general and high-level in their coverage (Colli et al., 2019; Gollhardt et al., 2020; Schumacher et al., 2019; Valdez-de-Leon, 2016). As a result, dimensions are not always comprehensible or practical in the application by an organisation. Added to this, high-level models lack specific depth in essential aspects like information and communication technologies (ICT). When models discuss the impact of ICT in more detail, the study typically focuses on a single technology, for example, an Enterprise Resource Planning (ERP) system (De Carolis et al., 2018). The lack of assessment and guidance on the IT architecture design leads to uncontrolled development of the IT landscape (Fürstenau & Rothe, 2014; Huber et al., 2014).

Several studies have shown that current digital maturity models are often complex and time-consuming to implement for organisations (Meyer et al., 2011; Proença & Borbinha, 2018; Trotta & Garengo, 2019). Some maturity assessments even must be performed by competent assessors. As a result of this complexity, maturity assessment can become an expensive and burdensome activity for organisations. Furthermore, current assessments are often aimed at and based on the management's perspective (Voß & Pawlowski, 2019). However, it would be interesting to see the perspective of employees.

Lastly, there is a lack of scientifically and methodologically profound digital maturity models (Aguiar et al., 2019; Thordsen et al., 2020). Authors rarely reveal their development processes, or they do not use a non-scientific development approach. As a result, there is a lack of scientific reliability.

1.3.2 Research Objective

From the problem definition, it becomes clear that there are several shortcomings in current maturity models. This research deals with these shortcomings by proposing the IT Architecture Maturity Model (ITA-MM). This model will assess the IT architecture of service-oriented organisations since there are currently no models that have this focus. To better support organisations during their Digital Transformation, this model will have a prescriptive approach. Furthermore, the ITA-MM will be a simple self-assessment that an employee can perform. The design of the model will be done based on a well-known design methodology. The research objective is as follows:

"To design a clear and concise IT architecture maturity model with a business-process point of view, that offers a prescriptive approach for organisations during their Digital Transformation journey."

1.3.3 Research Relevance

Nowadays, Digital Transformation is becoming increasingly important for organisations due to the many potential benefits, as discussed in Section 1.2.1. However, many organisations have difficulties with successfully executing Digital Transformation activities due to the question of how to assess and design their IT architecture and the lack of clear maturity models to help guide them. The originality of this research is that this IT Architecture Maturity Model (ITA-MM) contains a simple self-assessment for the employees of service-oriented organisations that also provides a prescriptive approach to identify improvement opportunities. Furthermore, a roadmap guides the organisation during their Digital Transformation journey.

1.3.4 Methodology & Research Questions

As mentioned in the research objective, this research aims to design a prescriptive IT architecture maturity model to assess and guide organisations during their Digital Transformation. The following main research question supports the research goal:

What is a suitable maturity model that allows organisations to assess their IT architecture from a business-process point of view and offers them a prescriptive approach to guide them during a Digital Transformation journey?

Answering the central research question will be done by several sub research questions. To answer these sub research questions in a structured and scientific manner, this research uses Design Science Research Methodology (DSRM). The DSRM is used to guide this research since it is a well-known methodology for doing research in the information systems field. The methodology focuses on solving a problem by doing research and developing an artefact to validate the solution. The DSRM has six phases, as shown in Figure 3 (Peffers et al., 2007). Below each phase is shortly discussed and gives an overview of the sub research questions answered during each phase.

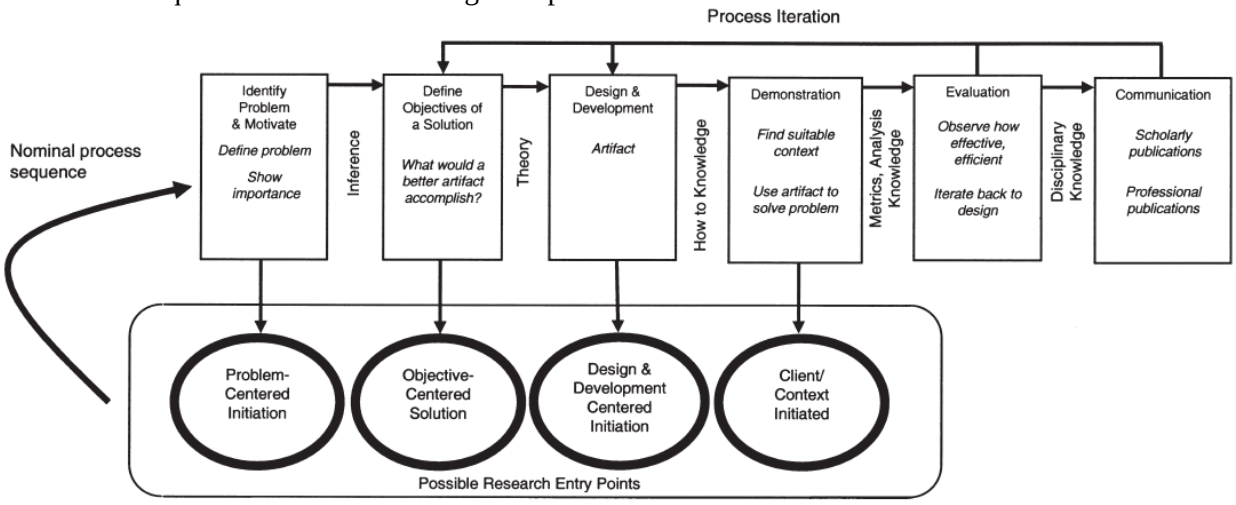

Figure 3: DSRM phases (Peffers et al., 2007)

Problem identification
The first phase defines a specific research problem and justifies the value of a solution. This research starts with conducting an initial background research to acquire a basic understanding of Digital Transformation, IT architecture and maturity models. The problem statement identifies a knowledge gap resulting from the initial background research. The problem identification phase answers the first research question:

RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?

Define objects for a solution
This phase defines the objectives for a solution from the problem definition and acquires knowledge of possible and feasible solutions. This phase answers the four research questions stated below. The second research question compares existing digital maturity models, found through a systematic literature review (SLR), to investigate how current models assess the digital maturity at organisations. Subsequently, the third research question goes into more detail about what the identified models find most important during a digital maturity assessment regarding the IT architecture. The fourth research question identifies challenges that organisations experience during a Digital Transformation but are not discussed in the identified maturity models. Lastly, the fifth research question identifies which methodologies researchers recommend to carry out a Digital Transformation project. The fourth and fifth research questions use the snowballing technique to identify a relevant set of papers. Appendix A discusses the review protocol used during this phase.

RQ2: How is the level of Digital Transformation engagement measured at an organisation?

RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment?

RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models?

RQ5: What methodologies do exist to carry out Digital Transformation projects?

Design & Development
The third phase starts with investigating and choosing guidelines specifically designed for the development of maturity models. Furthermore, the research defines the requirements and goals. After which, the ITA-MM is developed in two iterations and validated by user and expert interviews. Consequently, this phase answers the sixth research question and sub-questions:

RQ6: How to design a generally applicable maturity model for organisations, including a self assessment model and a roadmap?

- *RQ6.1: What are the guidelines to develop a maturity model?*
- *RQ6.2: What are the goals and requirements of the ITA-MM?*
- *RQ6.3: How to systematically assess the IT architecture of an organisation?*
- *RQ6.4: How to provide a roadmap for organisations to start with optimising their IT architecture?*

Demonstration
This phase demonstrates the use of the developed artefact in the intended problem context. In this research, a case study implements the ITA-MM and roadmap at ADIL to see how the artefact interacts within its intended problem context.

Evaluation
After the execution of the case study, the evaluation phase concludes whether the developed artefact contributes to solving the identified problem and thereby answers the eighth research question:

RQ7: Does the developed ITA-MM proves relevant in practice? What improvements should be made to the ITA-MM?

Communication
This thesis and the colloquium communicate the results of this research and the effectiveness of the artefact.

1.3.5 Thesis Outline

The structure of this thesis is based on the different phases of the DSRM. Table 1 shows an overview of the chapter arrangement relates to the six phases of the DSRM. In addition, the table presents which chapter and DSRM phase answers the introduced research questions.

This chapter discussed the problem identification and the research design. Next, Chapter 2 covers the performed literature review to define objects for a solution. Subsequently, Chapter 3 discusses the chosen development strategy and the first development iteration of the ITA-MM. Chapter 4 then validates and refines the initial version of the ITA-MM. After which, Chapter 5 demonstrates and evaluates the refined version of the ITA-MM. Lastly, Chapter 6 concludes the research and mentions the contribution to practice and theory and suggests points for further research.

Chapter	DSRM phase	Research questions
1. Introduction	Problem identification and motivation	RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?
2. Literature Review	Define objects for a solution	RQ2: How is the level of Digital Transformation engagement measured at an organisation? RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment? RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models? RQ5: What methodologies do exist in literature to carry out Digital Transformation and IT projects?
3. Design & Development		
	Design & Development	RQ6: How to design a generally applicable maturity model for organisations, including a self-assessment model and a roadmap? RQ6.1: What are the guidelines to develop a maturity model? RQ6.2: What are the goals and requirements of the ITA-MM? RQ6.3: How to systematically assess the IT architecture of an organisation? RQ6.4: How to provide a roadmap for organisations to start with optimising their IT architecture?
4. Validation & Refinement		
	Demonstration	
5. Demonstration & Evaluation		
	Evaluation	RQ7: Does the developed ITA-MM proves relevant in practice? What improvements should be made to the ITA-MM?
6. Conclusion	Communication	

Table 1: Thesis chapters related to the DSRM phases and research questions

2 Literature Review

This chapter reviews the current state of research to serve as a basis for developing the maturity model. First, Section 2.1 covers the Systematic Literature Review method. After which, Section 2.2 discusses the search process. Lastly, Sections 2.3 to 2.6 answer several research questions (RQ2 to RQ5).

2.1 Systematic Literature Review

This literature review aims to identify relevant research, to design a well-founded artefact. The review first investigates how current maturity models assess to what extent organisations are engaged in the Digital Transformation initiative. Secondly, it examines what current maturity models find essential when assessing the IT architecture of an organisation. Furthermore, the review identifies what challenges organisations experience during a Digital Transformation regarding their IT architecture, but not discussed by current digital maturity models. Lastly, the review investigates what methodologies do exist to carry out a Digital Transformation.

For knowledge acquired in a literature review to be of scientific value, a thorough and fair systematic literature review (SLR) has to be undertaken (Kitchenham & Charters, 2007). Therefore, this research contains an SLR using several concepts of Webster & Watson (2002), Kitchenham & Charters (2007) and Wolfswinkel, Furtmueller & Wilderom (2013).

Figure 4 summarises the stages of an SLR, as discussed by Kitchenham & Charters (2007), into three main phases: Planning the Review, Conducting the Review and Reporting the Review. The planning phase identifies the need for a systematic literature review and specifies the research question. Moreover, this phase develops a review protocol. This pre-defined protocol is a fundamental aspect of the SLR since it reduces the possibility of researcher bias. Appendix A discusses the review protocol for this SLR. The following sections cover the conduction and report the findings of the review.

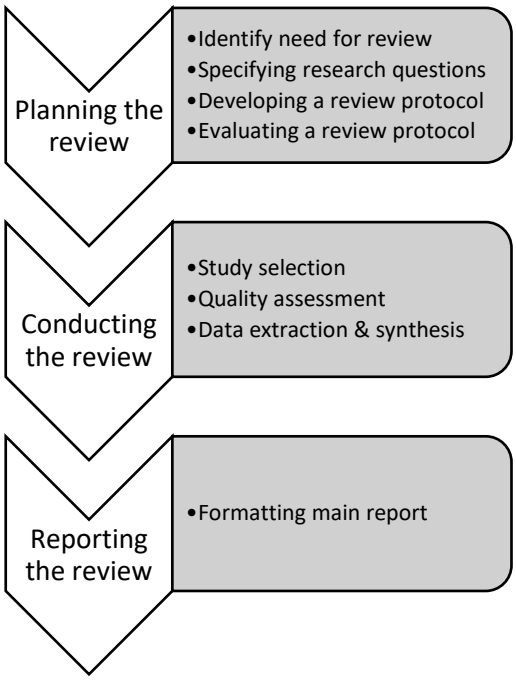

Figure 4: Systematic literature review phases

2.2 Literature Review Process

This section discusses the steps taken during the conduction of the systematic literature review.

Study selection

The initial search for digital maturity models resulted in 926 papers, as shown in Figure 5. After removing duplicate papers, 716 papers remain. Applying the selection criteria to both title and abstract resulted in respectively 468 and 159 papers excluded since they did not meet the selection criteria. The subsequent stage focused on the introduction and conclusion of papers, which led to the exclusion of 54 papers. Reading the full text of the remaining papers resulted in deleting an additional 23 papers. Lastly, two papers were added through citations since they were found relevant for this research. The result is a total of 14 relevant digital maturity models for this research.

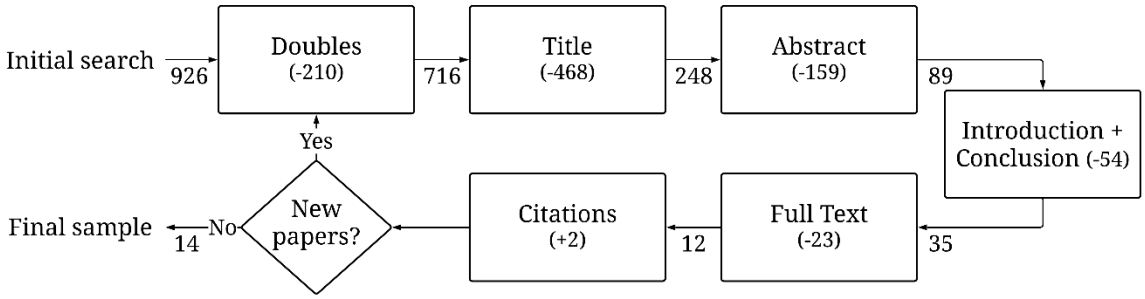

Figure 5: Selection process literature review

Quality assessment

Kitchenham & Charters (2007) discuss the importance of assessing the quality of the final sample of papers before analysing the data. This assessment guarantees the quality of the final sample. Table 2 shows an overview of the quality assessment. All papers clearly state their objective or research question(s). Furthermore, all researchers use a systematic literature review to gather information. In addition, eight papers conducted a business case, and two performed expert interviews to collect results. Since all papers meet the quality standards as stated in the review protocol, they are all included in the final sample.

Maturity model	Clear RQ or objective	Result gathering approach
Basl & Novakova (2019)	Yes, RQ	SLR & Business Case
Blatz et al. (2018)	Yes, Objective	SLR & Business Case
Chonsawat & Sopadang (2019)	Yes, Objective	SLR & Business Case
Cimini et al. (2020)	Yes, Objective	SLR
Colli et al. (2019)	Yes, RQ	SLR & Business Case
Cuylen et al. (2016)	Yes, RQ	SLR & Expert Interviews
De Carolis et al. (2018)	Yes, Objective	SLR & Business Case
Gollhardt et al. (2020)	Yes, Objective	SLR
Leyh et al. (2017)	Yes, RQ	SLR
Plomp & Batenburg (2010)	Yes, RQ	SLR & Business Case
Schumacher et al. (2019)	Yes, Objective	SLR & Business Case
Trotta & Garengo (2019)	Yes, Objective	SLR
Valdez-de-Leon (2016)	Yes, Objective	SLR & Expert Interviews
Zaoui & Souissi (2020)	Yes, Objective	SLR & Business Case

Table 2: Quality assessment results of final sample papers

Data extraction & synthesis

The data extraction phase for the second and third research questions uses two methods, as discussed in more detail in the review protocol. First, the maturity model analysis method, proposed by Proença & Borbinha (2016), compares maturity models by considering three aspects for each model: model structure, assessment and support. In addition, the analysis method of Wolfswinkel et al. (2013) extracts additional relevant information from the digital maturity models and visualises this in a concept matrix.

The fourth and fifth research questions require a less rigorous approach, as these questions have more of an exploratory purpose. Subsequently, the questions use the same concept method to extract information from the papers, but the results are not processed into a concept matrix.

2.3 Digital Transformation Maturity Models

The benefits of new digital technologies, as discussed in Section 1.2.1, are the main driver for organisations to start with Digital Transformation. However, Digital Transformation involves multi-disciplinary activities and intra- and inter-organisational collaborations (Colli et al., 2019), posing many challenges for organisations. As a result, there is a need for methods that help organisations with this transformation (Teichert, 2019). Many maturity models were developed in recent years to answer this need. Maturity models are considered beneficial in Digital Transformation processes due to the generation of awareness regarding the addressed domain and providing a framework to systematically design improvement activities (van de Vrande et al., 2009).

Before designing the ITA-MM, it needs to be determined how current digital maturity models measure maturity. Therefore, this section examines how the identified maturity models assess the level of Digital Transformation engagement at an organisation, thereby answering the second research question:

RQ2: How is the level of Digital Transformation engagement measured at an organisation?

2.3.1 Model Structure

Maturity models use attributes and levels to assess the maturity of an organisation systematically. The purpose of the attributes is to cover essential (business) areas impacted by Digital Transformation. The levels or stages articulate per attribute the progress of the Digital Transformation process. This descriptive use of a digital maturity assessment provides an organisation with an indication of the current maturity stage. Table 3 shows that the number of levels ranges from three to six, with most models using five levels. Many models base their maturity levels on the Capability Maturity Model Integration (CMII, 2010) or refer to the CMMI. The CMMI uses five levels, as shown in Figure 6. The first level starts with undefined and unpredictable processes. Next, the second level covers repeatable and reactive processes. The third level describes defined and proactive processes. After which, the fourth level covers managed processes that are measured and controlled. Lastly, the fifth level strives for continuous improvement.

Maturity model	Nr. Levels	Name of attributes	Nr of (sub) attributes	Maturity definition	Practicality
Basl & Novakova (2019)	6	Dimensions	4	No	Specific
Blatz et al. (2018)	3	Dimensions	6	No	General
Chonsawat & Sopadang (2019)	5	Dimensions	5 / 43	Yes	General
Cimini et al. (2020)	N/A	Categories	N/A	No	Specific
Colli et al. (2019)	6	Dimensions	5	Yes	General
Cuylen et al. (2016)	5	Categories	4 / 15	No	Specific
De Carolis et al. (2018)	5	Dimensions	4	Yes	General
Gollhardt et al. (2020)	N/A	Focus area's	5	Yes	General
Leyh et al. (2017)	5	Dimensions	4	No	Specific
Plomp & Batenburg (2010)	2 x 4	Dimensions	2	No	Specific
Schumacher et al. (2019)	4	Dimensions	8 / 65	No	General
Trotta & Garengo (2019)	5	Dimensions	5	No	General
Valdez-de-Leon (2016)	6	Dimensions	7	No	General
Zaoui & Souissi (2020)	3	Evaluation criteria	3	No	Specific

Table 3: Synthesis of the digital maturity models regarding model structure

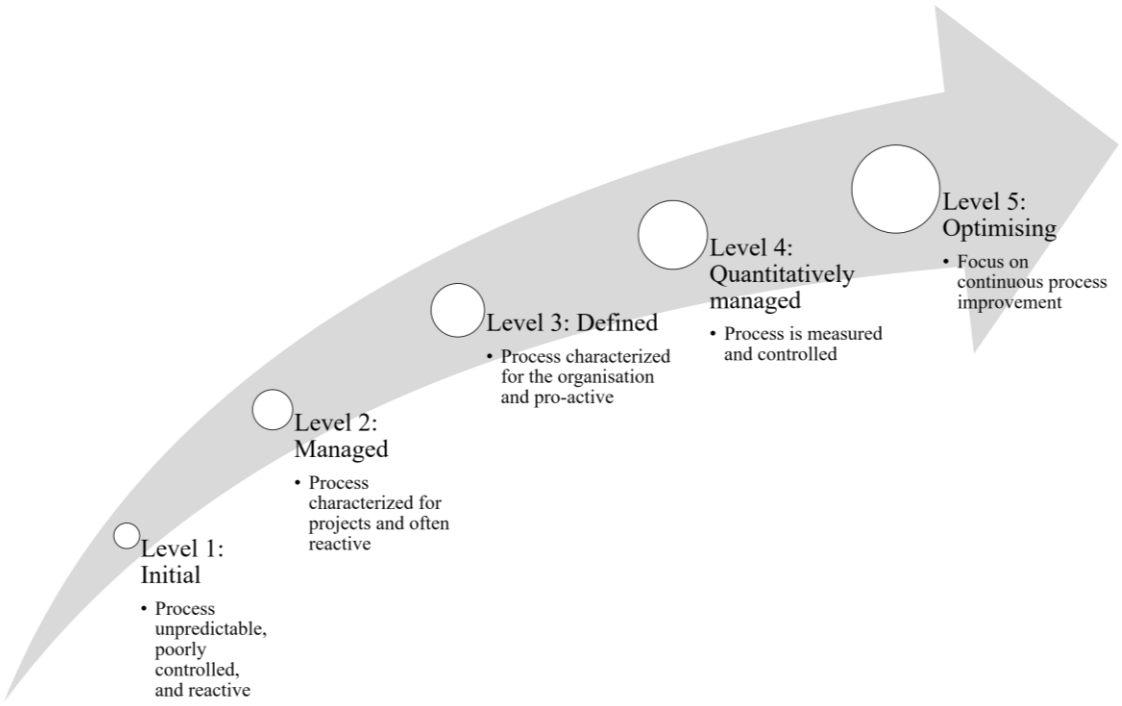

Figure 6: CMMI maturity levels definition based on CMMI (2010)

Most of the models use dimensions to indicate the different (business) areas in the assessment. For this reason, the remainder of this thesis uses the phrasing dimensions when discussing attributes. Later in this section, the different dimensions used by the maturity models are discussed in more detail.

Several maturity models added sub-attributes to further differentiate between assessment areas. Unfortunately, only four of the 14 models explain the definition of maturity. Not having a clear definition of maturity in a model could decrease homogeneity between maturity assessments or misunderstand the model's purpose. Eight of the maturity models address Digital Transformation in a general manner. The remaining models have a specific focus, for example, ERP systems (Basl & Novakova, 2019) and supply chain digitisation (Cimini et al., 2020; Plomp & Batenburg, 2010).

2.3.2 Model Assessment

The model assessment, shown in Table 4, evaluates the execution of the maturity assessment. Nine digital maturity models propose an assessment method. However, the exhaustiveness and prescriptiveness differentiate a lot between models. Three prescriptive models (Colli et al., 2019; De Carolis et al., 2018; Schumacher et al., 2019) implement a maturity assessment methodology consisting of an action plan to assess the maturity, identify strong and weak points, and prioritise the improvement opportunities. This prescriptive approach gives some guidance to organisations during their Digital Transformation and is discussed in more detail at the end of this section. Five models do not mention how to assess digital maturity. The remaining models only discuss the assessment.

Most maturity assessments use a questionnaire, where participants answer multiple questions per dimension based on the Likert Scale (Likert, 1932). This scale ranges from one to five, where one stands for "not implemented/not present" and five for "completely implemented/present". Subsequently, there are two methods used to determine the digital maturity of an organisation. The first method takes the most answered Likert score as a discrete denotation of digital maturity. The second method calculates the average level based on the Likert scores from the questionnaire, resulting in a continuous value for an organisation's digital maturity.

Maturity model	Assessment Method	Assessment Cost	Strong/Weak points identification	Continuous Assessment	Opportunities Prioritisation
Basl & Novakova (2019)	No	Low	Yes	No	No
Blatz et al. (2018)	Yes	Medium	Yes	No	No
Chonsawat & Sopadang (2019)	Yes	Medium	Yes	No	No
Cimini et al. (2020)	No	High	No	No	No
Colli et al. (2019)	Yes	High	Yes	Yes	Yes
Cuylen et al. (2016)	No	Low	Yes	No	No
De Carolis et al. (2018)	Yes	High	Yes	No	Yes
Gollhardt et al. (2020)	No	?	No	No	No
Leyh et al. (2017)	Yes	Low	Yes	No	No
Plomp & Batenburg (2010)	Yes	Medium	No	No	No
Schumacher et al. (2019)	Yes	High	Yes	No	Yes
Trotta & Garengo (2019)	Yes	Medium	Yes	No	No
Valdez-de-Leon (2016)	No	Medium	Yes	No	No
Zaoui & Souissi (2020)	Yes	Low	Yes	No	No

Table 4: Synthesis of the digital maturity models regarding model assessment

The costs of an assessment are estimated based on the extensiveness of the models and are divided into three levels: high, medium, and low. The estimation of the three prescriptive models is high since these models use an extensive assessment process guided by external assessors. In addition, the model of Cimini et al. has a high-cost estimation because this model proposes a framework requiring the use of different extensive methodologies and standards. Models with a medium estimation have either a lengthy assessment questionnaire, expect the use of external assessors, or depend on the involvement of multiple employees throughout an organisation, thus requiring time and resources. Subsequently, models with a low estimation of costs make use of a self-assessment variant to determine maturity. Lastly, one model does not yet offer a way to determine the maturity in the current version. Therefore, no estimation of cost is given for this maturity model.

The majority of the models give an indication of strong and weak points within the organisation. However, as with the assessment method, there is a significant difference in the extensiveness of strong and weak points identification. Only the three prescriptive models offer a clear identification of strong and weak points and a prioritisation of improvement opportunities, which give organisations the benefit of advancing to a higher maturity state. Lastly, one model implements an iterative assessment method and explicitly mentions the importance of a continuous assessment.

Maturity model	Training Available	Author Support Availability	Continuity from different versions	Origin	Accessible
Basl & Novakova (2019)	N/A	N/A	No	Academic	Yes
Blatz et al. (2018)	N/A	N/A	No	Academic	No
Chonsawat & Sopadang (2019)	N/A	N/A	Yes	Academic	No
Cimini et al. (2020)	N/A	N/A	No	Academic	No
Colli et al. (2019)	N/A	N/A	Yes	Academic	Yes
Cuylen et al. (2016)	N/A	N/A	No	Academic	Yes
De Carolis et al. (2018)	N/A	N/A	Yes	Academic	No
Gollhardt et al. (2020)	N/A	N/A	No	Academic	No
Leyh et al. (2017)	N/A	N/A	Yes	Academic	Yes
Plomp & Batenburg (2010)	N/A	N/A	Yes	Academic	No
Schumacher et al. (2019)	N/A	N/A	No	Academic	No
Trotta & Garengo (2019)	N/A	N/A	No	Academic	No
Valdez-de-Leon (2016)	N/A	N/A	No	Practitioners	Yes
Zaoui & Souissi (2020)	N/A	N/A	No	Academic	Yes

Table 5: Synthesis of the digital maturity models regarding model support

2.3.3 Model Support

When searching for the documentation of the 14 maturity models, it resulted in no extra documentation except the published papers. As a result, no training possibilities and no author support were found. Some models have revisions and adjustments. Most of the maturity models have an academic origin, with only one model originating from practitioners. As mentioned, none of the maturity models has documentation outside of the papers. Resulting in maturity models not being accessible for the general public when papers do not include a complete overview of the maturity model. Six digital maturity models include a full version of the maturity model and are thus accessible for the general public. Table 5 shows an overview of the model support comparison.

2.3.4 Model Dimensions

The previous sections evaluate the maturity models according to the maturity model analysis method (Proença & Borbinha, 2016). The concept analysis method proposed by Wolfswinkel et al. (2013) is used to further analyse the dimensions adopted by the digital maturity models. Table 6 combines all excerpts related to the dimensions of the digital maturity models. There are many similarities between the dimensions of the models since they all assess digital maturity, even though the focus areas of the models are different. However, the models do use different terms for the same concepts. Therefore, the table combines different concepts referring to the same dimension under a single term.

	Authors	Basl & Novakova (2019)	Blatz et al. (2018)	Chonsawat & Sopadang (2019)	Cimini et al. (2020)	Colli et al. (2019)	Cuylen et al. (2016)	De Carolis et al. (2018)	Gollhardt et al. (2020)	Leyh et al. (2017)	Plomp & Batenburg (2010)	Schumacher et al. (2019)	Trotta & Garengo (2019)	Valdez-de-Leon (2016)	Zaoui & Souissi (2020)
	Focus	ERP 4.0	Digitisation	Smart SMEs, I4.0	Digital Supply Chain	I4.0	E-invoice process	Digital Readiness	Digital Transformation for IT Companies	System Integration	Digital Supply Chain	I4.0, manufacturing	I4.0, manufacturing	Digital maturity of telecommunications	ICT, Digital Transformation
	Dimensions														
Technological	Operations / processes	X	X	X	X		X	X	X	X		X	X	X	
	Technology	X		X	X	X	X	X		X	X	X	X	X	X
	Data	X	X	X	X	X		X				X			X
	IT infrastructure		X		X	X				X					X
	Products		X									X	X		
Organisational	Strategy		X	X	X		X		X			X	X	X	
	Organisation		X	X		X		X	X		X	X		X	
	Culture		X			X	X		X					X	
	People			X								X	X		X
	Customer								X			X		X	

Table 6: Concept matrix of the dimensions covered in current digital maturity models

Since the digital maturity models assess the level of Digital Transformation engagement at organisations, it is unsurprising that all the models implement many technological dimensions. With 12 papers using the dimension technology, it is the most used dimension. This dimension evaluates to what extent an organisation implemented new digital innovations, e.g. I4.0 concepts and digital tools to use and process data. Several papers use the dimensions data, IT infrastructure, and products to go into more detail on the assessment of how technology is supported. The data dimension evaluates specifically data collection, storage, and integrity. Also, data security is an essential aspect of this dimension. Furthermore, IT infrastructure covers the hard- and software that facilitates all the systems used to carry out an organisation's business activities. Lastly, the products dimension assesses the smartness of products made by the organisation. For example, with the implementation of I4.0 concepts, products or items can send information to an organisation to improve the product or make decisions based on the information.

The second most used dimension is the operations & processes dimension, which assesses the degree of standardisation, digitisation and automation in the organisation's business and production processes. In addition, this dimension evaluates if organisations add new and improved services to their business activities, made possible by digitising processes. The third research question, covered in Section 2.4, discusses these technological dimensions in more detail.

The organisational dimensions used by the models evaluate if Digital Transformation is part of the organisation's strategy (strategy) and whether the work environment encourages participation and exploration into digital solutions (culture). Furthermore, the people dimension evaluates the willingness to improve and the required skills among the employees, whereas the organisation dimension assess if the organisation provide the information and tools to increase the willingness and

skills of the employees. Lastly, the customer dimension assesses the degree of customer consideration during Digital Transformation initiatives.

2.3.5 Prescriptive Maturity Models

The majority of the digital maturity models, 11 out of the 14, have a descriptive purpose. The goal of these models is to give organisations an indication of what their maturity level is. However, these models do not give recommendations or guidelines on improving the organisation's digital maturity. Three papers propose a prescriptive approach in their models.

Colli et al. (2019) discuss the lack of prescriptive approaches and propose a Problem Based Learning (PBL) approach to close this gap. With this PBL approach, the external assessment party actively engages the organisation during the assessment process and helps the organisation identify improvement areas.

The research of De Carolis et al. (2018) presents a four-step methodology. The first step starts with a maturity assessment, after which the second step identifies the strengths and weaknesses. Based on this, step three analyses the opportunities for the organisation and defines for each opportunity an improvement plan. The last step evaluates the feasibility of the opportunities and ranks the opportunities.

The last research presenting a prescriptive methodology is from Schumacher et al. (2019). This model has a 10-step approach, starting with raising awareness among stakeholders. After which, the maturity assessment is prepared and carried out. Subsequently, the method analyses the results, leading to determining the improvement opportunities of the organisation. Opportunities are prioritised based on the size of the identified gaps. Lastly, the method goes into more detail about several aspects of the Digital Transformation roadmap, e.g., timelines, cost-benefit-estimations, and concrete next steps.

According to characteristics described by de Bruin et al. (2005), the three maturity models discussed above are indeed prescriptive since the models provide an assessment method that identifies strong and weak points and prioritises the opportunities. In addition, all three assessment methods include a roadmap definition.

2.3.6 Summary

This section identified 14 relevant digital maturity models for this research. The models measure the digital maturity at organisations using dimensions and levels. Dimensions cover the fundamental (business) areas impacted by Digital Transformation, and maturity levels indicate the maturity of each dimension. The following section goes into more detail about the technological dimensions.

2.4 Digital Maturity Dimensions

The previous section discusses how current digital maturity models assess the level of Digital Transformation engagement of organisations. This section takes a closer look at the technological dimensions of the maturity models and discusses how these dimensions influence the IT architecture of an organisation. Thereby, this section answers the third research question:

RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment?

2.4.1 Technological Dimensions

The second research question shows how dimensions represent different aspects of an organisation affected during a Digital Transformation. Some of these dimensions cover areas that influence IT architecture. The remainder of this section discusses these dimensions in more detail.

Operations & processes
The operations & processes dimension is concerned with the execution of activities and tasks within an organisation. With 11 out of the 14 papers discussing this dimension, it can be seen as an essential dimension. Where it is economically and technologically reasonable, organisations need to eliminate manual operations, and autonomous processes should be established (Blatz et al., 2018). Most maturity models include the digitisation and automation of activities in this dimension. Additionally, Gollhardt et al. (2020) state the importance of standardisation of activities as a first step, which provides a foundation for further process improvements.

Various models emphasise the relevance of flexible processes (Blatz et al., 2018; Chonsawat & Sopadang, 2019; Cuylen et al., 2016; Valdez-de-Leon, 2016). Since Digital Transformation has a long-term perspective, it is essential that processes are also designed in this way. It ensures that processes can adapt to temporarily fluctuations, e.g., seasonal peaks and permanent long-term growth. Data and the implementation of I4.0 technologies, i.e. smart processes, are addressed by a few models (Gollhardt et al., 2020; Leyh et al., 2017; Trotta & Garengo, 2019). However, most models discuss these new technologies in more depth in the technology dimension.

Even though digitalising processes has many potential benefits, i.e., more efficient processes, it is a development that needs a carefully devised plan. Digitising processes has a significant impact on the IT architecture of an organisation since these processes become supported by IT applications (Blatz et al., 2018). Simply digitising processes without a careful design poses a major integration challenge of additional IT systems for the IT departments within organisations (Leyh et al., 2017). In addition, the implementation of new digital capabilities has an organisation-wide impact (Parviainen et al., 2017). Thus, good coordination and cooperation between departments are fundamental.

Technology
The second dimension, technology, evaluates the technological capabilities of an organisation and is discussed by almost all studies. Models that have manufacturing organisations as a focus consider implementing I4.0 trends, e.g., using sensors and robots in processes. These so-called smart processes enable the collection and usage of data. Other models that do not specifically focus on manufacturing also discuss technologies. However, these technologies facilitate the generation, access and use of data in business processes and activities, for example, applications that support digital services and data analytics opportunities (Valdez-de-Leon, 2016).

Comparable with the previous dimension, implementing new technologies within an organisation substantially impacts the IT architecture. The technologies that collect, process, store, and use data require implementing hard- and software solutions throughout the organisation (De Carolis et al., 2018). Since there is no large, all-encompassing IT system, IT departments face several challenges implementing these systems.

Data
Whereas the previous dimension focused more on the technologies that collect and use data, the data dimension focuses more on assessing how data is stored and processed. The use of sensors and other data collection technologies makes it increasingly easier to collect data, which leads to a large amount of data available. This data is very valuable and needs to be protected (Blatz et al., 2018; Chonsawat & Sopadang, 2019; Colli et al., 2019; Leyh et al., 2017). Consequently, these models discuss the importance of IT security. Furthermore, simply collecting data might not result in useful information and only wastes expensive resources. Therefore, data must support its defined purpose (Blatz et al., 2018; Leyh et al., 2017), meaning that data must be checked for completeness, consistency and relevance during the data collection process.

To make information out of data, it needs to be processed. Several models mention concepts like Artificial Intelligence (AI) and algorithms as methods to process data (Basl & Novakova, 2019;

Chonsawat & Sopadang, 2019; Cimini et al., 2020). Data is collected and processed to provide organisations with more information to make better-founded decisions, called data-driven decision-making. A step further is when a computer makes the decision, which is called autonomous data-driven decisions. Furthermore, real-time data monitoring, which also can be autonomous, detects inefficiencies during operation that can be improved instantly (Cimini et al., 2020).

The challenge for organisations is to manage data storage securely and reliably, yet accessible for those who need to access the data. Additionally, access to data poses an architecturally challenge on where to save the data and how to connect the different systems and interfaces to access and use the data.

IT infrastructure
The IT infrastructure dimension evaluates the overall design and efficiency of the IT infrastructure. Since more data becomes digitally available and different users need to access this data, interconnectivity is an essential indicator for digital maturity (Cimini et al., 2020; Colli et al., 2019; Leyh et al., 2017). In addition, the paper of Blatz et al. (2018) highlights the importance of an infrastructure that is capable of storing and processing the ever-increasing amount of data.

Many challenges from previous dimensions are also applicable to the IT infrastructure dimension. For example, having a high level of connectivity between systems poses the additional challenge to have a safe connection to guarantee IT security. Furthermore, having more applications in the IT infrastructure adds the number of access points for outsiders to attack an organisation's systems. Another dangerous pitfall for organisations engaged in Digital Transformation is only looking at their internal activities and systems (Cimini et al., 2020; Plomp & Batenburg, 2010). However, organisations today rarely operate in isolation but collaborate in various ways with suppliers, customers, or other organisations. It is therefore vital for organisations to include suppliers and customers in the Digital Transformation.

Products
The last technical dimension, products, covers the smartness of the products of an organisation. Comparable to smart processes, discussed in the first dimension, smart products are equipped with sensors, computing, and communication technology. The smart products also add more hard- and software components to the IT architecture, like the smart processes, and thereby influence an organisation's IT architecture design. This dimension assesses if organisations have implemented these smart products and use the information provided by them (Blatz et al., 2018; Schumacher et al., 2019; Trotta & Garengo, 2019).

2.4.2 Discussion
As discussed in detail in Section 1.2.2, IT architecture is the overall design of hard- and software components that support an organisation's business systems and IT-enabled processes. Since all the previously mentioned dimensions require some sort of technological implementation, they all influence the IT architecture. The operations & processes dimension, for example, suggest beginning with standardising and digitising work activities. Consequently, organisations need to implement an application or technological components to realise the digitisation of this activity. Another example is the ability to collect, process, and use data, which requires the use and thus the implementation of sensors and other computing technologies. As mentioned, this also has an impact on the IT architecture.

Besides that the dimensions all have an impact on IT architecture, they also impact each other. Take, for example, the dimension data, which is influence by all other technological dimensions. Digitising processes or implementing new technological innovations leads to increased data supply and usage, thus increasing the importance of data management. Unfortunately, this overlap cannot be prevented since many mentioned components are heavily dependent on each other.

Due to this interaction, there could be a correlation between the maturity levels of different dimensions (Blatz et al., 2018). An example of this is a scenario where an organisation has a very traditional (production) process, meaning that the organisation probably does not have a high maturity in the other

technological dimensions as well. Nonetheless, it does not mean that an organisation with a high maturity on the dimension Operations & Processes, due to smart processes, automatically scores high on the other dimensions. An organisation could have implemented smart processes, but the way data is stored, and processed could still not be according to high standards.

This overlap and, especially, the interaction of dimensions confirms the notation that a Digital Transformation process is a challenging process that simultaneously impacts multiple aspects of an organisation. This organisational-wide impact poses a challenge regarding the design of the IT architecture of the organisation and requires a carefully designed roadmap.

2.4.3 Summary

This section discussed five technological dimensions and how they influence each other. Each dimension impacts the IT architecture of an organisation, often in multiple ways and organisation-wide, which poses a challenge regarding Digital Transformation and requires a carefully designed roadmap.

2.5 Challenges

The previous sections discuss how current maturity models measure digital maturity and, in particular, evaluate the IT architecture. The previous research question also mentions some challenges that organisations do experience regarding their IT architecture. However, current digital maturity models do not discuss all challenges. For this reason, this section answers the fourth research question:

RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models?

2.5.1 Shadow IT

During a Digital Transformation, organisations improve their current business activities and at the same time try to add new values and functionalities to these activities. Since these improvements cannot be covered by one "large, all-encompassing" IT application or system, different applications are implemented by organisations (Leyh et al., 2017). This results in a challenge for the IT department, which need to implement and maintain these different applications. Furthermore, implementing new applications during a Digital Transformation also poses the risk of these applications becoming isolated operating components within the IT architecture of an organisation. Especially if these applications are developed without the knowledge of the IT department, also called shadow IT.

Shadow IT systems are applications or extensions to existing software which are not developed or controlled by the central IT department of an organisation (Fürstenau & Rothe, 2014). When there is a misalignment between the functionalities that an enterprise system offers (e.g. ERP systems) and the need for a particular functionality, individual users or departments develop their own solutions to support specific business activities (Zimmermann & Rentrop, 2014). While the development of shadow IT is not mentioned in current digital maturity models, it is a common problem that organisations experience.

Huber et al. (2016) conducted a literature review to provide an insight into the relationship between shadow IT and ERP systems. This review shows some interesting commonalities, differences, and complications between the two concepts. Shadow systems and ERP systems support both business processes. However, shadow systems are developed autonomously and are decentralised solutions, i.e., locally installed applications and spreadsheets. In contrast, ERP systems are developed by the IT department and use one common database and are thus highly centralised. Changing or extending such a system is a complex and timely process. Shadow IT solutions, in contrast, are relative quickly developed and implemented by an individual user. For this reason, users of an ERP system, both individual and departments, develop and implement shadow IT solutions to bypass this extensive implementation process.

Microsoft Excel is the software of choice for developing shadow IT solutions since it is inexpensive, ubiquitous, and relatively easy to work with (Fürstenau & Rothe, 2014). These solutions are, at their implementation, often simple. However, they can become very complex and business process critical during their life cycle (Huber et al., 2016). In addition to the shadow IT solutions, interfaces are created to transfer data between developed shadow solutions and applications developed by the IT department (Fürstenau & Rothe, 2014).

The problem with shadow IT development is that organisations do not experience these challenges directly and may not be aware of them, but indirectly they are experiencing adverse effects. The dependence of these shadow solutions has considerable disadvantages (Fürstenau & Rothe, 2014). To begin with, these shadow solutions are not maintained as well as an enterprise systems system. When a shadow IT solution has become process-critical and has a failure due to poor development or maintenance, it can significantly impact the performance of business activities. In addition, it can affect the transformation of an organisation's IT architecture. These shadow systems are embedded in the daily business activities but not registered at the IT department. Consequently, the IT department's new developed applications do not work since the functionalities and added values of the shadow solutions were not considered. Lastly, there is a significant data security risk. With enterprise systems, users need to log in to access the data. The IT department controls these access rights. On the other hand, a shadow solution is often a local application or file, which is not as securely managed, especially if the file is openly shared, e.g., via email or shared drives.

2.5.2 Summary

This section covers shadow IT and its risks. Shadow IT solutions are developed to overcome the deficiencies of enterprise systems. However, the development is done without the knowledge of the central IT department, which poses several risks for the organisation.

2.6 Digital Transformation Methodologies

By now, it is clear that Digital Transformation is not a simple process but that it requires multi-disciplinary activities and has an organisation-wide impact. As a result, there is a demand from organisations for a simple approach that guides them during a digital transformation. However, there is a lack of prescriptive digital maturity models that help to guide organisations during their Digital Transformation. In addition, it became clear in the second research question that even current prescriptive maturity models do not provide sufficient support during the entire improvement process. Therefore, this section examines what literature does exist, explaining how organisations need to carry out their Digital Transformation and thereby answers the fifth research question:

RQ5: What methodologies do exist in literature to carry out Digital Transformation and IT projects?

2.6.1 Agile Methodologies

The literature shows a development where organisations start with Digital Transformation also strive to become agile (Fuchs & Hess, 2018). This change is mirrored from the software industry (Porter & Heppelmann, 2015), which is not surprising. With the evolution of smart products and the digitalisation of business activities, organisations are required to have an IT department that essentially operates as an internal software company. In addition to agile software development, organisations are also implementing agile methods in areas such as product development (Bharadwaj et al., 2013). This described trend seems to be a positive one. Observations from case studies demonstrate that organisations working according to an agile methodology succeed more often in their Digital Transformation (Wolf et al., 2018).

Agile methodologies work with small incremental releases of upgrades and implementations instead of long-term, major releases. The advantage is that organisations get new products and services faster to the market to be responsive to and meet customer needs (Fuchs & Hess, 2018; Porter & Heppelmann, 2015). In addition, the iterative nature of agile methods incorporates elements like learning from

mistakes, quick evaluation and adjustment of development paths and a quick trial and error. This advances the improvement process of internal business activities as well (Wolf et al., 2018).

2.6.2 Bimodal IT Development

Organisations are trying to adapt and exploit the opportunities that come with Digital Transformation. However, many, especially older organisations, are facing several challenges doing so. Digital-born pioneers have an advantage because they have entered the market with digitally supported solutions. Besides that, the systems on which their products, services and business activities rely are newly built and contain the latest digital solutions and trends (Remfert & Stockhinger, 2018; Sebastian et al., 2017). These organisations also show that the digital mentality has its roots throughout the organisation.

In contrast, organisations from before the digital era have to catch up to these digital-born pioneers. These organisations have large and aged enterprise systems and depend on legacy information systems (Haffke et al., 2017). As discussed in the previous section, it takes much time to implement new features in these enterprise systems. Furthermore, the digital mentality is not as present as in those younger organisations. As a result of the points mentioned above, older organisations have more difficulties adapting their business activities to the possibilities that the latest technologies offer.

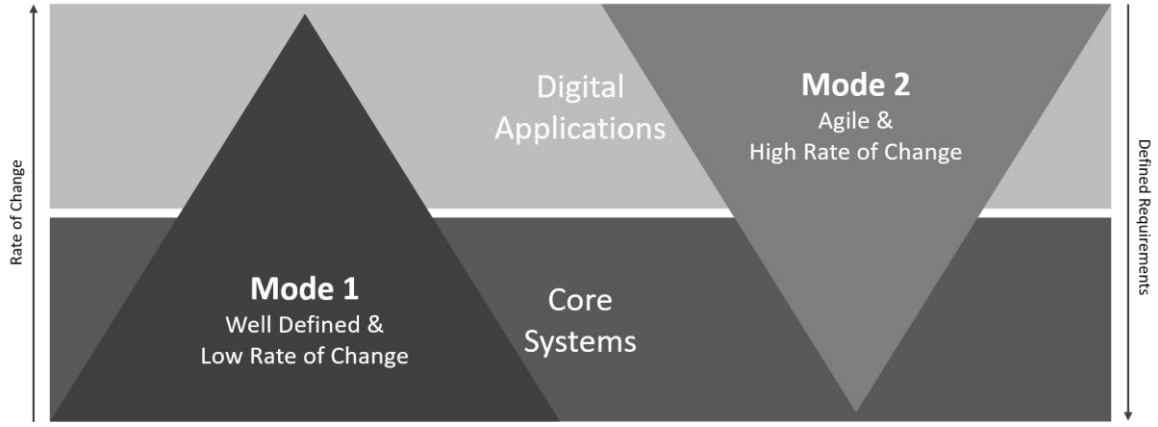

Figure 7: Overview of Bimodal IT characteristics

The dilemma for these organisations is that they want to deliver better services and products to their customers and improve their internal business activities. On the other hand, organisations want to do this reliably without interruptions for their customers and employees. To balance both, organisations need two technology-enabled assets: an operational backbone and a digital service platform (Remfert & Stockhinger, 2018). This Bimodal IT (Haffke et al., 2017; Wolf et al., 2018) enables an agile environment to support the organisation with exploratory digital innovations while maintaining reliable core systems, as shown in Figure 7. Mode 1 includes the maintenance of the core systems. Requirements are well defined, and there is a low rate of change. In contrast, mode 2 has agile requirements and a high rate of change to keep innovating digital applications. These two modes should operate in parallel, a slow-moving process for introducing essential improvements in the enterprise system and a rapid development process for constantly providing the applications in the agile environment with improvements, or in other words, a Two-Speed IT design (Remfert & Stockhinger, 2018).

2.6.3 Summary

This section covers the development where organisations starting with Digital Transformation also strive to become agile. In line with this, literature proposes the Bimodal IT development strategy, which balances between the operational backbone and an agile application environment of an organisation.

3 Design & Development

In this chapter, the proposed IT architecture maturity model (ITA-MM) is designed based on knowledge acquired during the previous chapter's systematic literature review (SLR). First, Section 3.1 examines the development strategy. Second, Section 3.2 states the goal and requirements. After which, Section 3.3 develops the initial version of the ITA-MM. Lastly, Section 3.4 discusses the design of a roadmap to guide organisations during their Digital Transformation journey. Subsequently, this chapter, and the following chapter, answer the sixth research question and four sub-questions:

RQ6: How to design a generally applicable maturity model for organisations, including a self-assessment model and a roadmap?

RQ6.1: What are the guidelines to develop a maturity model?

RQ6.2: What are the goals and requirements of the ITA-MM?

RQ6.3: How to systematically assess the IT architecture of an organisation?

RQ6.4: How to provide a roadmap for organisations to start with optimising their IT architecture?

3.1 Development Strategy

One of the goals of this research is to design a scientific profound IT architecture maturity model. Therefore, this thesis uses the Design Science Research Methodology (DSRM) as a research methodology. The DSRM is a well-known methodology in the information systems field. Section 1.3.4 discusses the DSRM in more detail. However, there are several guidelines for developing a maturity model, which the DSRM does not cover. Consequently, this section discusses a short review investigating existing guidelines for the development of maturity models.

3.1.1 Guidelines for Developing Maturity Models

Current maturity models often do not specify which methodology and methods are adopted or researchers use their own methodologies, even though there are some well-formed methodologies in the scientific community (Pereira & Serrano, 2020). Based on citation count and the references found in the papers used in this research, the guidelines of Becker et al. (2009) and de Bruin et al. (2005) are the most well-known guidelines for developing a maturity model. The two models are shortly discussed below. Table 7 presents an overview of the two guidelines mapped to the phases of the DSRM.

De Bruin et al. (2005) concluded that there were no proper guidelines for developing maturity models. Therefore, the authors were one of the first who designed a theoretically sound, rigorously tested and widely accepted development guideline. This guideline includes the following six phases:

Phase 1 – Scope: Determines the scope and stakeholders of the maturity model.

Phase 2 – Design: Works out a design that forms a basis for further development.

Phase 3 – Populate: Identifies what and how the maturity model measures.

Phase 4 – Test: Demonstrates the maturity model to assess the model's construct and the validity, reliability, and generalisability of the model's instruments.

Phase 5 – Deploy: The maturity model is made available for use.

Phase 6 – Maintain: Maintaining the model over time ensures an enduring relevance of the maturity model.

DSRM (Peffers et al. 2007)	Bruin et al. (2005)	Becker et al. (2009)
Problem identification	Scope	Problem definition
Define objects for a solution	Design	Comparison of existing Maturity models
Design & Development	Populate	Determination of development strategy & Iterative maturity model development
Demonstration	Test, Deploy	Conception of transfer and evaluation & Implementation of transfer data
Evaluation	Maintain	Evaluation
Communication		

Table 7: DSRM compared to maturity model development guidelines

The development guideline from Becker et al. (2009) bases the guidelines on the design science research method (Hevner et al., 2004). This method is a well-known method within the information system research but is not specific for maturity model development. Becker et al. build on top of this model by proposing seven guidelines specific to maturity model development:

Problem definition – Defines the problem that the model aims to solve.

Comparison of existing maturity models – Compare existing maturity models to increase knowledge and determine the design strategy.

Determination of development strategy – Constructing a completely new model, developing a model by combining existing models or transferring parts of existing models into a new model.

Iterative maturity model development – The development of the maturity model is done based on an iterative approach.

Conception of transfer and evaluation – Share the results with the academic and practitioner community.

Implementation of transfer media – Make the maturity model accessible to the target audience.

Evaluation – Test whether the maturity model provides the projected benefits. If insufficient, a reiteration of the design process is possible.

3.1.2 Development Guideline ITA-MM

This thesis applies the DSRM as a research methodology, as discussed in Section 1.3.4. However, the DSRM is a more general methodology for researching and designing an artefact in the IS field. It lacks specific guidelines specifically designed for the development of maturity models, as explained in the previous section. Consequently, the decision is made to extend the DSRM with guidelines from Becker et al. (2009) and implement several concepts from the study of Bruin et al. (2005) during the development of the ITA-MM. Using these guidelines results in a more rigorous design process for the ITA-MM. Figure 8 shows the phases of the guideline used during the development of the ITA-MM. Below is discussed how the phases of the guideline are applied to this research:

- *Phase 1. Problem definition* starts with identifying the research problem, establishes the research relevance and formulates the research goals. The problem statement of this research, Section 1.3.1, discusses the problem definition.
- *Phase 2. Comparison of existing maturity models* identifies current digital maturity models by performing a systematic literature review using the approach of Kitchenham & Charters (2007). Chapter 2 covers the review and analysis.

- *Phase 3. Determination of the development strategy* advances from the analysis of the current digital maturity models. Based on the results, Section 3.1.3 determines the development process for the ITA-MM, based on several strategies proposed by Becker et al. (2009).
- *Phase 4. Iterative model development* covers the actual development of the ITA-MM. The first iteration, discussed in Section 3.3, develops the initial version of the ITA-MM. After which, Chapter 4 validates the initial version and covers the second development iteration.
- *Phase 5. Conception of transfer and evaluation, Implementation of transfer data* and *Evaluation* are combined into a case study. This phase demonstrates the use of the ITA-MM in practice by carrying out a case study at ADIL and evaluates the applicability of the model and roadmap. Chapter 5 discusses the execution and results of the case study.

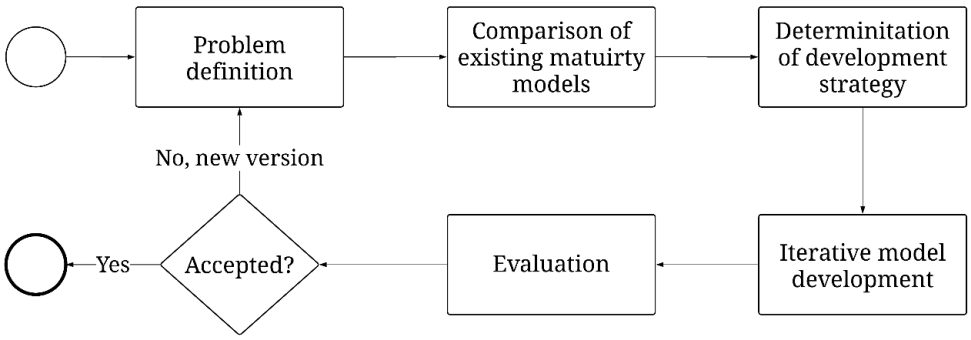

Figure 8: Maturity model development guideline based on Becker et al. (2009)

3.1.3 Determination of Development Strategy

The research of Becker et al. (2009) proposes several basic development strategies for a maturity model: constructing a completely new model, enhance an existing model, combining several maturity models into a new one and lastly, transferring parts of the structure or content from existing models into a new model. Based on the comparison of existing digital maturity models, there is a strong indication that several relevant dimensions will be included in the ITA-MM. However, some new concepts are added since there are aspects that current digital maturity models do not cover. The last development strategy is, therefore, the best strategy for developing the ITA-MM.

The guidelines of Becker et al. (2009) propose an iterative development approach. Each development iteration has a different objective to design and test a section of the model. The first iteration develops an initial version of the ITA-MM based on the results from the literature review. The initial version of the ITA-MM uses concepts from existing maturity models and draws up new concepts to overcome the flaws of existing models. The initial version is validated with user and expert interviews. The second development iteration refines the initial version based on the results from these validation interviews.

3.2 Goal and Requirements

The research design of this thesis shortly discusses several requirements for the ITA-MM. However, to give more structure to these requirements, two decision tables from Bruin et al. (2005) are used. Table 8 and Table 9 show the decisions, which are discussed in more detail below. The bold text in the tables indicates the requirements for the ITA-MM.

Criterion	**Characteristic**			
Focus of model	**Domain-Specific**		General	
Development Stakeholders	Academia	Practitioners	Government	**Combination**

Table 8: Decisions when scoping a maturity model based on de Bruin et al. (2005)

The scope of the model, as discussed in the research design, is a domain-specific focus. The ITA-MM scope is service-oriented organisations and assesses the maturity of the IT architecture at these organisations. The development stakeholders are both academia and practitioners since the ITA-MM is developed for a master thesis. Subsequentially, the model must meet specific scientifical requirements and thus has academic stakeholders. The need to meet scientific requirements is reinforced because current digital maturity models are often not developed scientifically. The ITA-MM tries to overcome this lack of scientific development. Besides this, the model does take the practitioners stakeholders into account since these are going to use the ITA-MM.

Criterion	**Characteristic**		
Audience	**Internal**	External	
Method of Applications	**Self-Assessment**	Third party Assisted	Certified Practitioner
Driver of Application	Internal Requirement	**External Requirement**	Both
Respondents	Management	**Staff**	Business Partners
Application	1 entity / 1 region	**Multiple entities / single region**	Multiple entities / multiple region

Table 9: Decisions when designing a maturity model based on de Bruin et al. (2015)

Table 9 shows the decisions about the maturity model. The audience is internal since the employees of an organisation are the audience. The application method is a self-assessment, which is also one of the requirements of the ITA-MM. The driver of the application is external since this research identifies a gap between practice and literature, which describes the challenge of organisations that are not aware of how their IT architecture performs and do not know how to improve. Respondents are primarily the people on the work floor, thus the staff. Although, the ITA-MM is also relevant for the management. The last consideration is the representation of the maturity stages. The ITA-MM focuses only on the IT architecture of an organisation and has, therefore, a single region. The model has multiple entities since the model addresses several areas within the IT architecture.

A requirement not mentioned in the tables but discussed in the research design of this thesis and by de Bruin et al. (2005) is the type of maturity model. The three types of maturity models are descriptive, prescriptive, and comparative. Section 1.2.3 discusses the different types of maturity models in more detail. The ITA-MM has a prescriptive approach since the goal is to guide organisations during their Digital Transformation. Two functional requirements are fundamental for prescriptive maturity models (de Bruin et al., 2005). The requirements are mapped to this research:

1. The ITA-MM must enable a self-assessment of the current IT architecture. In addition, it needs to be clear how to measure and assign the maturity level.
2. The ITA-MM must enable the identification of improvement measures and their priority.

3.3 First Development Iteration of ITA-MM

This first development iteration of the ITA-MM synthesises the maturity levels of existing models. Subsequently, the addition of a new dimension is discussed and corroborated. After which, the maturity levels of the ITA-MM are identified. Lastly, this section proposes the initial version of the ITA-MM.

3.3.1 Identifying Relevant Dimensions & Capabilities

The third research question, covered in Section 2.4, discusses the most frequently mentioned technological dimensions in the 14 digital maturity models. These dimensions have a high potential to be included in the ITA-MM since they all significantly impact the IT architecture of an organisation. However, some of the dimensions are more focused on the manufacturing industry and are less relevant for service-oriented organisations, which is the focus of this research. Consequently, those dimensions

are not included in the ITA-MM. Applying this filter on the technological dimensions results in four initial dimensions for the ITA-MM: operations & processes, technology, data, and IT infrastructure. The remainder of this section discusses each dimension, including some capabilities per dimensions mentioned by current digital maturity models. Figure 9 summarises the capabilities per technological dimension. Section 2.4 discusses the dimensions in more detail.

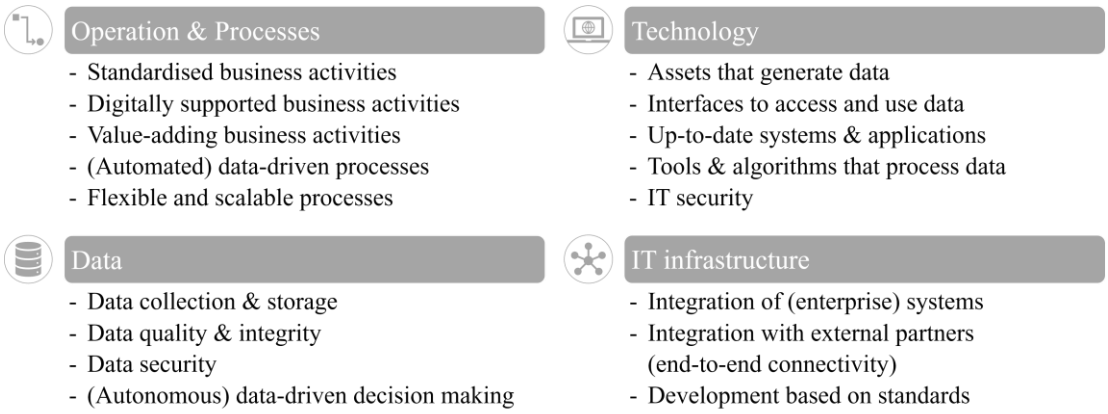

Figure 9: Core capabilities per technological dimension

The operations & processes dimension deals with the execution of business activities and tasks within an organisation. According to 11 digital maturity models, organisations need to make their processes more efficient and reliable by digitising and automating their processes where possible. Having digital processes also enables organisations to add new and improved services and functionalities to these processes.

The technology dimension evaluates the use of technological capabilities in an organisation. In the digital maturity models from the SLR, many of these capabilities focus on manufacturing processes. However, many technologies can be implemented in service-oriented processes as well. Some of the capabilities in the technology dimension relate to data. However, the difference between the Technology and Data dimensions' capabilities is that Technology capability includes tools and assets that generate and process data. In contrast, the data dimension discusses how the data is handled and saved.

Data is an essential and yet underestimated dimension. Nowadays, data is often a given, but studies indicate that available data must be handled with greater care. IT security is a critical aspect since data is valuable. In addition, data must support a defined purpose, as just collecting data might result in non-relevant data and a waste of expensive resources.

Lastly, the IT infrastructure is the hard- and software that facilitates all the systems used for carrying out the business processes. A vital aspect mentioned by the digital maturity models is the end-to-end connectivity of systems to provide every user with the required information.

Shadow IT

The fourth research question discusses shadow IT, a challenge that many organisations experience. However, current digital maturity models do not cover this topic. The development of applications and other IT solutions without the knowledge of the IT department poses many risks to, among others, IT security and the continuity of business activities. The biggest argument for users to develop shadow IT is to overcome the complexity and timely process of implementing new or missing functionalities in enterprise systems. As a result, users implement their own small shadow IT solutions, which they can quickly develop and implement. Section 2.5.1 discusses shadow IT and its disadvantages in more detail.

Managers or third-party assessment teams assess the digital maturity in current models, which could explain why current digital maturity models do not specifically mention the use of shadow IT. These

people are not aware of the shadow IT used within an organisation since individual users or departments develop shadow IT outside of the scope of managers and the IT department. However, the audience of the ITA-MM is the individual user who is aware of the shadow IT usage or even develops it. Therefore, it makes sense to include a dimension in the ITA-MM that assesses shadow IT use within an organisation. This way, the ITA-MM raises awareness among the users and developers of shadow IT since they are often unaware of the risks associated with developing these solutions.

Third-party involvement

A challenge mentioned in various digital maturity models is the lack of customer focus when optimising business activities (Blatz et al., 2018; Cimini et al., 2020; Plomp & Batenburg, 2010). This is compelling since the fact is that sales generate revenue, and thus customer satisfaction is a vital aspect for organisations. Furthermore, these same models state that customer needs are continuously changing due to technological changes. Consequently, the ITA-MM emphasises the involvement of third parties during the optimisations of business activities and consideration of the impact processes have on activities from third parties.

Data integrity

The studies of Blatz et al. (2018) and Leyh et al. (2017) discuss data integrity. However, the dimensions do not reflect much on this capability. For example, Leyh et al. mention in the first level of their maturity model that data integrity is not guaranteed, yet the model does not mention in any of the levels if the integrity is guaranteed. Furthermore, Leyh et al. mention the lack of data integrity in the technology dimension, while it would be more comprehensible to add this capability to the data dimension. As a result, the ITA-MM implements data integrity within the data dimension.

Author	Levels	Stages	0	1	2	3	4	5
CMMI	1 to 5	Seq. stages		Initial	Managed	Defined	Quantitatively managed	Optimizing
Basl & Novakova (2019)	0 to 5	Seq. stages						
Blatz et al. (2018)	1 to 3	Cont. stages						
Chonsawat & Sopadang (2019)	0 to 4	Seq. stages	Not relevant	Not implemented	Partly implemented		Mostly implemented	Fully implemented
Cimini et al. (2020)	N/A	N/A						
Colli et al. (2019)	0 to 5	Seq. stages	None	Basic	Transparent	Aware	Autonomous	Integrated
Cuylen et al. (2016)	0 to 4	Seq. stages	Non-existent	Initial	Encouraged		Enabled/ performed	Continuous improvement
De Carolis et al. (2018)	1 to 5	Cont. stages		Initial	Managed	Defined	Integrated and Interoperable	Digital Oriented
Gollhardt et al. (2020)	N/A	N/A						
Leyh et al. (2017)	1 to 5	Seq. stages		Basic Digitization	Cross-Department Digitization	Horizontal and Vertical Digitization	Full Digitization	Optimized Full Digitization
Plomp & Batenburg (2010)	2 x 1 to 4	Seq. stages	No chain automation / No chain collaboration	E-Business / Bilateral collaboration		E-Collaboration/ Multilateral Collaboration		Open & n-tier sourcing / Extended chain
Schumacher et al. (2019)	1 to 4	Cont. stages						
Trotta & Garengo (2019)	1 to 5	Cont. stages						
Valdez-de-Leon (2016)	0 to 5	Seq. stages	Not started	Initiating	Enabling	Integrating	Optimizing	Pioneering
Zaoui & Souissi (2020)	1 to 3	Seq. stages		Low		Moderate		High

Table 10: Comparison of maturity levels from the identified digital maturity models

3.3.2 Identifying Maturity Levels

Table 10 presents the maturity levels from all 14 digital maturity models. Many maturity models, including the relevant digital maturity models from the SLR of this research, base their maturity levels on the Capability Maturity Model Integration (CMII, 2010) or refer to the CMMI. Consequently, the CMMI is added to the table to compare the level definitions from the maturity models to the CMMI definition.

All maturity levels are mapped to the CMMI definition to make this comparison. However, several levels were rearranged since some models use three or four levels. Furthermore, some maturity models introduced a level 0, in addition to the start level 1 from the CMMI. This level 0 indicates that there are no initiatives taken to start with Digital Transformation. Table 10 shows the rearrangement of the levels so that they are correctly aligned with each other. For example, the last two dimensions of the model from Chonsawat & Sopadang (2019) are now mapped to the fourth and fifth dimensions instead of the third and fourth dimensions.

There are two different ways to identify a maturity level, sequential and continuous stages. Models using continuous stages calculate the maturity using a formula, resulting in a continuous value. With sequential stages, an organisation moves to a higher level by implementing specific (recommended) improvements. These models have an integer value as maturity level.

All levels from current digital maturity models are reviewed to identify the maturity levels of the ITA-MM. Based on this review, the ITA-MM implements a maturity scale from 0 to 5 with sequential stages. Resulting in a total of 6 subsequent levels, which ensures clear and concise levels for the self-assessment. The ITA-MM includes level 0 to indicate the absolute start for organisations that are not started with their Digital Transformation. Table 11 shows an overview and description of the levels. The following section discusses how the maturity level is determined.

Level		Description
0	Non-existent	The organisation has not started with Digital Transformation
1	Initiating	The decision is made to move toward a Digital Enterprise, and initial steps are taken
2	Enabling	First initiatives are implemented and form a foundation for further improvements
3	Integrating	Integration of initiatives across the organisation, first steps towards end-to-end connectivity
4	Optimising	Initiatives are fine-tuned and further improved to increase overall performance
5	Continuous improvement	Initiatives are continuously improved, and there is full end-to-end connectivity

Table 11: ITA-MM maturity levels

3.3.3 ITA-MM Version 1.0

This section presents the initial version of the ITA-MM. The previous section identified the dimensions, capabilities, and maturity levels for the initial version of the ITA-MM. Table 12 shows the high-level maturity model to operationalise the ITA-MM. The columns and rows represent the five dimensions and six maturity levels. The capabilities delineate per dimensions the maturity level. Appendix B covers the capabilities used to carry out the maturity assessment in more detail.

	Level	Operations & Processes	Technology	Data	Integration	Shadow IT
0	Non-existent	BA are not digitally supported.	No tools that generate digital data.	No data is collected.	There is no integration.	Users make use of non-digital solutions to assist their work.
1	Initiating	Standardised BA, and first initiatives to digitise BA and collect data.	First tools in place that collect data from BA, no IT security in place.	Data is collected and available for eventual needs, and data availability and integrity are not guaranteed.	Some initial application integrations on a user level.	Users make personal tools to support work activities without sharing the (existence of the) tools.
2	Enabling	Systems and applications in place to support digital BA and use digital data, considering customers and suppliers during improvement initiatives.	Interfaces in place to access and visualise data, implementation of IT security.	Data is collected and shared where needed.	Integration of ES on a departmental level.	The development of tools is documented and discussed within a department.
3	Integrating	Integration of third-party services and tools in BA in cooperation with third parties, and processes are scalable.	Tools in use to process and analyse data, and advanced IT security, authentication of access.	Analysis of data to better understand business insights.	Cross-departmental integration and development based on standards.	New ideas or functionalities are proposed to the IT department, which does the development.
	Optimizing	Optimised BA, and real-time use of data to make decisions.	Tools are capable of acting autonomous based on data.	Data-driven decision making, and data integrity is guaranteed.	Enterprise-wide integration and development based on a single standard.	Functionalities are implemented with cooperation between users and the IT department.
5	Continuous improvement	CI of BA, in cooperation with customers and suppliers, full implementation of real-time automated decision making.	Use of advanced algorithms, real-time optimisation of BA and IT security.	Autonomous data-driven decision making.	Integration throughout the whole SC, end-to-end connectivity.	Departments have the ability to maintain their systems and implement small features under the supervision of the IT department.

Table 12: ITA-MM high-level overview

The capabilities determine the maturity level per dimension. Each level includes a set of capabilities that an organisation must meet to be situated at that particular level. Each level builds on the previous one. It is possible for organisations to focus on a single or a couple of dimensions at once, resulting in different levels among the dimensions. Figure 10 shows this visually.

An overall maturity is calculated by summing up each dimension's maturity level and dividing the sum by five. This overall maturity indicates the general IT architecture maturity. This can easily be communicated to stakeholders, management, etc. Furthermore, if a maturity level from a specific dimension is much lower than the overall maturity, it can be considered a weakness. On the other hand, if a dimension's maturity level is much higher, it identifies a strength.

	D1	D2	D3	D4	D5
L0			X		
L1	X				X
L2		X		X	
L3					
L4					
L5					

Figure 10: Example of an assessment with different maturity levels per dimension

Prescriptiveness
Besides that, the capabilities determine the current maturity level, they also have a prescriptive purpose. Organisations can use the capabilities from higher maturity levels to set as their goal and determine what improvements to make to reach a higher maturity level. However, the ITA-MM does not suggest that level 5 is a requirement for all organisations. Instead, the model gives an indication of the current maturity and suggests what improvements an organisation could make. It is, however, to the organisation to decide their objective maturity level. The ITA-MM roadmap, developed in the following section, further increases the prescriptiveness of the ITA-MM.

3.4 ITA-MM Roadmap

With the help of the current version of the ITA-MM, organisations can assess their IT architecture. However, one of the requirements for developing the ITA-MM is to design a prescriptive maturity model that guides organisations. Therefore, this section discusses the development of a roadmap that helps organisations to use the ITA-MM properly, identify improvement opportunities and guide them during their Digital Transformation.

The remainder of this thesis uses the concept development team to indicate the team which is actively involved in the Digital Transformation and uses the ITA-MM and roadmap to improve the IT architecture of their organisation. Furthermore, stakeholders are involved in the transformation and during the execution of the roadmap. However, they are not part of the development team. Stakeholders could be both internal and external.

The roadmap is based on the three prescriptive digital maturity models found during the systematic literature review. Table 13 shows an overview of the three assessment approaches. The second research question, covered in Section 2.3, discuss the prescriptive models in more detail. One of the conclusions was that these prescriptive maturity models assist organisations in determining digital maturity and identifying improvement opportunities. However, the models do not guide organisations throughout the Digital Transformation journey. Therefore, the ITA-MM gives more attention to developing a roadmap that also includes a development approach, a development phase and an evaluation phase which evaluates both the execution of the roadmap and the maturity level of the improved situation.

Colli et al. (2019)	De Carolis et al. (2018)	Schumacher et al. (2013)
Iterative approach		
Creation of awareness within the organisation		Creation of participant alignment and commitment
		Collection of company's activities
Definition of scope		
Data collection	Maturity assessment	Maturity assessment
Evaluation and solution selection	Strengths and weakness identification	Data collection and creation of maturity report
	Opportunities identification	Determination of company goals
		Set target maturity levels
		Select items with a large maturity gap to improve
		Development of realisation paths
		Specification of action fields
	Digital roadmap definition	Roadmap definition
Debriefing		

Table 13: Comparison of prescriptive assessment methods

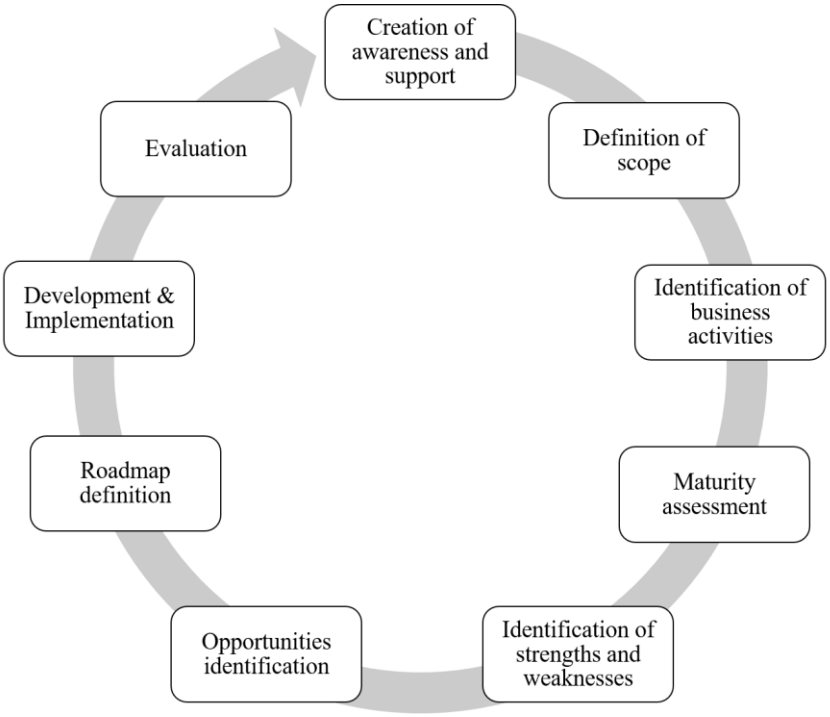

Figure 11: ITA-MM Roadmap

Digital maturity is not a static concept because the digital landscape is changing continuously (Teichert, 2019). Therefore, organisations need to continuously improve their processes and thus assess their IT architecture maturity over time. In addition, agile methods have proven successful in carrying out Digital Transformation projects, as discussed in Section 2.6.1. As a result, the roadmap is an iterative approach. Figure 11 shows the nine steps of the roadmap, which are discussed below in more detail.

Each iteration has a project start in which the development team describes in short what the iteration is about and applies an initial scope if necessary. This helps to identify and include stakeholders from the start of the project. Furthermore, it already gives an indication of the scope and goal of the iteration.

Creation of awareness and support

This first phase aims to create digital awareness and support throughout the organisation with the help of multiple creative sessions. Several studies mention that it is critical for all stakeholders to have an open mindset towards Digital Transformation for it to succeed (Blatz et al., 2018; Chonsawat & Sopadang, 2019). Other studies also discuss the importance of employees with a proactive attitude during Digital Transformation (Cuylen et al., 2016; Gollhardt et al., 2020; Valdez-de-Leon, 2016). This includes having employees with an affinity for IT and digital solutions willing to improve their IT skills and thrive the organisation towards a higher maturity. In addition, the readiness to collaborate and share is a critical factor. This digital collaboration culture increases the amount of knowledge and information shared within an organisation. Which in turn, ensures that more information is available during the Digital Transformation, resulting in more visibility and better-informed choices (Cimini et al., 2020; Gollhardt et al., 2020; Lotfi et al., 2013; Wolf et al., 2018). Figure 12 summarises the inputs, activities, and outputs of this phase.

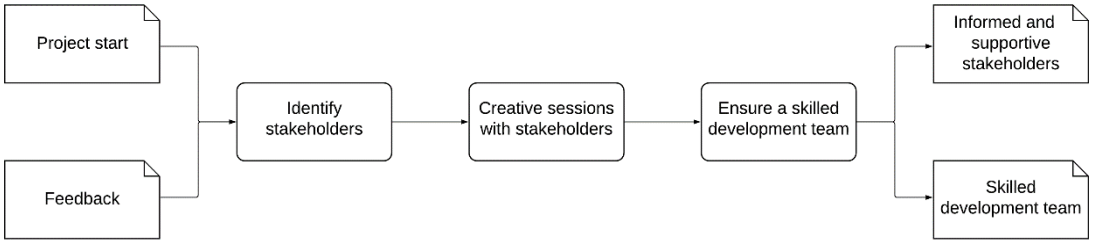

Figure 12: Inputs, activities, and outputs of phase 1

Definition of scope

During the second phase, the development team and stakeholders discuss to reach a common understanding of the scope and goal of the current iteration. The ITA-MM facilitates different opportunities for an organisation to assess its IT architecture. The model can be used to assess and improve a single process, evaluate the IT architecture maturity of a specific department, or carry out an organisation-wide assessment. Not having sessions to identify the scope and goal often results in highly diverse and even contradictory expectations (Schumacher et al., 2019). Concept ideas from stakeholders not included in the scope and goal of this iteration are added to a list for future iterations. In addition, this step identifies all the key challenges and limitations. Figure 13 summarises the inputs, activities, and outputs of this phase.

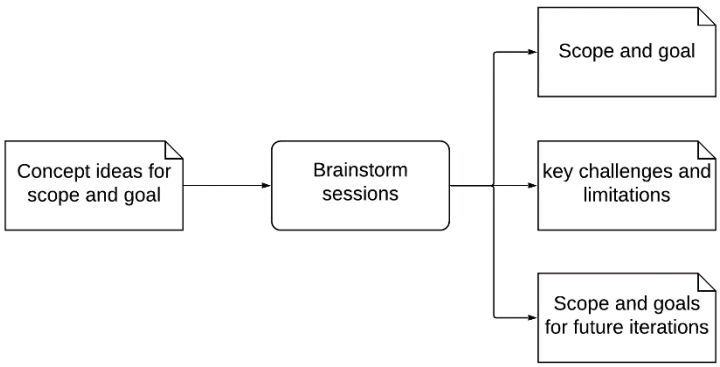

Figure 13: Inputs, activities, and outputs of phase 2

Identification of business activities

The third phase identifies and documents the organisation's current business activities and the current digitalisation initiatives and activities, which are part of the iteration scope. Understanding the "as-is" situation gives a foundation for contextualising the maturity assessment performed in the next phase. The "as-is" situation is also the start point for the identification of strengths and weaknesses, improvement opportunities identification, roadmap definition and development phase. Moreover, the new situation is compared with the "as-is" situation during the evaluation phase. Lastly, the "as-is" situation serves as a reference for the development team to trace changes from previous iterations and visualise the transformation of the organisation.

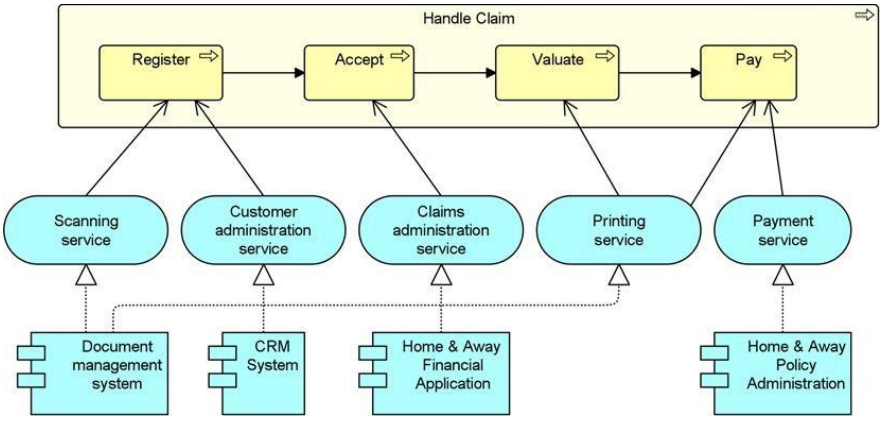

Figure 14: Business process viewpoint example

The roadmap proposes to visualise the organisation's business activities according to the ArchiMate standard, which is discussed in detail in Section 1.2.2. Figure 14 shows an example of an ArchiMate model that visualises a business process and the applications realising the business activities. Figure 15 summarises the inputs, activities, and outputs of this phase.

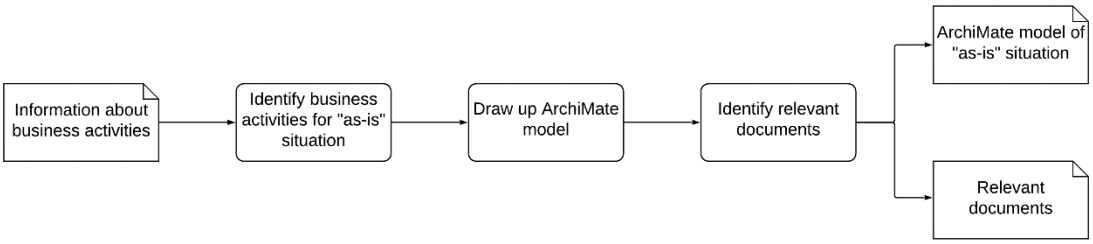

Figure 15: Inputs, activities, and outputs of phase 3

Maturity assessment

This fourth phase assesses the maturity of the organisation's IT architecture. The development team uses the presented ITA-MM to determine the maturity level of the "as-is" situation for each of the dimensions. The individual team members and stakeholders with enough knowledge about the IT business activities and IT architecture fill in the self-assessment. After which, all maturity assessments are compared with each other to determine an average maturity level for each dimension. The individual assessments are still relevant for the following phases to determine the strengths and weaknesses and identifying improvement opportunities. Figure 16 summarises the inputs, activities, and outputs of this phase.

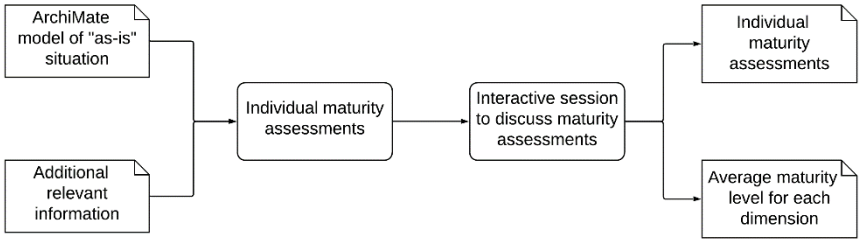

Figure 16: Inputs, activities, and outputs of phase 4

Identification of strengths and weaknesses

In the fifth phase, the development team and stakeholders identify the strengths and weaknesses of the IT architecture. In general, if a dimension has a maturity level of two or lower, it is considered a weakness. A maturity level of four or higher is considered a strength. The third maturity level is either a strength or weakness, depending on the goals agreed on in phase two. However, this does not apply to all organisations. When the organisation has an appropriate reason, they can choose to move away from this identification method. In addition, significant deviations between dimensions indicate strong and weak dimensions. Figure 17 summarises the inputs, activities, and outputs of this phase.

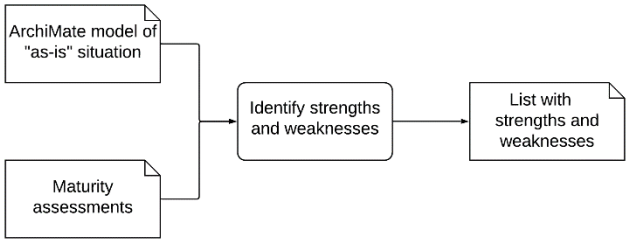

Figure 17: Inputs, activities, and outputs of phase 5

Opportunities identification

Phase six identifies improvement opportunities based on the “as-is” situation and the strengths and weaknesses from phases two and five. While analysing the identified opportunities, some may be unfeasible to the organisation. When this is the case, it is important to understand why (De Carolis et al., 2018). Some reasons might be related to the lack of resources or no genuine interest of the organisation to change. After discussing the unfeasible opportunities, the development team either removes them or takes action to overcome the reasons behind them. To this end, the team obtains a concrete overview of what actions to undertake to improve IT architecture maturity. Figure 18 summarises the inputs, activities, and outputs of this phase.

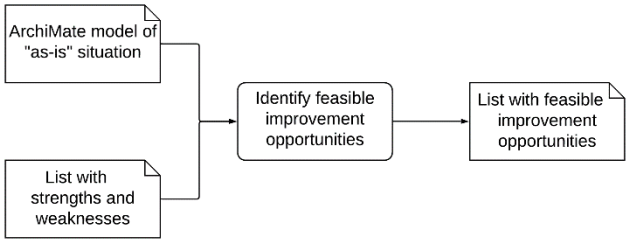

Figure 18: Inputs, activities, and outputs of phase 6

Roadmap definition

The seventh phase starts with prioritising the feasible opportunities, according to a ranking logic agreed on by the development team and stakeholders. Examples of ranking strategies are prioritisation based on ease of implementation, highest cost savings or time reduction. The following step is to cluster similar opportunities, which can be realised simultaneously by a single solution. After clustering, the team and stakeholders visualise the preferred situation in an ArchiMate model. Subsequently, they define concrete next steps, responsibilities, and a timeline for the opportunity or cluster of opportunities with the highest prioritisation to realise the preferred situation.

In addition, they define a realisation path for developing and implementing the improvement. The fifth research question of this research, covered in Section 2.6, proposes using a Bimodal IT development strategy. This strategy develops solutions in an agile way, parallel to the organisation's day-to-day operations, resulting in a reliable IT operation. Opportunities not included in this improvement cycle are added to a list for reference during future iterations. Figure 19 summarises the inputs, activities, and outputs of this phase.

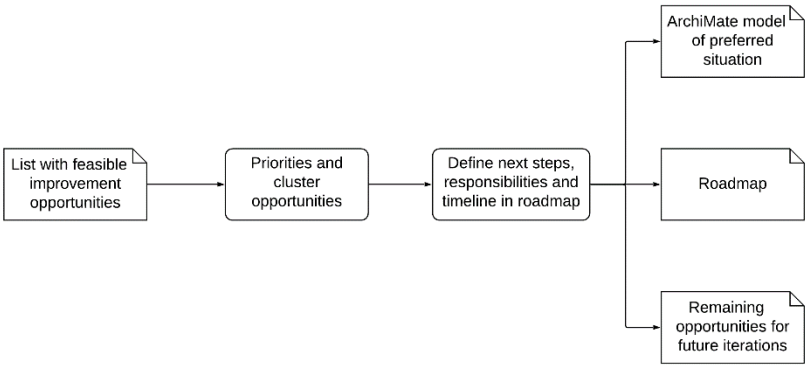

Figure 19: Inputs, activities, and outputs of phase 7

Development & Implementation

Phase eight covers the development and implementation of the improvement based on the previous phase's chosen strategy. Depending on the chosen opportunities, this phase could take relatively more time than the other phases. This phase results in the implementation of a fully functional solution. Figure 20 summarises the inputs, activities, and outputs of this phase.

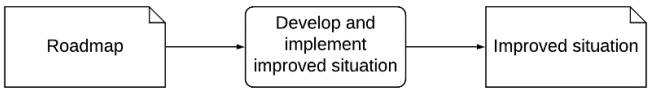

Figure 20: Inputs, activities, and outputs of phase 8

Evaluation

The last phase evaluates the execution of the iteration cycle and the implemented solution. The development team discusses with the stakeholders all experienced obstacles during any of the phases since they could learn from them. Furthermore, they identify if the solution improved the maturity for the chosen opportunity and if the solution impacted other unforeseen areas. Figure 21 summarises the inputs, activities, and outputs of this phase.

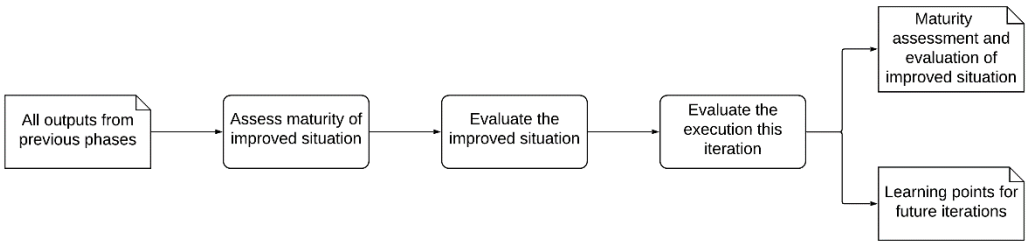

Figure 21: Inputs, activities, and outputs of phase 9

3.5 Summary

This chapter discusses the first development iteration of the ITA-MM and roadmap, based on the maturity development guidelines of Becker et al. (2009) and de Bruin et al. (2005). The initial version of the ITA-MM is based on current digital maturity models. From these models, four relevant dimensions are identified: operations & processes, technology, data, and integration. The ITA-MM adds a fifth dimension to evaluate the level of shadow IT use within an organisation. Six levels measure the IT architecture maturity, ranging from no action taken to continuous improvement. Five assessment tables incorporate a set of capabilities used to assess the IT architecture. The capabilities also identify improvement opportunities, ensuring the prescriptive nature of the ITA-MM. This is reinforced with the development of the roadmap. The roadmap consists of nine steps and guides organisations during their Digital Transformation journey.

4 Validation & Refinement

The goal of the ITA-MM is to guide organisations during a Digital Transformation. For this to happen, it is vital that users intend to use the model and roadmap. This chapter, therefore, validates the willingness of users and experts to use the ITA-MM. First Section 4.1 discusses the preparation process of the validation. After which, Section 4.2 covers the validation results. Lastly, Section 4.3 discusses the second development iteration of the ITA-MM.

4.1 Validation preparation

Wieringa (2014) defines the aim of validation as "developing a design theory that allows researchers to predict how an artefact will interact with its context when implemented within the intended problem context". The validation of the ITA-MM consists of two methods. Firstly, this chapter validates the willingness of users and experts to use the ITA-MM. Based on the results, the ITA-MM will be refined. Secondly, the next chapter evaluates the use of the ITA-MM in practice with an implementation study.

4.1.1 Validation Research Goal

The requirements captured before the development of the ITA-MM enable validation by assessing to what extent the ITA-MM meets these requirements when implemented in the intended problem context. Subsequently, the goal of the validation research is to verify whether the ITA-MM meets these requirements. In addition, the validation research investigates the willingness to adopt the ITA-MM.

4.1.2 Validation Research Method

As mentioned at the beginning of this section, validation predicts how the artefact interacts within its intended problem context. The validation research of Wieringa (2014) uses a validation model which represents the target situation. The validation model consists of a model of the artefact interacting with a model of the problem context. These two models represent the target, consisting of the implemented artefact interacting with a real-world problem context. Figure 22 shows a visual representation of the validation model and target.

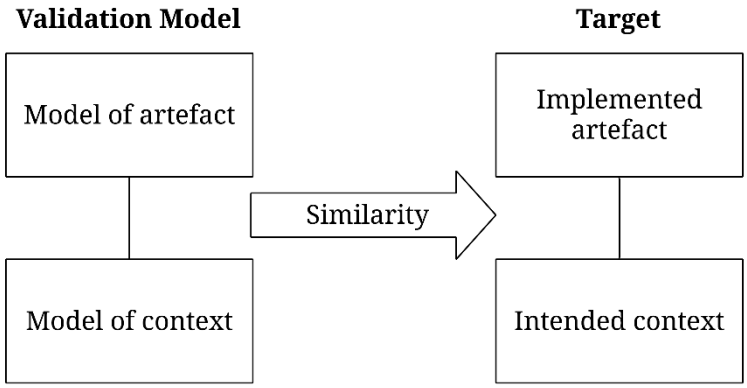

Figure 22: Validation model (Wieringa, 2014)

There are several methods to study validation models. This research incorporates one of the most used methods for qualitative research, user, and expert interviews (Wieringa, 2014), to study the validation model. Within this research, the ITA-MM represents the model of the artefact. The interviews serve as the model of context. During the interviews, users and experts imagine how the artefact will interact within the problem context and predict what the effects will be. If these results do not satisfy the requirements, then the ITA-MM must be redesigned.

In total, there are five participants in the validation research, as shown in Table 14. From the Ahold Delhaize Inbound Logistics department, four employees participate in the validation of the ITA-MM. As these employees are the intended users of the ITA-MM, their opinion on the understandability, ease of use, and usefulness are essential. In addition, there is one expert interview with an expert in the field of Digital Transformation. This participant has a different perspective compared to the employees during the validation of the ITA-MM.

Name (acronym)	Organisation	Role	Experience within organisation / current role
Interviewee A	Ahold Delhaize	Data team	3 years / 8 months
Interviewee B	Ahold Delhaize	Data team	3.5 years / 10 months
Interviewee C	Ahold Delhaize	Data team	1 year / 7 months
Interviewee D	Ahold Delhaize	Data team manager	1.5 years
Interviewee E	Research Organisation	Project manager SCM	2.5 years

Table 14: Participants user and expert interviews

4.1.3 Validation Criteria

This validation research implements the validation template of Salah et al. (2014) to validate the ITA-MM. This template incorporates requirements from various well-known papers on maturity model development, among others the papers from Becker et al. (2009) and de Bruin et al. (2005), which are already discussed in this research. The template includes several validation criteria for the maturity levels, dimensions, and the maturity model's use. In addition, the template proposes a set of statements to score the criteria on a 5-point Likert Scale and a set of open questions for identifying potential improvements. Table 15 shows an overview of all the criteria as incorporated within the validation of the ITA-MM and roadmap.

Criteria	Description
Sufficiency	The maturity levels are sufficient to represent all maturation stages of Digital Transformation.
Accuracy	There is no overlap between maturity level and dimension descriptions.
Relevance	The dimensions are relevant to the IT architecture domain.
Comprehensiveness	The dimensions cover all aspects impacted and involved in the IT architecture domain.
Mutual Exclusion	The dimensions are distinct.
Understandability	The maturity levels, dimensions, capability tables and roadmap are understandable.
Ease of Use	The maturity model, capability tables and roadmap are easy to use.
Usefulness	The maturity model and roadmap are useful for conducting maturity assessments and guiding organisations during their Digital Transformation.

Table 15: Validation criteria based on Salah et al. (2014)

The technology acceptance model (TAM) of Davis et al. (1989) discusses the theory of how users come to accept a particular method or system in the technology field. The research states that the acceptance is based more on how effective the user *thinks* a method is rather than on how effective a method is. According to Davis et al., two factors influence the user's intention to use a method, the perceived usefulness, and the perceived ease of use. The last two criteria from Table 15 are thus essential in determining the intention that users will adopt the ITA-MM. Figure 23 visualises how these two factors influence the intention to use. The definitions of the different concepts are as followed:

- Perceived Ease of Use (PE): the degree to which a person believes that using a particular method would be free of effort.
- Perceived Usefulness (PU): the degree to which a person believes that a particular method will effectively achieve its objects.
- Behavioural Intention to Use (BU): the degree to which an individual intends to use a particular method.

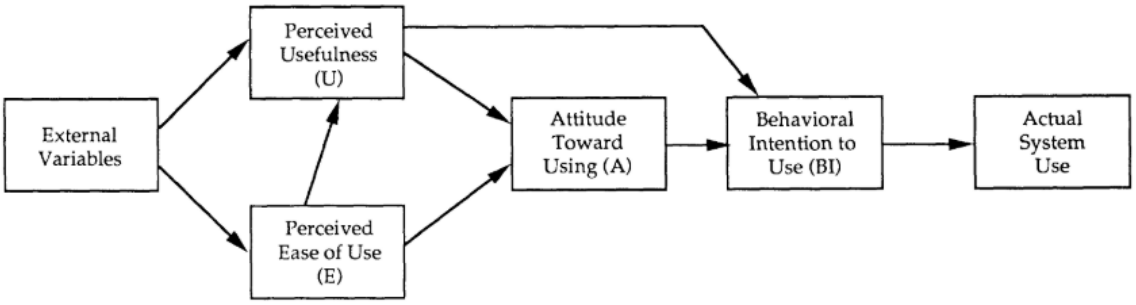

Figure 23: Technology Acceptance Model (Davis et al., 1989)

4.1.4 Interview Protocol

The interview is divided into several sections, covering the different aspects of the ITA-MM and the criteria to achieve the stated validation goals. All sections incorporate both closed statements and open questions. The interviewee scores a statement based on the Likert Scale. The open questions allow the interviewee to propose improvements for the model, add something that is not covered in the stated questions, and share some personal opinions about using the model and roadmap. Appendix C shows the formulated statements and open questions for the interviews.

Before the interview, the interviewees received a document with the ITA-MM. This document contains the tables and figures from the initial version of the ITA-MM and roadmap. In addition, the document contains a summarised version of the documentation on how to use the ITA-MM and roadmap. The interviewees were asked to read the document before the validation. In addition, the interviewees were told to imagine how the ITA-MM will interact with the intended problem context and validate the ITA-MM based on this prediction.

4.1.5 Bias

To limit the bias of the interviewees, the researcher would not give them additional information and explanation before the interview, since this interferes with the validation results. Furthermore, the researcher bias is limited by using the validation template of Salah et al. (2014), and following the interview protocol with the predefined statements and open questions. Lastly, the intention to use the ITA-MM and roadmap is independently determined according to the TAM of Davis et al. (1989).

4.2 Validation Results

This section discusses the results from the user and expert interviews. Appendix D covers the complete transcription, and Table 16 shows the statements' results. The remainder of this section discusses, by validation section, the results. The following section covers the recommended improvements for the ITA-MM based on the validation results.

Maturity Levels

All interviewees find the maturity levels sufficient to represent all the stages of a Digital Transformation and recommend not adding extra maturity levels. In addition to this, two interviewees indicate that the current levels are quite extensive. However, the none of interviewees would delete any of the levels. According to the interviewees, the current levels allow for a clear distinction between the levels and provide enough details to assess the maturity levels accurately. One interviewee thinks the fourth and fifth levels have some overlap. Furthermore, there is a comment that an organisation can work on

multiple initiatives on different levels and that the document does not reflect much on this situation now. Lastly, the capabilities are correctly assigned to their respective maturity levels.

Dimensions
The dimensions from the ITA-MM are relevant to assess the IT architecture of an organisation. Furthermore, three interviewees indicate that the dimensions cover all areas involved in assessing the IT architecture. However, two interviewees also accentuate the lack of people-related dimensions.

There is some overlap between the dimensions. However, none of the interviewees would delete a dimension since this results in the loss of relevant aspects. Nonetheless, the overlap is not seen as a bad thing since the capabilities are linked very well. In addition, many capabilities within the area of IT do influence each other, which makes it very hard not to have any overlap between the dimensions. Lastly, the capabilities are correctly assigned to their respective dimensions.

Interviewee	A	B	C	D	E
Maturity levels					
The maturity levels are sufficient to represent all stages of Digital Transformation engagement. (Sufficiency)	4	5	5	5	5
There is no overlap between the descriptions of the maturity levels. (Accuracy)	3	4	4	3	3
Capabilities are correctly assigned to their respective maturity level. (Accuracy)	4	4	5	5	4
Dimensions					
The dimensions are relevant to assess the IT architecture of an organisation. (Relevance)	5	5	5	5	5
The dimensions cover all areas involved in the assessment of the IT architecture of an organisation. (Comprehensiveness)	4	5	3	5	2
There is no overlap between the distinct dimensions. (Mutual Exclusion)	3	4	3	4	4
Capabilities are correctly assigned to their respective dimensions. (Accuracy)	4	5	4	5	4
Understandability					
The maturity levels are understandable.	4	5	5	5	4
The dimensions are understandable.	3	5	5	5	4
The assessment guidelines are understandable.	4	4	5	5	4
Ease of use					
The assessment tables are easy to use.	4	4	4	3	4
Usefulness					
The ITA-MM is useful for assessing the IT architecture of the organisation.	4	5	5	5	3
The ITA-MM helps to better understand how to improve the IT architecture.	4	5	5	5	4
ITA-MM Roadmap					
The goal and purpose of each roadmap step are clear (Understandability).	4	5	4	5	5
The roadmap easy to use (Ease of use).	4	4	4	4	4
The roadmap is useful to formulate and execute improvement initiatives (Usefulness).	4	5	4	5	4

Table 16: Validation criteria scores from interviews

Understandability
All the interviewees agree on the understandability of the maturity levels, dimensions, and maturity assessment guidelines. However, the current definition of the dimensions might allow for some interpretation, according to two interviewees. They add that some extra introduction of the model, maturity levels and dimensions, as explained in the research itself, could make the model clearer. Furthermore, there is a suggestion to make the ITA-MM visual and reduce the amount of text.

Ease of Use
The scoring tables are quite extensive, according to the interviewees. On the one hand, they mention that this level of detail ensures that the maturity level can be precisely determined. On the other hand, however, they also argue that this amount of information in the scoring tables can seem overwhelming and lead to misconception. In contrast, there is a remark that if a user is involved in a Digital Transformation, that he or she also needs to take time to read and understand the model thoroughly.

Four interviewees propose another format, e.g. (online) tool or questionnaire, for the ITA-MM to make it easier to use. Furthermore, there is an idea to implement the four-eyes principle, meaning that at least two stakeholders must approve at the maturity level. In addition, the interviewee suggests seeing the maturity assessments of different stakeholders in a single overview. There is also a suggestion to discuss that it is not crucial that the maturity indication is perfectly correct but indicates further improvement steps. Lastly, despite the suggestions to make the ITA-MM easier to use, all interviewees indicate that they can use the assessment without supervision.

Usefulness
The interviewees indicated that the ITA-MM will help to assess the maturity of the organisation's IT architecture. Furthermore, they suggest that the ITA-MM helps to understand better how to improve the IT architecture.

All interviewees indicate that the ITA-MM would have benefitted recent projects by assessing the current situation, determining the next steps towards a new or improved solution, and creating solutions that better contribute to improving the IT architecture maturity of the department. For the same reason, the interviewees would use the ITA-MM in future improvement projects. One interviewee highlight that it does depend on the impact of the project. Nevertheless, for larger projects requiring multiple disciplines, the ITA-MM does help to provide a clear overview for all stakeholders involved. In his opinion, this benefits the understanding and follow-up of the improvement project.

ITA-MM Roadmap
The goal and purpose of each step are clear for all interviewees. As with the ITA-MM, there are suggestions for the roadmap to make it more straightforward and more useable with the help of an (online) tool or another format. Furthermore, an interviewee proposes the addition of a time indication for each roadmap step.

As for ease of use, the roadmap is relatively easy to use. However, the interviewees experienced the amount of information as overwhelming seeing it for the first time. Again, changing the format of how the information is presented would make a significant impact.

All interviewees indicate that the ITA-MM is useful to formulate and execute improvement initiatives. Furthermore, they add that the roadmap would have been of added value in recent projects since it gives them a clear overview of steps to take in the improvement process. There is also a comment that, without any guidance, it is easy to forget or skip steps that could be important or beneficial for a project. In addition to this, one interviewee mentions that having defined a scope and carried out an assessment earlier in a recent project would have saved them much rework. All the interviewees state that they would use the roadmap for future improvement projects to provide the team with a detailed guide throughout improvement projects. In addition to this, the roadmap is seen as something that can be shared with the stakeholders and clearly shows what is part of and expected from a project.

Intention to Use

The validation research also investigates the perceived ease of use and perceived usefulness, influencing the behavioural intention to use a particular method or system (Davis et al., 1989). The previous section explains the technology acceptance model from Davis et al. in more detail. Both the ITA-MM and roadmap score on average a 3.8 and 4 on ease of use. The usefulness of the ITA-MM and roadmap is, on average, respectively 4.5 and 4.4. These scores indicate a relatively high perceived ease of use and high perceived usefulness for the ITA-MM and roadmap. From the theory of Davis et al., it can be concluded that the intention to use is therefore also high. This confirms the answers given by the interviewees, where they were asked if they would use the ITA-MM and roadmap. There are, however, some improvement points, as discussed in the following section.

4.3 Refinement ITA-MM

This section discusses the second development iteration of the ITA-MM and refines the initial version of the ITA-MM based on the validation results.

4.3.1 ITA-MM Tool

The most significant change from the initial version is the development of the ITA-MM tool. All interviewees suggested that a different format could improve the ITA-MM's understandability and ease of use. Subsequently, the ITA-MM is now represented in a tool developed with OutSystems. The following section discusses the tool in more detail.

4.3.2 Maturity Levels

No maturity levels are added or removed. Even though several interviewees mention the extensiveness of the levels, they also mention that his level of detail would help them during a maturity assessment. According to the interviewees, removing any levels would result in a less accurate maturity assessment.

Based on the validation results, the ITA-MM tool includes some extra documentation in the introduction of the maturity levels to increase the understandability of the maturity levels. Furthermore, the documentation emphasises that organisations can work on multiple dimensions and different maturity levels. Lastly, the documentation highlights that the goal of the maturity assessment is to indicate the IT architecture's maturity and provide further improvement steps.

4.3.3 Dimensions

The interviewees indicated that the current dimensions are relevant to assess the organisation's current IT architecture maturity. Furthermore, two interviewees indicated the lack of people-related dimensions. However, this is not added to the dimensions. This research chooses to include only the technical related dimensions in the maturity model to assess the IT architecture of an organisation.

Nevertheless, the roadmap does emphasise the people side of a Digital Transformation journey. The roadmap indicates the importance of involving stakeholders from the beginning and throughout the journey. Furthermore, the roadmap emphasises the value of having open-minded and cooperative employees within the organisation as well as having enough skills within the team who does the development. By separating the technical and human aspects, the maturity model focuses on assessing the IT architecture and the roadmap guarantees the necessary skills and openness of the employees and stakeholders. Lastly, the ITA-MM tool provides some additional introduction for each dimension to increase the understandability of the dimensions.

4.3.4 Roadmap

One finding of all interviewees was the amount of information given at one time when introducing the roadmap. The newly developed ITA-MM tool already solves this and increases, thereby the understandability and ease of use.

Furthermore, there was a comment about considering swapping the first and second phases. The interviewee mentioned that in order to create awareness and support among the stakeholders, a team should first define a clear scope to identify who the stakeholders are. However, one of the inputs for the first phase is the project start. Although this is apparently not clear in the initial version of the ITA-MM, the project start is intended to indicate the direction of the upcoming iteration. The ITA-MM tool allows documenting the general direction for the upcoming iteration while starting a new project.

The roadmap's fourth step includes the maturity assessment. From the validation results, there was a suggestion to use the four-eyes principle. The ITA-MM tool implements this principle by warning the users if there is only one maturity assessment created. Furthermore, multiple maturity assessments can be compared to each other in a single overview, as suggested in the validation.

Lastly, an interviewee mentioned the addition of a time indication for each roadmap step. Subsequently, the ITA-MM tool gives a time indication for each phase. The tool recommends for most phases 1 to 3 creative sessions to encourage the discussion between all stakeholders. However, some phases only need a single session to agree on a decision. The tool only gives an indication, if organisations need more sessions, they are free to do so.

4.4 ITA-MM Tool

The development of the ITA-MM tool results from the validation research, where the interviewees proposed using a different format to increase the ITA-MM's understandability and ease of use. The tool is made with OutSystems, a low-code platform that provides tools to develop applications rapidly.

The ITA-MM tool guides the development team through the nine roadmap steps. At each step, the team can read and document the necessary information. Then, after filling in the required information, the tool guides the development team to the next phase. The progress of an improvement project can be saved at any time to continue at a later time.

4.4.1 Tool Description

The home page of the tool, as shown in Figure 24, shows all the projects, including their progress, start date and end date. From the home page, the development team can start a new project or open an existing one. When opening an existing project, the tool continues to the current phase.

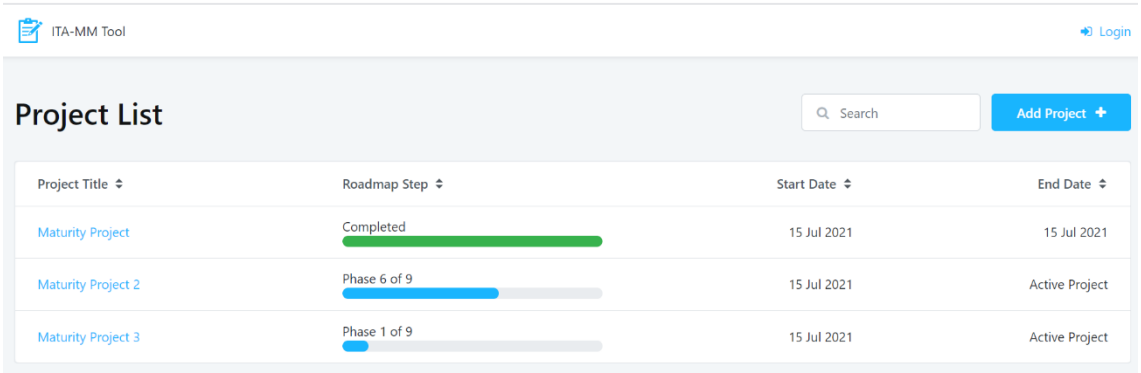

Figure 24: Screenshot of ITA-MM home page

After creating a new project, the project start gives a short introduction of the tool's goal and shows the nine roadmap steps, as shown in Figure 25. During the project start, the development team describes in short what the project is about. Based on this description, the stakeholders can be involved during the next phase.

The development team can navigate through the tool using the arrow buttons and clicking a phase in the progression bar. Furthermore, the team can return to the project details page, by pressing the eponymous button. The 'save' button saves the input so that the team can continue at a later time. The phase is completed by pressing the 'complete phase' button.

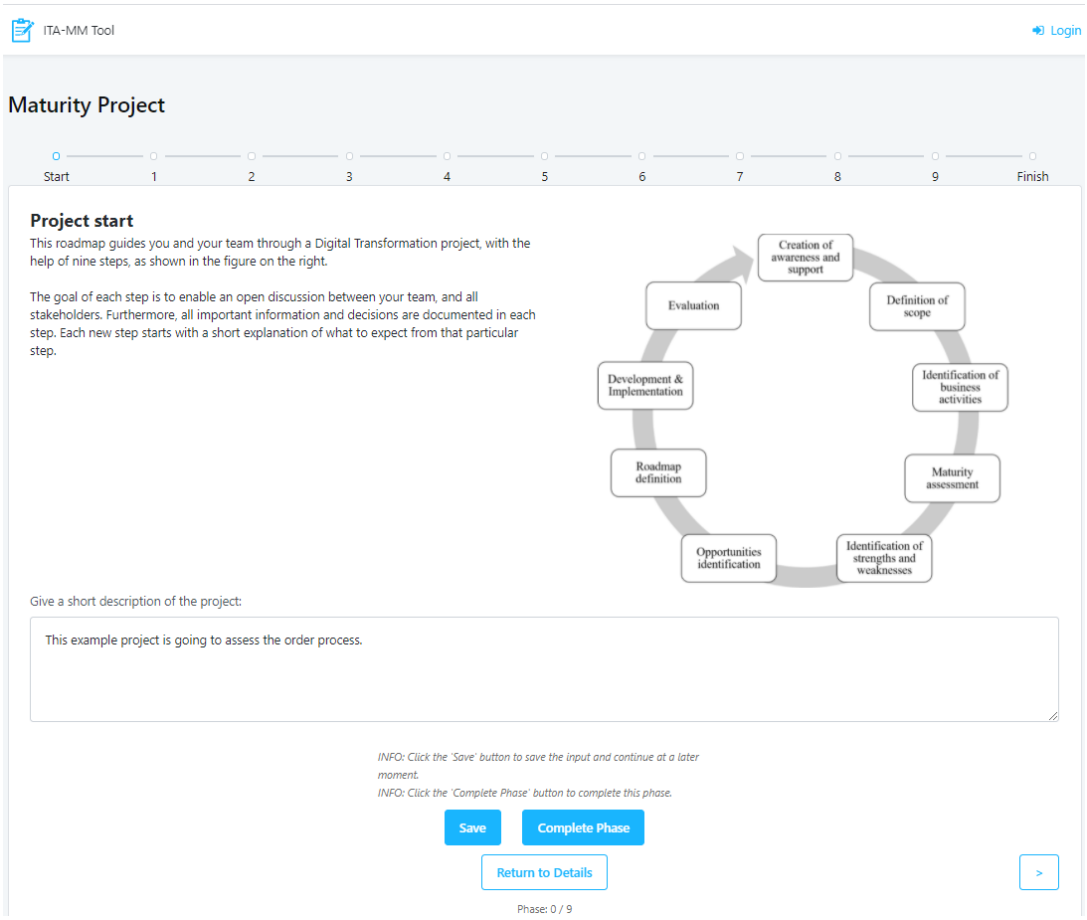

Figure 25: Screenshot of ITA-MM project start

Each phase starts with an introduction page, which states the goal of the phase, discusses the activities which need to be carried out and explains the reasoning behind them. Furthermore, an input output diagram visualises the inputs, activities, and outputs. Lastly, based on an interviewee's comment, the tool gives a time indication for each phase. Figure 26 shows the introduction of the evaluation phase.

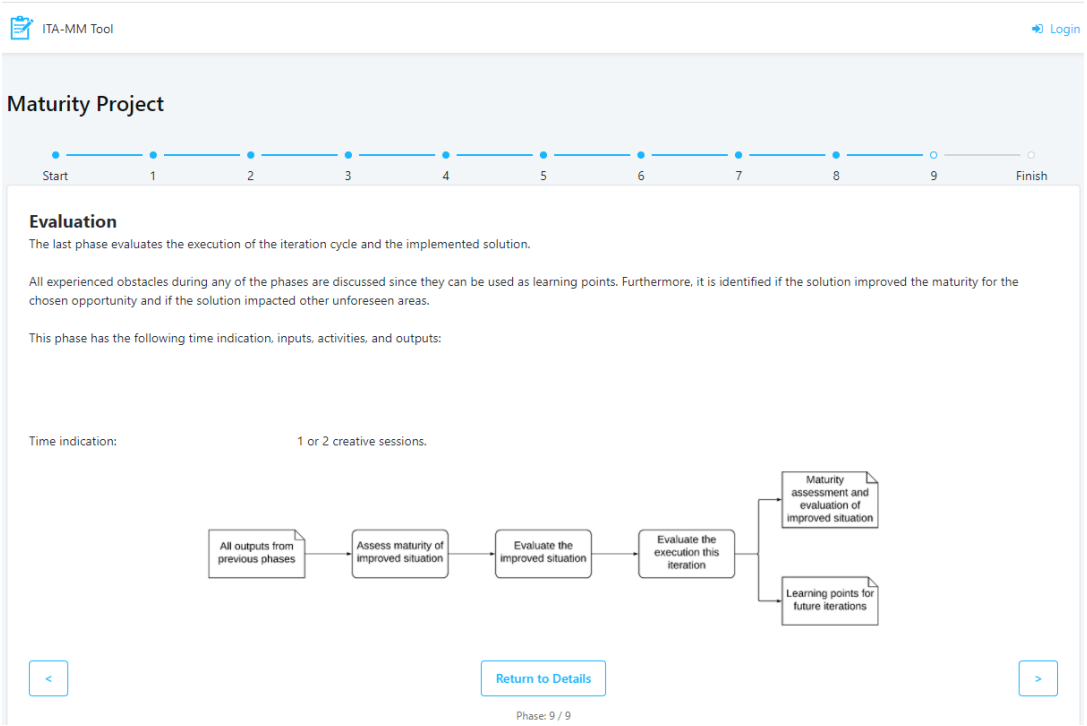

Figure 26: Screenshot of the evaluation introduction page

After the introduction, the tool guides the development team to an input page where several questions are stated to start the discussion between the team and stakeholders. Figure 27 shows an example of the evaluation phase. After discussion, the information, decisions, and results are documented on the page. Furthermore, there is room for additional notes and, as the figure shows, the team can upload and download models and documents during several phases.

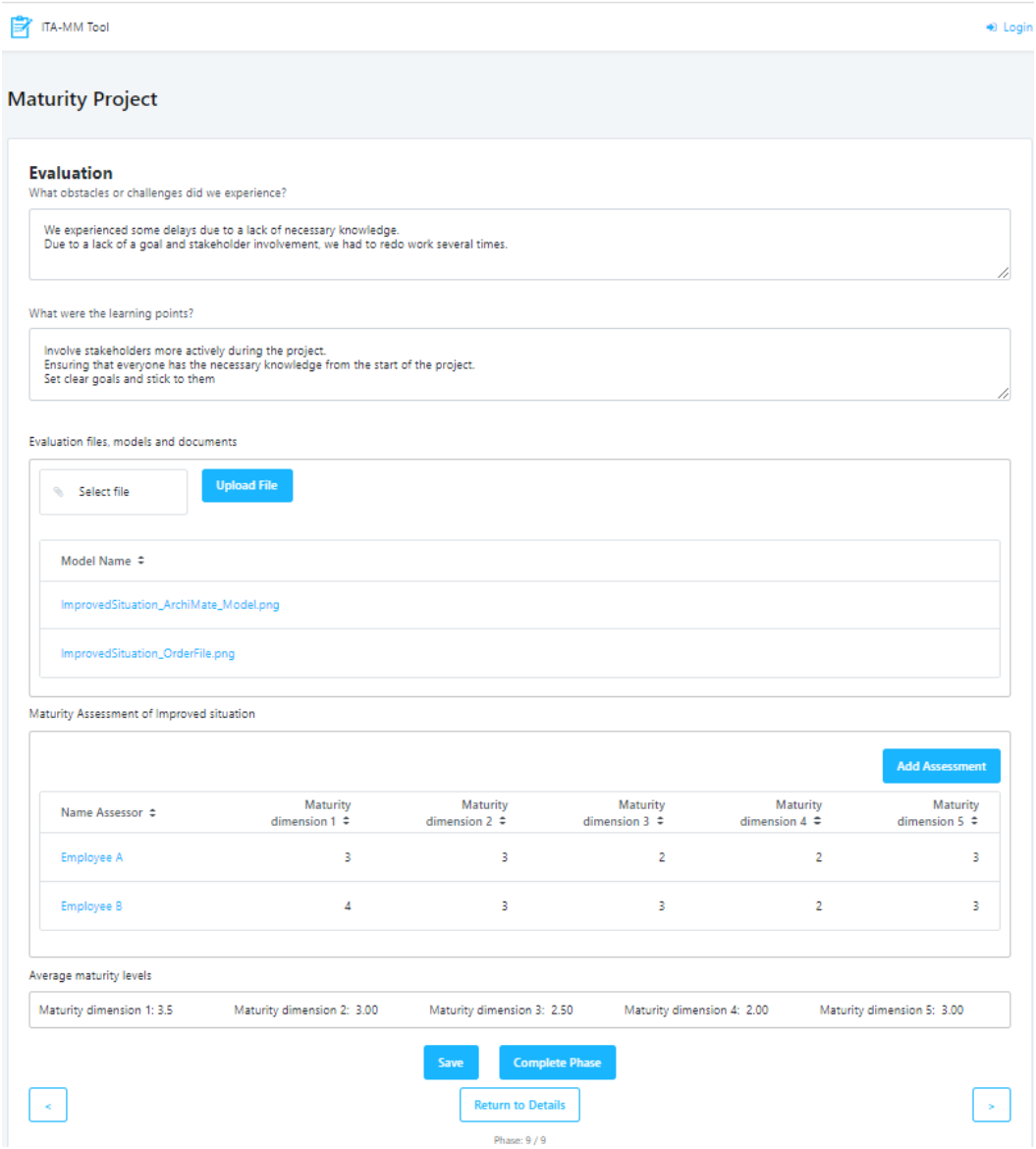

Figure 27:Screenshot of evaluation input page

4.4.2 Maturity Assessment

Phases four and nine of the roadmap carry out a maturity assessment, which evaluates the IT architecture's "as-is" and improved situation. The input pages of these phases show the performed assessments and the average maturity level, as shown in Figure 27.

When a team member or stakeholder creates a new maturity assessment, the tool shows the capabilities per maturity level, as shown in Figure 28. The assessor indicates per capability with a switch if the "as-is" situation meets a specific capability. The assessment has five tab pages, one for each dimension. After filling in the assessment, the assessor saves the assessment and returns automatically to the overview page of the fourth phase. When saving the assessment, the tool calculates the maturity levels of the assessment, and updates the average value over all the assessments per dimension.

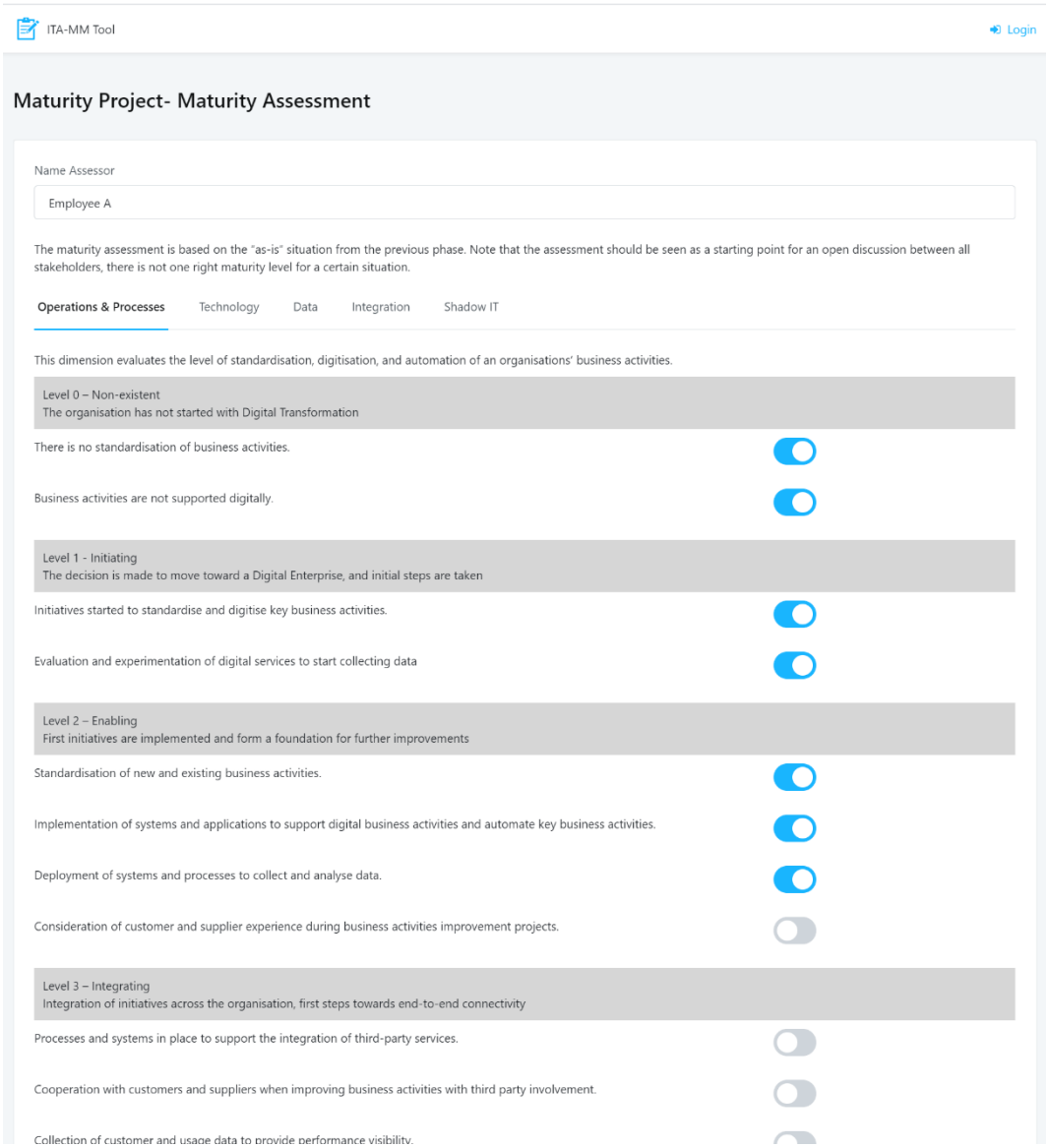

Figure 28: Screenshot of the maturity assessment page

4.5 Summary

This chapter validates the initial version of the ITA-MM through the use of user and expert interviews. Five participants rated statements and answered open questions to validate whether the ITA-MM meets the requirements and validation criteria. The validation results show, in general, high perceived usefulness and ease of use, resulting in a high intention to use the ITA-MM. However, there are several points for improvement, which resulted in the development of the ITA-MM tool, incorporating several refinements. The following chapter evaluates the ITA-MM, including the refinements, in practice.

5 Demonstration & Evaluation

The validation of the previous section resulted in the final iteration of the ITA-MM. After the iterative maturity model development, the maturity model is evaluated, as discussed in the development guideline used in this research. Therefore, this chapter discusses the demonstration and evaluation of the ITA-MM tool. First, Section 5.1 considers the case study preparation. After which, Section 5.2 discusses the execution of the case study. Lastly, Section 5.3 evaluates the case study. Subsequently, this chapter answers the seventh research question:

RQ7: Does the developed ITA-MM proves relevant in practice? What improvements should be made to the ITA-MM?

5.1 Case Study Preparation

Where validation predicts how an artefact will interact within its intended problem context, evaluation investigates the real-world interaction of the artefact (Wieringa, 2014). The demonstration and evaluation phases of the Design Science Research Methodology implement and evaluate the developed artefact in practice. This research uses a case study to demonstrate the ITA-MM tool in a real-world scenario. After which is evaluated whether the tool proves relevant in practice.

5.1.1 Case Study Protocol

The main goal of the case study is to evaluate whether the ITA-MM tool proves relevant in practice. The case study investigates this by evaluating if the model and roadmap meet the formulated requirements and the willingness of potential users to adopt the ITA-MM tool. The evaluation research uses the same criteria as mentioned in Section 4.1.3.

The case study is performed at the Ahold Delhaize Inbound Logistics (ADIL) department. This department is involved in several improvement projects that are part of their Digital Transformation, which is the typical application scenario for the ITA-MM. Wieringa (2014) states the importance of participants understanding the artefact before evaluating it. Therefore, the participants received beforehand the updated version of the ITA-MM tool to read and go through as preparation. In addition, the participants were already acquainted with the ITA-MM since they validated the initial version.

Due to constraints in terms of time and available cases for participation in the case study, an ongoing improvement project from the department is chosen. The development team just implemented the solution and is ready for the evaluation phase. This gives the opportunity to evaluate the use of the ITA-MM tool while the development team evaluates the development process of their solution. For the case study, the development team goes once again through the development process, following the nine roadmap steps.

5.1.2 Case Description

The Demand & Supply team of ADIL is responsible for processing the sales and purchase orders. Purchase orders are sent by ADIL to suppliers when the inventory level of a product falls below a certain threshold. The customers send sales orders towards ADIL. If a customer places an order before eleven o'clock, the customer receives the products the following day.

However, it can happen that products ordered by the customer are not available. When this is the case, the order deviations are added to the daily performance overview (DPO), which is sent daily to the customers of ADIL. This file indicates which products are not available, why they are not available, and when customers can order them again. Preparing this file is a tedious and time-consuming process, with much room for improvement.

5.1.3 Researcher Bias

To limit the research bias in this evaluation research, the researcher does not actively participate in the evaluation research. Instead, the researcher observes the execution of the case study by monitoring whether the steps are applied correctly and keeping track of whether problems arise while going through the roadmap.

5.2 Case Study ADIL

As stated in the case study protocol, the improvement of drawing up the DPO is a running project which is now in the evaluation phase. The evaluation phase of the DPO project is used to demonstrate the ITA-MM tool and evaluate their execution of the DPO improvement process simultaneously.

Some development team members go through the DPO project again and execute each of the nine roadmap steps to the DPO project as they would have if it had been a new project. Subsequently, the case study compares both executions with each other. On the one hand, to investigate whether the roadmap would have helped them during the project, on the other hand, the case study explores whether the development team used steps in their process which the ITA-MM does not cover. Lastly, the evaluation concludes whether the ITA-MM tool proves relevant in practice. The remainder of this section discusses the implementation of each phase of the ITA-MM tool.

5.2.1 Phase 1: Creation of Awareness and Support

The first phase aims to create digital awareness and support among the stakeholders involved. Figure 29 shows all the stakeholders involved in drawing up and using the DPO. The development team did approach some of the stakeholders. The commerce and logistic departments of the customers were asked how the current DPO influences their work and what data they need to perform their business activities successfully. Initially, the customers were open to the idea of an improved DPO. However, the team did not involve the customers during the design and development of the solution. As a result, there was some resistance during the implementation of the solution, more on this in phase 8.

The planners, who draw up the DPO, were not approached in this phase of the project. A development team member did fulfil the role as a stakeholder for the planners since he had been a planner before switching roles internally. However, the development team admitted that they encountered some issues because they did not approach the planners as stakeholders. Some business activities were changed since the team member switched roles. Furthermore, there is a slight difference in how planners approach the DPO, these insights were now not considered.

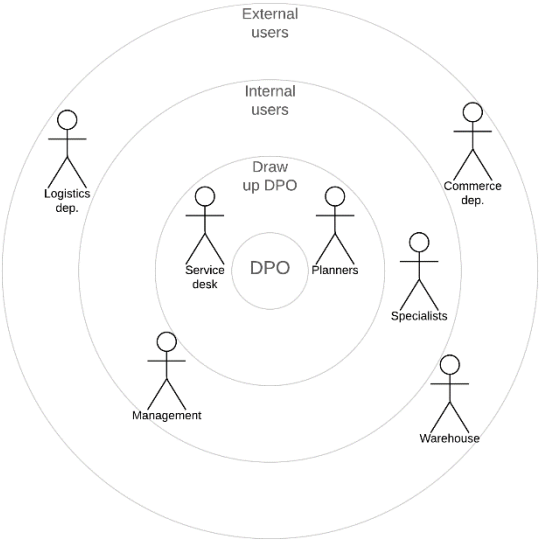

Figure 29: Stakeholders DPO

The first phase also states the importance of having enough skills within the development team to execute improvement projects successfully. However, part of the development team was not familiar with the methodologies used to carry out IT projects and the program used to develop the solution. As a result, there were some delays at the beginning and during the development of the project.

After the first phase of the case study, the development team mentioned that having the stakeholders actively involved during the DPO project would have saved them time. Furthermore, fewer challenges would have occurred during the project. Lastly, the team indicated that more time would be saved if they had acquired all the required skills during this first phase.

5.2.2 Phase 2: Definition of Scope

A clear goal and scope supported by all stakeholders ensure that the improvement project runs smoothly in one direction. The development team formulated a goal for the DPO project themselves. However, there were no brainstorm sessions with stakeholders, the goal and scope were not explicitly documented and also not communicated to the stakeholders.

During the case study, the development team indicated that they would include stakeholders to receive their input for a scope and goal during future projects. The team sees the added value of having the stakeholder's input for a scope and goal since they are involved in and influenced by the improvement. Table 17 gives an overview of the inputs that were documented afterwards.

Questions for discussion	**Inputs**
What are the ideas of the stakeholders for this project?	- A more efficient way to draw up the DPO (planners and service desk) - Reason codes that cover the actual reason for the order deviation (planners and management) - A clearer and more professional overview of order deviations and the reason codes (management, commerce, and logistics)
Key challenges or limitations	There are no key challenges or limitations.
What is the scope?	The scope is the process of drawing up the DPO.
What is the goal?	The goal is threefold: - More efficient process to draw up the DPO - More clarifying order deviations and reason codes - More professional reporting towards customers

Table 17: Inputs for phase 2

5.2.3 Phase 3: Identification of Business Activities

The development team used the Business Process Modelling Notation (BPMN) to visualise the process of drawing up the DPO. The model does also visualise the stakeholders and some of the tools used. The developers used this visual representation of the process during the development of the solution.

The ITA-MM proposes to visualise the "as-is" situation according to the ArchiMate standard since this will give a more detailed overview of the IT architecture. Figure 30 shows an ArchiMate model of the process of drawing up the DPO. In addition, the team uploaded, in the ITA-MM tool, the current version of the DPO as a reference.

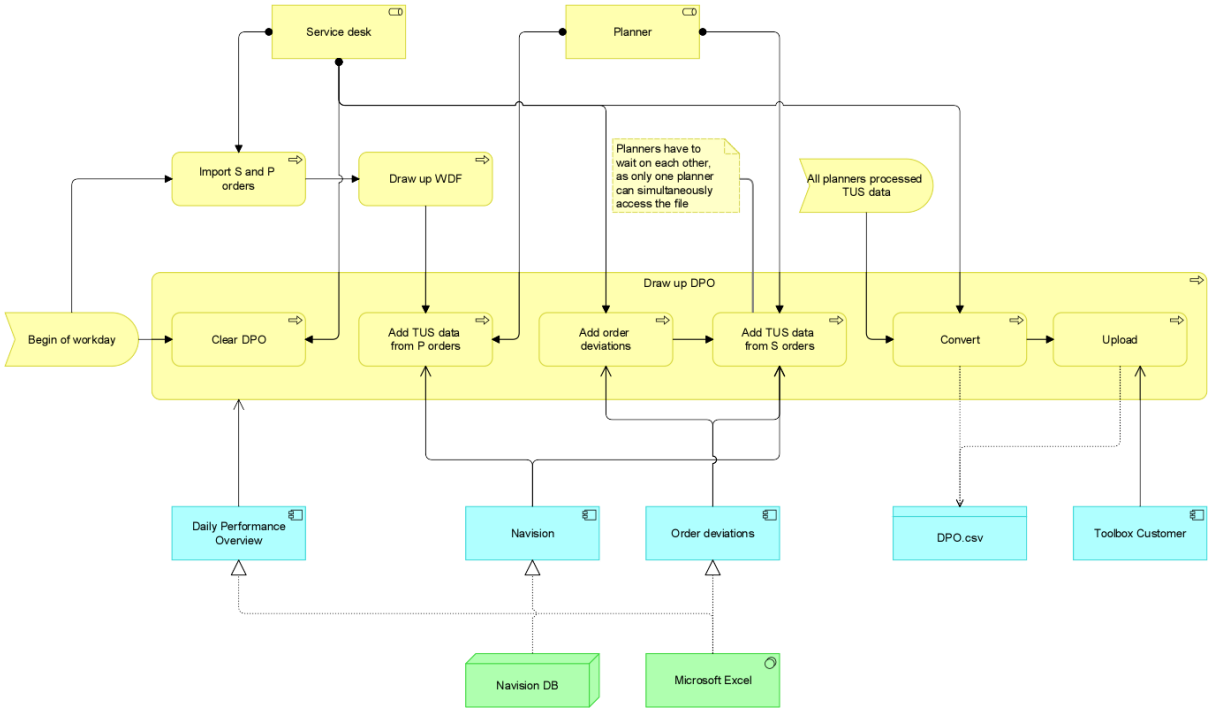

Figure 30: ArchiMate model "as-is" situation

5.2.4 Phase 4: Maturity Assessment

The maturity assessment helps the development team to understand the current state of the IT architecture. Furthermore, the assessment helps them identify the strengths and weaknesses of business activities that are part of the defined scope. The development team did not do some form of maturity assessment.

During the case study, two team members did a maturity assessment of the “as-is” situation from the previous phase. The participants knew there was much room for improvement, still, they were surprised by the low maturity levels. The maturity assessment gave them a better understanding of the “as-is” performance and a first indication of what to improve. Figure 31 shows the maturity levels from the assessments.

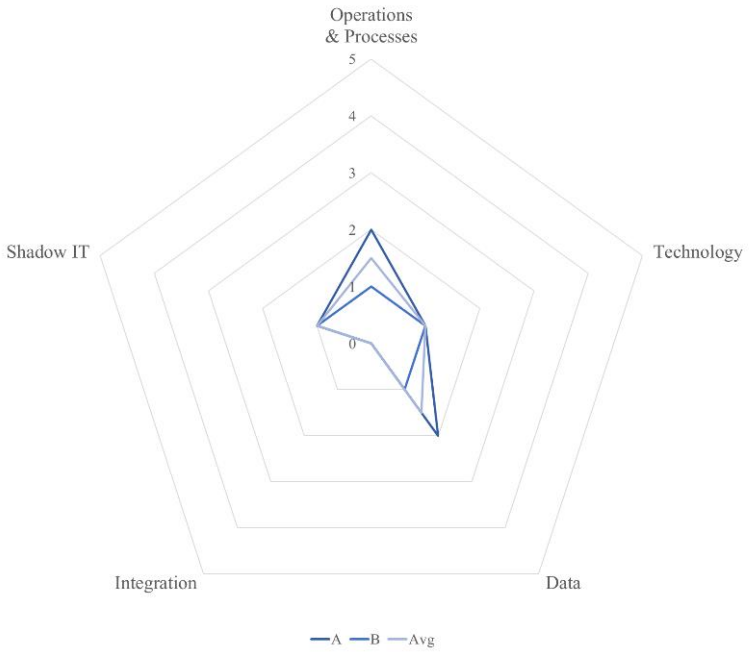

Figure 31: Maturity levels of the "as-is" situation

The operations & processes dimensions scored on average 1.5. Both members agreed that the process of drawing up the DPO has started with initiatives to standardise and digitise key business activities and collect data. Furthermore, they indicate customer experience is considered. However, they disagree on the implementation of systems and applications. Participant A indicates that the DPO process uses systems and applications and scores this dimension a maturity level of 2, while participant B mentions the processes uses tools rather than applications and scores a maturity level of 1.

The two members indicate that the DPO process uses tools to collect data. Furthermore, pilots are initiated to test new systems and applications and there is no real IT security in place yet. Therefore, both members score the technology dimension a maturity level of 1.

According to both members, the DPO process uses collected data, which is available for eventual needs. However, participant A thinks that the use of data is a maturity level higher than what participant B indicates. Resulting in respective maturity levels of 2 and 1.

The integration dimension scores from both members a 0, since not much attention has been paid to the design of an IT architecture at the moment. The shadow IT dimensions scores a 1. Both participants indicate that planners use simple tools to help themselves, however, they are not shared with colleagues.

5.2.5 Phase 5: Identification of Strengths and Weaknesses

The roadmap identifies strengths and weaknesses based on the "as-is" situation and the maturity assessment results. Initially, the development team did not do a maturity assessment and was therefore unable to determine strengths and weaknesses based on that. However, the team indicated that they had not given much thought to identifying strengths and weaknesses anyhow. Instead, there was an idea of what the new solution should look like.

During the case study, the development team did do the maturity assessment. Based on this assessment and the "as-is" situation, they could also define clear strengths and weaknesses. Which, in retrospect, would have helped them to define the improvement opportunities more clearly. Table 18 shows the identified strengths and weaknesses.

Strengths	Weaknesses
Customer experience is taken into account	Processes are not very time efficient
Initiatives started to standardise and digitise the business activities	The tools used are very basic and lacking functionalities
Data is collected and used	There is not much data security
There are ideas to improve the data collection and usage	Data integrity is not guaranteed and therefore data usage is not optimal
	No integration of systems, manual data sharing

Table 18: Strengths and weaknesses of the "as-is" situation

5.2.6 Phase 6: Opportunities Identification

The development did identify several improvement opportunities based on the ideas and insights of the team member fulfilling the planners' stakeholder role. However, in hindsight, the development team concluded that this was not optimal to identify improvement opportunities. The improvement opportunities would have been more specific when the team involved active planners as stakeholders.

The team pointed out that now they did identify the strengths and weaknesses during the case study, they also could specify the improvement opportunities better. The development team identified the following four improvement opportunities:

1. Develop a solution that enables a more efficient flow of activities
2. Implement data security
3. Guarantee the integrity of data
4. Make integrations with other (enterprise) systems

All the opportunities are feasible, except the fourth. The department currently does not have its own internal server where they can run an application. As a result, they cannot make integrations with their internal systems for now.

5.2.7 Phase 7: Roadmap Definition

The development team has not defined a specific roadmap in advance. During the design and development of the solution, the team looked at what needed to be worked on at that moment. This caused some confusion during the development.

During the case study, the team noted that they would have liked a roadmap in advance to guide them during the project. In addition, they mention that this would probably have resulted in a closer involvement of the stakeholders in the design and development phases of the project.

The development team grouped the three feasible improvement opportunities from the previous step together, since they could be solved by the solution they had in mind. The solution will be made with OutSystems, which is the same platform used to develop the ITA-MM tool. The department is familiar with this platform and satisfied with its capabilities. One of these capabilities is that the platform allows the department to develop and implement other business activities within the same environment. Figure 32 shows the ArchiMate model of the preferred situation.

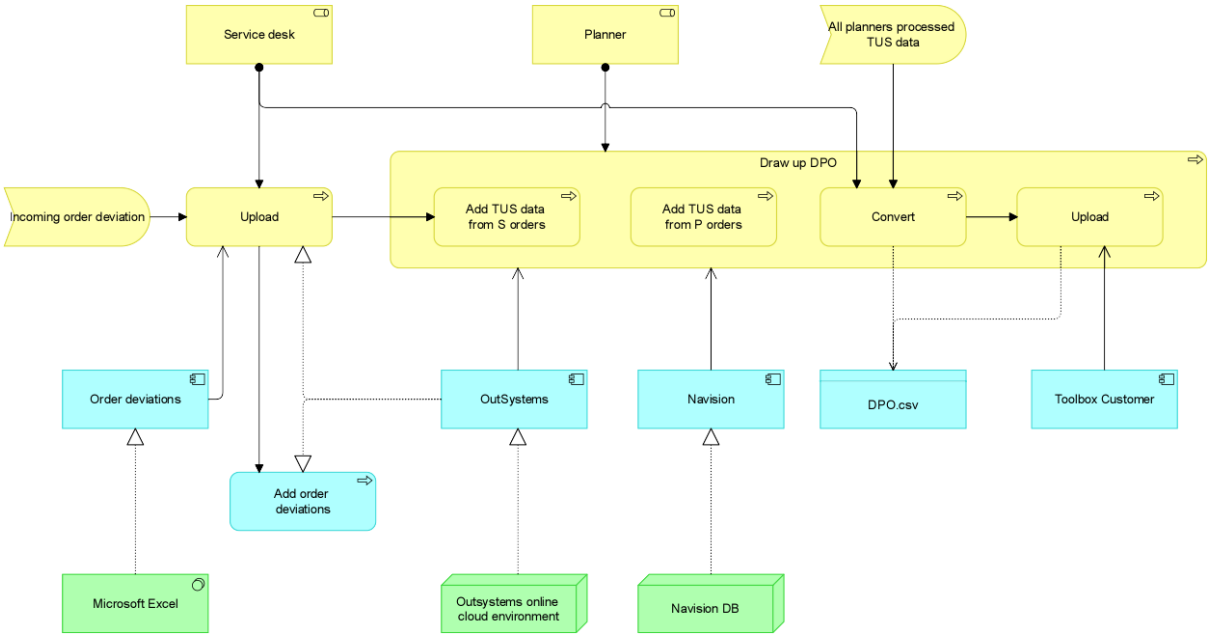

Figure 32: ArchiMate model of the preferred situation

5.2.8 Phase 8: Development & Implementation

As already mentioned, there were some difficulties during the design and development of the solution. This was a result of not involving stakeholders throughout the project. Subsequently, much time passed between the first contact moment with the stakeholders until the implementation of the solution. As a result, stakeholders had to re-examine the impact of this solution on their current way of working. In addition, the stakeholders were only now able to provide feedback for the first time, resulting in rework and a delay in the implementation of the solution. As the team already indicated several times, they would involve the stakeholders throughout the project to prevent these obstacles in following projects.

5.2.9 Phase 9: Evaluation

The evaluation phase is still ongoing, as indicated in the case study preparation. However, by going through the entire process again with the roadmap as a guide, the development team has gained many new insights into the development process and the solution. The lessons learned about the development process are discussed throughout the previous sub-sections.

The two members of the development team did a second maturity assessment, now on the improved situation. The maturity levels of all dimensions did increase with the implementation of the new DPO and the processes of drawing up the DPO. As Figure 33 shows, both members were unanimous about the maturity levels of the improved situation.

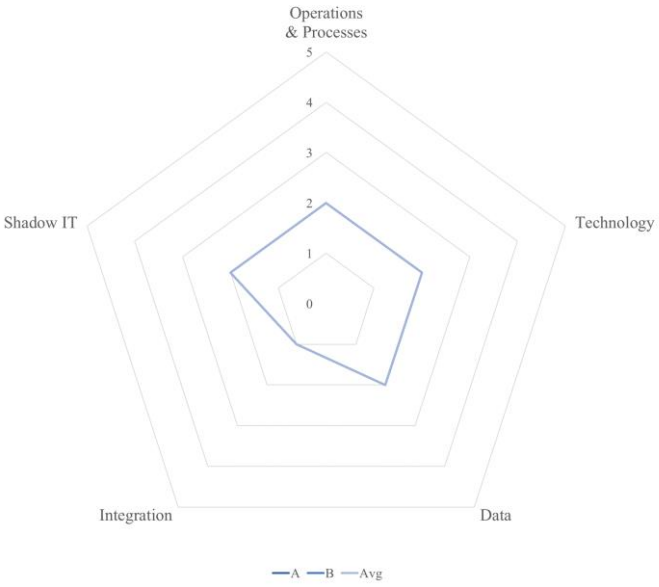

Figure 33: Maturity assessment of the improved situation

The operations & processes dimension increased to maturity level 2. Participant B who thought the "as-is" situation used tools instead of applications, now indicates that the process uses an application with the implementation of the OutSystems solution.

The technology dimension increased a full maturity level. Both members indicate that the improved situation uses systems and applications to support digital services. Furthermore, interfaces are in place to access, visualise and analyse customer data. Lastly, the improved situation gives more thought to IT security by implementing user credentials to access the developed application.

Improving the method of collecting, processing, and using data ensures that the data dimension also increases slightly to a maturity level of 2.

There is still not much integration, however, the development team did start with defining an IT architecture and some first simple integrations were made. Therefore, the integration dimension has a maturity level of 1.

Lastly, the improved solution decreases the need for planners to use several personal shadow IT tools. The tools which are still in use, are shared among colleagues. As a result, the maturity level of the shadow IT dimension is 2.

The following section covers the lessons learned about the practical usability of the ITA-MM.

5.3 Evaluation

Going through the nine roadmap steps during the case study resulted in positive feedback from the development team and the identification of possible improvement points for the ITA-MM. This section covers first the results, after which the following section discusses the points for improvement. Furthermore, the team members who also participated in the validation research filled in the statements survey with the criteria, as discussed in Section 4.1.3. Table 19 shows an overview of all statements and scores.

Interviewee	A	B
Maturity levels		
The maturity levels are sufficient to represent all stages of Digital Transformation engagement. (Sufficiency)	4	5
There is no overlap between the descriptions of the maturity levels. (Accuracy)	4	4
Capabilities are correctly assigned to their respective maturity level. (Accuracy)	4	4
Dimensions		
The dimensions are relevant to assess the IT architecture of an organisation. (Relevance)	5	5
The dimensions cover all areas involved in the assessment of the IT architecture of an organisation. (Comprehensiveness)	4	5
There is no overlap between the distinct dimensions. (Mutual Exclusion)	3	4
Capabilities are correctly assigned to their respective dimensions. (Accuracy)	4	5
Understandability		
The maturity levels are understandable.	5	5
The dimensions are understandable.	4	5
The assessment guidelines are understandable.	4	5
Ease of use		
The assessment tables are easy to use.	5	5
Usefulness		
The ITA-MM is useful for assessing the IT architecture of the organisation.	5	5
The ITA-MM helps to better understand how to improve the IT architecture.	5	5
ITA-MM Roadmap		
The goal and purpose of each roadmap step are clear (Understandability).	5	5
The roadmap is easy to use (Ease of use).	5	5
The roadmap is useful to formulate and execute improvement initiatives (Usefulness).	5	5

Table 19: Evaluation criteria scores from the case study

5.3.1 Understandability

The refinement of the ITA-MM does not implement many improvements to the maturity levels and dimensions. Nevertheless, the participants in the case study indicate that the understandability of the levels and dimensions has been increased by using the developed tool. The extra introductions and the change of visualising all information contribute to increasing the understandability of the maturity model.

5.3.2 Ease of Use

In line with the increased understandability, the ease of use also improved with the ITA-MM tool. The participants indicate the maturity assessment of the initial version was a bit overwhelming. However, the tool gives more guidance on how to approach the maturity assessment and is visually more pleasant to look at. As a result, the maturity assessment is easier to carry out.

While the validation indicated that the capabilities were clear to determine the maturity and to identify improvement points. In practice, it appears that the capabilities allow some room for personal opinions and interpretations. As discussed in the previous section, there were several differences between the maturity levels given by the team members. This resulted from different interpretations of the capabilities.

5.3.3 Usefulness

During the validation, the participants indicated that they would use the ITA-MM in future projects, as the model would help them to understand the current situation and identify improvement opportunities. The case study confirms these statements. During and after the case study, the participants mentioned that the ITA-MM indeed is useful to determine the maturity of the current situation.

The maturity assessment helps the development team to understand the current situation better and gives them a good indication of the performance of the "as-is" situation. In addition, it helps the team to identify weak aspects and thus improvement points for the current situation. The way in which the ITA-MM tool shows the capabilities makes it even more straightforward for the team to identify opportunities for improvement, compared to the initial version.

5.3.4 ITA-MM Roadmap

The most significant change from the initial version is the development of the ITA-MM tool. Therefore, the participants also perceived the biggest improvements in the use of the roadmap. According to the participants, the new ITA-MM tool provides them with a more straightforward guide to carry out the phases of the roadmap. Furthermore, they indicate that the tool gives a better overview of all the information. This is a result of the format change, as the tool uses separate pages for each phase, less information is shown at once. In contrast, the initial version consisted of a single document containing all the information. Based on the case study results, it can be concluded that the understandability and ease of use did increase compared to the initial version of the ITA-MM.

The participants mentioned in the validation research that they expect the roadmap to help them execute an improvement project. The case study confirms this statement in practice since it gave them some new insights into how to approach and carry out an improvement project. One of the most important learning points for the development team is the involvement of stakeholders throughout the project. The case study confirms the value of stakeholder involvement since the development team indicated that several obstacles would have been prevented if they actively involved all stakeholders throughout the process. Closer cooperation between the team and stakeholders would have resulted in less rework and smoother implementation.

The ITA-MM tool enforces the development team and stakeholders to have open discussions during each phase. In addition, the tool gives the opportunity to document the information, decisions and comments resulting from those discussions. The development team indicates that the ITA-MM tool indeed helps them to start the discussion. They also mention that because the tool guides them through each phase, they are also made to consider and document information about topics that they normally do not think about. As an example, the participants mention the documentation of the goal. Having this written down helps the team to focus on this goal throughout the project. In addition, having a clear scope ensures that the project does not change direction.

Furthermore, they mention that it is helpful to use this documentation as a reference. Lastly, according to the participants, the tool makes it easy to share the progress of the project and documentation with the stakeholders involved. Based on the case study results, it can be concluded that the participants still see the added value of the ITA-MM. As a result, the usefulness of the ITA-MM tool increased.

5.3.5 Intention to Use

According to the Technology Acceptance Model (TAM) from Davis et al. (1989), the perceived ease of use and perceived usefulness influence the behavioural intention to use a particular method or system. During the validation, the ITA-MM and roadmap scored on average a 3.8 and 4 on the perceived ease of use. After the refinement, both score a 5 during the evaluation. The perceived usefulness scored a 4.5 and 4.4 for respectively the ITA-MM and roadmap. Again, both scored a 5 during the evaluation. Based on these scores it can be concluded that the behavioural intention to use the ITA-MM tool also increased compared to the initial version.

The high intention to use the ITA-MM tool confirms with the statements from the development team, which mention, as discussed before, the added value of both the maturity model and the roadmap.

5.3.6 Points for improvement

As mentioned in the previous section, the new ITA-MM tool provides a clearer overview of the capabilities used during the assessment to identify the maturity levels. However, where the validation indicated that the capabilities were clear to determine the maturity and to identify improvement points, in practice, it appears that the capabilities allow some room for personal opinions and interpretations.

On the one hand, this is not a bad thing since it does start a discussion between the various stakeholders, which ensures that they think carefully about the process and the capabilities. On the other hand, however, it is not the intention that the capabilities have too much room for interpretation.

An example of this, is the use of the concepts tools, applications, interfaces, and systems in the capabilities. It may be hard to distinguish the difference between a tool and an application when the stakeholder has not a broad enough knowledge area of what is possible in IT. A practical illustration of this is Excel. Some stakeholders see the use of Excel as a mature application. However, as discussed by the fourth research question, an Excel file is in the IT field seen as a tool and not as a full-fledged application for business-critical processes. This has to do with the shortcomings and risks of such tools, as discussed in more detail in Section 2.5.

In line with this, the case study showed that stakeholders may disagree about whether the “as-is” situation meets certain capabilities. However, there is not one maturity level that is right for a specific situation. It must be clear to the stakeholders that the roadmap and especially the maturity assessment are seen as a tool to start the discussion. Stakeholders must think carefully about the current situation, the possibilities for improvement and the implementation thereof.

5.4 Conclusion

This chapter discusses the demonstration of the ITA-MM tool through a case study. By implementing the ITA-MM in practice, it is evaluated whether the maturity model and roadmap prove relevant in practice. From the case study results, it can be concluded that the ITA-MM tool proves relevant in practice.

6 Conclusion

This chapter concludes the research. First Section 6.1 shortly discusses the research questions answered in the chapters of this thesis. After which, Section 6.2 & 6.3 cover the contribution to the theory and practice. Then, Section 6.4 describe the limitations of this research and mentions points for further research. Lastly, Section 6.5 gives some general recommendations.

6.1 Answering the Research Questions

To goal of this research is to provide an answer to the following main research question:

What is a suitable maturity model that allows organisations to assess their IT architecture from a business-process point of view and offers them a prescriptive approach to guide them during a Digital Transformation journey?

To answer this main research question, several sub research questions have been formulated. The remainder of this section shortly discusses these research questions since the conclusions throughout the thesis already answer these research questions.

RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?

The rise of new digital technologies allows organisations to change and improve their business activities radically. This transformation is often referred to as Digital Transformation. However, there is no commonly accepted definition for this trend. This research refers to Digital Transformation as a fundamental transformation process enabled by digital innovations, which impacts an organisation's IT, business, and organisational aspects.

Digital Transformation incorporates all kinds of implementations and changes of digital technologies and solutions, which has a significant impact on the IT architecture of an organisation. However, organisations are not aware of the current state of their (business) processes, applications, and technologies, which makes it hard to determine where and how to start with Digital Transformation.

To cope with these challenges, organisations look for existing frameworks to navigate their Digital Transformation journey, resulting in the development of many maturity models in recent years. However, current maturity models have several shortcomings. First of all, digital maturity models tend to be too general and high-level in their coverage, which makes practical implementation for an organisation difficult. In addition to this, several studies show that current digital maturity models are often complex and time-consuming to execute and that external assessors must even perform assessments. As a result of this complexity, maturity assessment can become an expensive and burdensome activity for organisations.

Furthermore, digital maturity models are developed with a descriptive rather than a prescriptive purpose. These descriptive models assess the current state but do not prescribe actions to overcome the identified weaknesses. Lastly, there is a lack of scientifically and methodologically profound digital maturity models.

An open research area is to design a maturity model that addresses the shortcomings of current digital maturity models as discussed above.

RQ2: How is the level of Digital Transformation engagement measured at an organisation?

A systematic literature review was performed to identify digital maturity models that could be used as a basis for the ITA-MM. The review identified 14 models. The maturity models use dimensions and levels to measure the digital maturity at organisations. Dimensions cover the fundamental (business) areas impacted by Digital Transformation, and maturity levels indicate the maturity of each dimension.

Most models use a questionnaire to determine an organisation's digital maturity. The questionnaires implement the Likert Scale to give a clear structure to the questions and answers. The majority of the models are descriptive, only giving organisations an indication of their digital maturity. Three prescriptive models give an organisation more guidance on determining improvement opportunities. However, these models do not provide information on how to carry out Digital Transformation. Section 2.3 discusses in more detail how current models measure digital maturity.

RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment?

Table 20 shows the five technological dimensions used by current digital maturity models, as discussed in Section 2.4. Each dimension impacts the IT architecture of an organisation, often in multiple ways and organisation-wide. This poses a challenge regarding the execution and management of a Digital Transformation journey and requires a carefully designed IT architecture.

Dimension	**Description**
Operations & processes	Evaluates the standardisation, digitisation, and automation of business activities.
Technology	Covers the technological capabilities of an organisation.
Data	Examines the data collection, usage, storage, and integrity.
IT architecture	Discusses the hard- and software that facilitates all systems used for carrying out the business activities, including the connectivity of these systems.
Products	Addresses the 'smartness' of the products of an organisation.

Table 20: Technological dimensions overview

RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models?

A challenge discussed in the literature but not incorporated in current digital maturity models is the existence of shadow IT within organisations. Individual users or departments develop shadow IT solutions when there is a misalignment between the functionalities that an enterprise system offers and the need for a particular functionality that is not available. However, this development is done without the knowledge of the central IT department, which poses several risks. Section 2.5 covers these risks in more detail.

RQ5: What methodologies do exist in literature to carry out Digital Transformation and IT projects?

The literature shows a development where organisations that start with a Digital Transformation also strive to be agile. As a result, organisations are responsive to meet the ever-changing customer needs. Furthermore, agile working incorporates elements like learning from mistakes, quick evaluation, and adjustment of development paths. Thus, improving both skills of employees and optimising the business activities. In line with this, more and more organisations use Bimodal IT development. This strategy balances the operational backbone and an agile application environment.

RQ6: How to design a generally applicable maturity model for organisations, including a self-assessment model and a roadmap?

This research question is answered by four sub-questions, discussed below.

RQ6.1: What are the guidelines to develop a maturity model?

The guidelines of Becker et al. (2009) and de Bruin et al. (2005) are the most well-known guidelines for developing a maturity model. The development of the ITA-MM uses the guidelines from Becker et

al. and implements several concepts from de Bruin et al. Section 3.1.2 covers the implementation of both guidelines in more detail.

RQ6.2: What are the goals and requirements of the ITA-MM?

For the ITA-MM to be a concise and prescriptive maturity model, it must enable a self-assessment of the current IT architecture and identify improvement measures and their priority. Furthermore, Table 21 shows an overview of the design decisions. Section 3.2 covers the goals, requirements, and decisions in more detail.

Criterion	Characteristic
Focus of model	Domain-specific, service-oriented organisations
Model type	Prescriptive maturity model
Development stakeholders	Both academia and practitioners
Audience	Internal employees
Method of application	Self-assessment
Driver of application	Both internal and external requirements
Respondents	Staff
Application	Multiple entities (several IT dimensions) / single region (IT architecture)

Table 21: Overview of requirements and decisions for the ITA-MM

RQ6.3: How to systematically assess the IT architecture of an organisation?

After two development iterations (Section 3.3 and 4.3), the ITA-MM uses six maturity levels; Non-existent, Initiating, Enabling, Integrating, Optimizing and Continuous improvement to evaluate the five digital dimensions; Operations & Processes, Technology, Data, Integration and Shadow IT. Furthermore, the ITA-MM incorporates multiple capabilities for each dimension and maturity level, as shown in Appendix B.

RQ6.4: How to provide a roadmap for organisations to start with optimising their IT architecture?

The roadmap, developed in Section 3.4, offers a guideline for the Digital Transformation journey of organisations. Section 4.4 discusses the development of the ITA-MM tool, which results from the validation. This tool increases the ITA-MM's ease of use by offering a more straightforward format to execute the roadmap. The roadmap consists of nine phases, as shown in Figure 34.

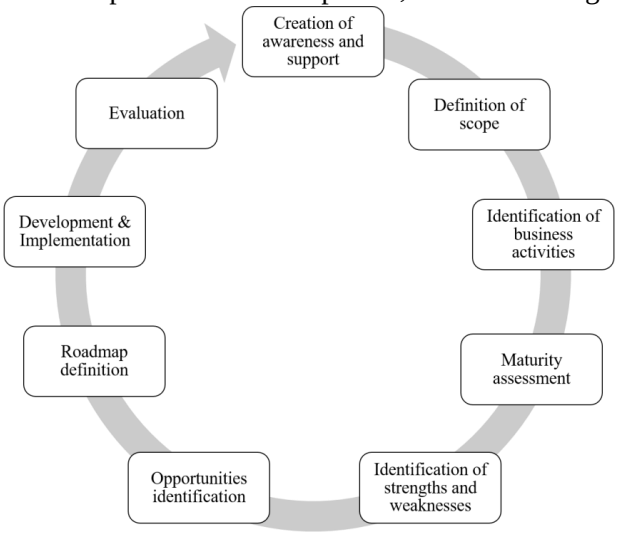

Figure 34: ITA-MM Roadmap

RQ7: Does the developed ITA-MM proves relevant in practice? What improvements should be made to the ITA-MM?

Using the ITA-MM in practice started the discussion between stakeholders about the current situation, the improvement opportunities, and the Digital Transformation journey. The participants indicate that the ITA-MM tool offers straightforward guidance during the execution of the roadmap. Furthermore, the maturity model assesses the organisation's IT architecture. In addition, the model helps to identify improvement opportunities and increases the knowledge on how to improve the IT architecture. Based on the evaluation results, it can be concluded that the ITA-MM proves relevant in practice. The main point for improvement is to make the capabilities more unambiguous.

What is a suitable maturity model that allows organisations to assess their IT architecture from a business-process point of view and offers them a prescriptive approach to guide them during a Digital Transformation journey?

The research questions (RQ1 to RQ7) resulted in a suitable prescriptive maturity model and assessment method that allows organisations to assess their IT architecture and identify improvement opportunities. Furthermore, the roadmap offers a straightforward guide during a Digital Transformation journey. Thereby, this research satisfies the research objective as set out at the beginning of this research.

The ITA-MM and roadmap were validated by the intended user stakeholders and an external expert. During these interviews, the participants rated the validation criteria from 1 (strongly disagree) to 5 (strongly agree). Furthermore, there were open questions to go more in-depth on several aspects and provide the participants with the opportunity to propose improvements. The scores from the perceived ease of use and perceived usefulness from both the ITA-MM and roadmap were between 4 and 5. These scores indicate, based on the Technology Acceptance Model (TAM) from Davis et al. (1989), a high behavioural intention to use the ITA-MM and roadmap.

After the validation, a case study demonstrates the refined version of the ITA-MM and developed tool. The development team indicated that the ITA-MM offers straightforward guidance during a Digital Transformation journey, especially with the developed tool. The evaluation also shows an increase in the understandability, ease of use and usefulness of the maturity model and roadmap. As a result, the intention to use the ITA-MM tool increases, according to the TAM, compared to the initial version.

Based on the validation and evaluation, it can be concluded that the ITA-MM is a suitable maturity model that allows organisations to assess their IT architecture and define improvement opportunities. Furthermore, the roadmap guides them during their Digital Transformation journey.

6.2 Contribution to Theory

Digital Transformation and maturity models are both popular research fields. Combined with the demand from organisations to be guided during their Digital Transformation, various digital maturity models have been developed in recent years. This scientific research contributes to research by introducing a unique maturity model, which can be used as a starting point by other researchers.

The maturity model presented in this research is unique since it combines several existing concepts into a new maturity model and has a different focus than existing models. To begin with, the maturity model has an employee focus rather than the management of an organisation. Furthermore, the ITA-MM incorporates a self-assessment and does not need expensive external assessors. Current digital maturity models tend to be too general and high-level in their coverage, whereas the ITA-MM focuses on assessing the IT architecture, with a business-process viewpoint, of an organisation. Combined with the fact that the ITA-MM identifies points for further improvements, it means that the ITA-MM can be used as a prescriptive maturity model to improve the IT architecture of an organisation. Lastly, this is the first maturity model that includes a dimension that assesses shadow IT use within an organisation. This is possible by the employee focus of the model, who is also developing the shadow IT solutions.

6.3 Contribution to Practice

The practical contribution of this research is twofold. First, the research provides the ITA-MM, which can be used to assess the IT architecture of an organisation and identify improvement opportunities. Second, this research proposes a roadmap for organisations to guide them during a Digital Transformation.

Organisations can directly use the ITA-MM tool to assess their IT architecture or a particular business activity. The maturity model presents a set of capabilities for each dimension and maturity level. These capabilities indicate whether the organisation meets a certain maturity level. In addition, the capabilities also identify opportunities for further improvements to increase the maturity level, which ensures the prescriptive nature of the ITA-MM.

The ITA-MM tool, which operationalises the roadmap, offers organisations a guideline to follow during their Digital Transformation journey. The roadmap encourages the involvement of stakeholders throughout the journey, starts open discussion between the stakeholders and documents important information, decisions, comments, and documents within the tool.

The validation and evaluation of the ITA-MM show promising results, as the participants, who are also the intended users, gave the ITA-MM high scores to all the evaluation criteria. Especially the high scores on the perceived ease of use and perceived usefulness of the ITA-MM are interesting since this results in a high behavioural intention to use the ITA-MM tool, according to the Technology Acceptance Model (Davis et al., 1989). Which the participants confirm during the case study.

6.4 Research Limitations and Future Work

This research provides an overview of existing digital maturity models through a literature review since there is a lack of maturity models that discuss the combination of IT architecture and Digital Transformation. Subsequently, the research builds upon this to develop the ITA-MM and roadmap with the help of user and expert interviews. However, limitations inherent to these methods are the risk of overlooking specific sources, biased or influenced users, experts and researchers (Wieringa, 2014). Furthermore, there was a time constraint for this master research. These limitations result in future research opportunities, described in the remainder of this section.

The systematic literature review, performed to identify existing digital maturity models, aimed to be as inclusive and thorough as possible. The review consulted various digital libraries, which only include scientific papers and some books. However, other sources containing, for example, non-scientifical papers and articles were not used. Based on this research, studies could consult sources not used by this literature review to broaden the set of existing digital maturity models. A broader set of maturity models could also result in the identification of more relevant capabilities for assessing the maturity of the IT architecture of organisations.

According to Wieringa (2014), participants in validation interviews might be biased or (unconsciously) influenced during the research. Therefore, the participants were not involved during the development of the first version of the ITA-MM to limit the level of influence as much as possible. Wieringa also discusses the research bias towards positive research results, influencing the validation criteria to persuade positive feedback. Using a research methodology, maturity model development guidelines, validation methodology and maturity model validation criteria, the researcher attempts to limit the researcher bias. Furthermore, the research did not actively participate in the case study. Instead, the researcher only observed the execution of the case study.

The validation research of the ITA-MM and roadmap uses interviews with three users and one external expert. For further research, more users and experts need to validate the ITA-MM and roadmap, resulting in a more exhaustive validation research and a further improvement of the current ITA-MM and roadmap. Preferable, the future validation research also incorporates participants from various

organisations to widen the validation scope even more. Including several organisations also examines the generalisability of the maturity model and roadmap.

6.5 Recommendations for Application

The ITA-MM tool's current version helps organisations determine their IT architecture's maturity level and identify improvement opportunities. Furthermore, the roadmap guides them during a Digital Transformation journey. Organisations implementing the ITA-MM and roadmap should follow all the proposed roadmap steps during a project, as each step adds a specific value to the project by having open discussions about several topics. Lastly, organisations should see the roadmap and especially the maturity assessment as a tool to start the discussion between stakeholders. The ITA-MM encourages stakeholders to think carefully and discuss openly the current situation, the possibilities for the improvement and the implementation thereof. Using the ITA-MM and roadmap as intended contributes to fully exploiting the benefits of each improvement project as much as possible.

6.5.1 Recommendations for ADIL

Throughout the course of this research, the department started with several projects to improve its business activities and IT architecture. Some of these projects started based on brainstorming sessions during the problem identification of this thesis. It is promising to see that the ideas are quickly picked up and that initiatives are started to improve certain activities. In addition, the department hired a few enthusiastic employees to make even more progress in this area.

The participants from the validation and evaluation studies in this research indicated that they see the added value of the ITA-MM tool. The tool helps them to gain knowledge on how to approach and execute improvement projects. For example, why it is important to involve stakeholders throughout the project and what the benefits are from establishing and documenting a scope and goal. Furthermore, the tool helped the participants to document important decisions, which can be easily shared with stakeholders and used as a reference. Finally, the maturity assessment helped the participants to better understand the current situation and identify clear improvement opportunities.

Therefore, the recommendation for ADIL is to continue this positive trend of starting improvement projects and to use the ITA-MM tool as a guide during their Digital Transformation journey. The tool structures and standardises how the department executes improvement projects. Furthermore, it offers the possibility to assess the current state of their IT architecture and identify improvement opportunities.

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Appendices

Appendix A – Systematic Literature Review Protocol

This appendix covers the review protocol of the systematic literature review (SLR) conducted during this research. It is necessary to obtain a solid theoretical background and a comprehensive overview of all available academic literature to design a well-founded artefact. Therefore, this research incorporates an SLR since it provides a thorough and fair approach. The pre-defined review protocol in this section is a fundamental aspect of the SLR since it reduces the possibility of researcher bias (Kitchenham & Charters, 2007). The main concepts of this protocol are from Kitchenham & Charters. In addition, several supporting concepts from Webster & Watson (2002) and Wolfswinkel, Furtmueller & Wilderom (2013) complement the review protocol.

- Background – covers the rationale behind the review.
- Research questions – are questions answered by the review.
- Search strategy – determines the used search terms and resources.
- Study selection criteria and procedure – addresses the criteria for including or excluding papers and the procedure of how these criteria are applied.
- Study quality assessment – discusses the quality assessment of the paper.
- Data collection and analysis – mentions the data extraction method used to derive information from the papers.

A 1 Background

This literature review aims to identify relevant research about digital maturity models to design a well-founded ITA-MM. First, the current state of the art regarding Digital Transformation and IT architecture is examined. Then is investigated how current models measure digital maturity. After which, the review identifies what current digital maturity models find important regarding the IT architecture and what challenges are not discussed by the identified studies. Lastly, the review investigates what methodologies are used for a Digital Transformation.

A 2 Research Questions

The review protocol includes the following research questions to study the concepts mentioned in the background:

RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?

RQ2: How is the level of Digital Transformation engagement measured at an organisation?

RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment?

RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models?

RQ5: What methodologies do exist to carry out Digital Transformation and IT projects?

A 3 Search Strategy

A searching process is defined beforehand to ensure a structured approach during the review. The searching process includes specific search strategies, sources, selection criteria and search terms.

Snowballing

The objective of an SLR is to identify all relevant research. However, some of the research questions have an exploratory purpose. These questions need broader search terms, which results in a large set of papers, many of which will be found irrelevant. For this reason, these research questions use an

alternative search approach called snowballing. Snowballing is a search technique that makes use of an initial set of relevant papers. New papers are added by backward and forward snowballing from this set if they are relevant (Wohlin, 2014). Snowballing intends to always have a set of papers relevant to the research question in mind.

The first step of snowballing is to identify a start set of papers. According to Wohlin (2014), a good start set is identified by search strings, formulated from keywords in the research question and synonyms. Furthermore, the set of papers need to be diverse. The most relevant and highly cited papers are added to the initial set of papers if too many papers are found.

After identifying the initial set of papers, new papers are added by backward and forward snowballing. Backward snowballing uses the reference list to identify new papers to include. Forward snowballing involves identifying new papers based on citations in the current set of papers.

Sources to be searched
The digital libraries used during this SLR were pre-selected to ensure at least a certain level of academic quality of the selected research. The preliminary search for the papers' title, keywords, and abstract uses the digital libraries of Scopus and Web of Science. Due to the high number of duplicate papers, we remark that adding more sources is not likely to result in additional relevant papers. Investigating the search terms in IEEE Xplore confirms this assumption. This review uses IEEE Xplore and Research Gate as additional sources to download the full papers.

Some additional restrictions are applied to these sources to further increase the relevance of the papers in the initial search. The selection of papers is restricted to the following research fields: Business, Management & Accounting, Computer Science, Decision Sciences, and Social Sciences.

Selection Criteria
Selection criteria are used to determine whether to include the studies found during the literature search in the final sample of papers. Table A-1 shows the selection criteria used in this review. As the study of Kitchenham & Charter (Kitchenham & Charters, 2007) suggests, the selection criteria have been piloted on a small subset of the initial literature from the review. This pilot showed that the selection criteria correctly classified the studies as relevant or not relevant for the review.

Inclusion Criteria
1. The paper contributes to answering the research question.
2. The paper was published in English.
Exclusion Criteria
1. The paper does not originate from the selected fields of study.
2. The paper is not publicly available or via external databases entitled to the UT.
2. Papers published before 2000.

Table A-1: Selection criteria

Search Terms
A general approach to draw up search terms is to break down the research question into individual facets. Then draw up a list of synonyms, abbreviations, and alternative spellings. Boolean operators such as “AND” and “OR” combine the individual terms to construct more sophisticated search strings. The wildcard application “*” simplifies search terms, e.g., organization and organisation merge to organi*ation and digital* covers, among other terms, Digital Transformation, Digitalisation and Digital Enterprise. Below is described for each research question the used search terms or selection of papers to answer the questions.

RQ1: What is the current state of the art regarding the combination of Digital Transformation and IT architecture? What are open research areas?

The first research question provides a foundation of knowledge for the research by investigating the current state of the art regarding the combination of Digital Transformation and IT architecture. In addition, the background search defines several definitions. This background search uses the snowballing technique.

RQ2: How is the level of Digital Transformation engagement measured at an organisation?

The second research question discusses how Digital Transformation engagement is measured at an organisation by examining the current state of the art regarding digital maturity models. This research question uses the search term "digital*" AND ("maturity model" OR "assessment model" OR "capability model") to gather a sample with current digital and Digital Transformation maturity models. The search term includes several synonyms for 'maturity model'. Since this research aims to design a maturity model that focuses on IT architecture, it also examines relevant Enterprise Architecture maturity models. The second search term is, therefore, "enterprise architecture" AND "maturity model".

RQ3: What concepts regarding IT architecture do current maturity models find important during the digital maturity assessment?

The third research question uses the final sample papers from the second research question.

RQ4: What challenges regarding Digital Transformation do organisations experience that are not part of current digital maturity models?

This question uses the snowballing technique. The start sample of papers consisted of papers gathered during the background research, which were relevant to answer this research question. A new search to find additional papers to answer the question uses the term ("it architecture" or "it infrastructure") AND "challenge". Striking and high citation papers, which seemed relevant for answering the question, were added to the start sample.

RQ5: What methodologies do exist to carry out Digital Transformation and IT projects?

The fifth research question also incorporates the snowballing approach, including a start sample of already found papers from the previous searches. Furthermore, this question uses an extra search with the term "Digital Transformation" AND ("methodology" OR "implementation"), from which several papers were added to the start sample.

A 4 Study Selection Procedure

Selection criteria are applied to the initial set of papers to ensure that the final sample consists of only relevant papers. This literature review uses the selection process of Wolfswinkel et al. (2013). This iterative selection process starts with filtering out double papers from different sources. After which, the selection procedure applies the selection criteria to the title and abstract of each paper. This review considers both title and abstract as two separate steps due to the large set of papers. Additionally, the selection procedure uses two extra steps where the selection criteria are applied to both the paper's introductions and conclusions. From the remaining sample, the full text is evaluated on relevance. Lastly, forward and backward citations evaluate whether the references used by the authors contain relevant papers to enrich the final sample of papers. Newly selected papers go through the same selection process and must meet all the selection criteria. The literature search concludes when the forward and backward citations do not result in the addition of new papers. Figure A-1 shows the iterative literature processes used during the literature review.

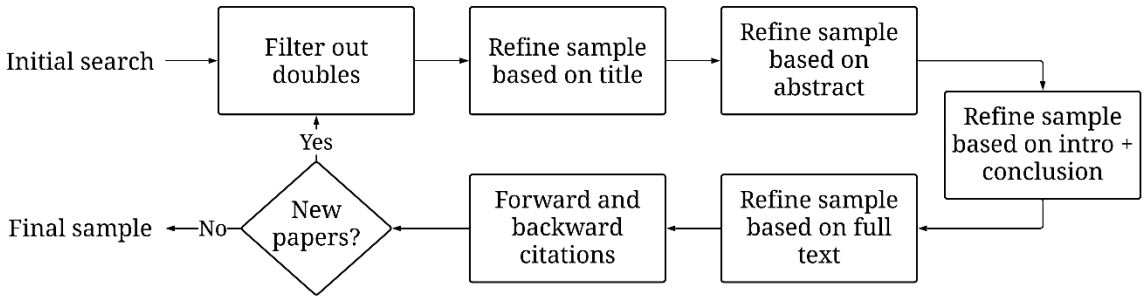

Figure A-1: Literature selection process based on Wolfswinkel et al. (2013)

A 5 Study Quality Assessment

The final sample of the review contains only relevant papers for this research using the selection criteria and process. However, it is also considered critical to assess the quality of the papers before analysing the data (Kitchenham & Charters, 2007). This quality assessment avoids the addition of papers with lower quality standards that potentially corrupt the literature review results into the final sample of papers. The quality assessment asks the following two questions to guarantee a certain level of scientific quality in the final set of papers:

1. Is the research question or objective of the paper clearly stated?
2. Are the findings based on a realistic case or a systematic literature review?

The first question aims to evaluate whether the paper has clear and thorough research questions or objectives. In addition, the second question assesses the quality of the results of the paper.

A 6 Data Collection and Analysis

The next step is to review the literature and combine the results with the final selection of papers. The data collection and analysis process uses two approaches to analyse the papers systematically. The first approach is the maturity model analysis method by Proença & Borbinha (2016). This methodology uses a systematic comparison approach, divided into three aspects: the model structure, assessment, and support. Each aspect consists of several elements:

Model structure:

1. Name of the maturity model: Name and primary reference of the maturity model.
2. Number of levels: The number of maturity levels.
3. Name of attributes: Definition of the attributes used by the maturity model.
4. Number of attributes: The number of attributes and sub-attributes used.
5. Maturity definition: Identifies if the maturity model defines the maturity stages in detail.
6. Practicality: Indicates if the recommendations are practical or problem specific.

Model assessment:

1. Name of the maturity model: Name and primary reference of the maturity model.
2. Assessment method described: Indication if the model uses an inherent assessment method.
3. Assessment cost: Indicates the degree of expenditure of a maturity assessment project.
4. Strong/weak points identification: Shows whether the maturity model identifies the weaknesses and strong points of an organisation.
5. Continuous assessment: Details if the maturity model encourages continuous improvement.
6. Improvement opportunities prioritisation: Indicates whether the maturity model prioritises the improvement opportunities of the organisation.

Model support:

1. Name of the maturity model: Name and primary reference of the maturity model.
2. Training available: Presence of training opportunities to become an expert on the model and assessment.
3. Autor support availability: The level of support the author provides for the model.
4. Continuity from different versions: Shows adaptability to newer versions of the model.
5. The origin of the model: Academic of practical origin.
6. Accessible: Whether the model is accessible to the general public.

The second approach is the analysis method of Wolfswinkel et al. (2013) and extracts additional relevant information from the set of papers. Their paper proposes picking a paper and highlighting any findings and insights that seem relevant to the research scope or correspond to the research questions. Each highlighted word, sentence or paragraph represents a relevant 'excerpt'. The process uses three phases of coding to form concepts from these excerpts and find connections between concepts:

1. 'Open coding' identifies a set of higher-abstraction level type of concepts from reading all the excerpts in the papers once more.
2. 'Axial coding' could lead to revisiting the defined concepts due to new insights. Moreover, interrelations between (sub-)concepts can be defined.
3. 'Selective coding' further integrates and refines concepts by going through the excerpts from the previous phases.

Documenting the coding process is fundamental so that the emerging and changing concepts can be traced and comprehended. Wolfswinkel et al. (2013) recommend visualising these concepts in a matrix based on the original matrix of Webster & Watson (2002). Table A-2 shows an example of this matrix.

Articles	**Concepts**		
	A	B	C
Example (Year)	X		X
Example et al. (Year)		X	X
…			

Table A-2: Concept matrix example (Wolfswinkel et al., 2013)

Appendix B – Capabilities of the ITA-MM

B 1 Capabilities for the operations & processes dimension

This dimension evaluates the standardisation, digitisation, and automation of an organisations' business activities.

Level 0 – Non-existent The organisation has not started with Digital Transformation
OP0.1 There is no standardisation of business activities. OP0.2 Business activities are not supported digitally.
Level 1 - Initiating The decision is made to move toward a Digital Enterprise, and initial steps are taken
OP1.1 Initiatives started to standardise and digitise key business activities. OP1.2 Evaluation and experimentation of digital services to start collecting data.
Level 2 – Enabling First initiatives are implemented and form a foundation for further improvements
OP2.1 Standardisation of new and existing business activities. OP2.2 Implementation of systems and applications to support digital business activities. OP2.3 Deployment of systems and processes to collect and analyse data. OP2.4 Consideration of customer and supplier experience during business activities improvement projects.
Level 3 – Integrating Integration of initiatives across the organisation, first steps towards end-to-end connectivity
OP3.1 Processes and systems in place to support the integration of third-party services. OP3.2 Cooperation with customers and suppliers when improving business activities with third party involvement. OP3.3 Collection of customer and usage data to provide performance visibility. OP3.4 Automation of digital key business activities.
Level 4 – Optimising Initiatives are fine-tuned and further improved to increase overall performance
OP4.1 Optimisation of (automated) business processes to improve efficiency and reduce costs. OP4.2 Real-time collection of customer and usage data to analyse and optimise service reliability. OP4.3 Implementation of some real-time automated decision making. OP4.4 Processes and systems are capable of handling temporary and long-term growth.
Level 5 – Continuous improvement Initiatives are continuously improved, and there is full end-to-end connectivity
OP5.1 Customer and usage data analysis is now driving innovation within the organisation. OP5.2 Continuous improvement of business activities in cooperation with customers and suppliers. OP5.3 Automated end-to-end processes ensure real-time data flow for improved performance and real-time, automated decision making.

Table B-1: Capabilities for the operations & processes dimension

B 2 Capabilities for the technology dimension

The technology dimension evaluates the tools and assets that generate and use data and interfaces to access data.

Level 0 – Non-existent The organisation has not started with Digital Transformation	
T0.1	There are not tools that generate or use digital data.
T0.2	No interfaces in place to access data.
Level 1 - Initiating The decision is made to move toward a Digital Enterprise, and initial steps are taken	
T1.1	First tools in place to collect data from the business activities.
T1.2	Preparation of initial pilots to test new systems and applications.
T1.3	There is no IT security in place.
Level 2 – Enabling First initiatives are implemented and form a foundation for further improvements	
T2.1	Deployment of systems and applications to support digital services.
T2.2	Interfaces in place to access, visualise and analyse customer and usage data.
T2.3	Implementation of an IT security strategy and applying user credentials.
Level 3 – Integrating Integration of initiatives across the organisation, first steps towards end-to-end connectivity	
T3.1	Tools and algorithms in use to process and analyse customer and usage data.
T3.3	Advanced IT security measures in place, e.g., two-factor authentication.
Level 4 – Optimising Initiatives are fine-tuned and further improved to increase overall performance	
T4.1	Algorithms using real-time customer and usage data to make decisions.
T4.2	Initial tools make autonomous decisions based on real-time data.
T4.3	Evaluation and experimentation with machine learning algorithms.
Level 5 – Continuous improvement Initiatives are continuously improved, and there is full end-to-end connectivity	
T5.1	Implementation of advanced and autonomous algorithms which use real-time data to optimise business activities continuously.
T5.2	Implementation of machine learning across the organisation for predictive activities.

Table B-2: Capabilities for the technology dimension

B 3 Capabilities for the data dimension

This dimension evaluates data collection, storage, integrity, and security.

Level 0 – Non-existent The organisation has not started with Digital Transformation	
D0.1	No data is collected.
Level 1 - Initiating The decision is made to move toward a Digital Enterprise, and initial steps are taken	
D1.1	Organisation started with the collection of data.
D1.2	Data is available for eventual needs.
D1.3	Data availability, integrity and security are not guaranteed.
Level 2 – Enabling First initiatives are implemented and form a foundation for further improvements	
D2.1	Collection of customer and usage data.
D2.2	Data is shared according to value stream needs.
D2.3	Implementation of data access rights to guarantee data security.
Level 3 – Integrating Integration of initiatives across the organisation, first steps towards end-to-end connectivity	
D3.1	Algorithms and tools in place to analyse customer and usage data and capture valuable information to understand business insights.
D3.2	Ensuring the completeness, validity, and consistency of data for the users (data quality).
Level 4 – Optimising Initiatives are fine-tuned and further improved to increase overall performance	
D4.1	Implementation of (real-time) data-driven decision making.
D4.2	Ensuring the accuracy, reliability, relevancy, and quality of data across its lifecycle (data integrity).
Level 5 – Continuous improvement Initiatives are continuously improved, and there is full end-to-end connectivity	
D5.1	Organisation uses autonomous real-time, data-driven decision-making tools.
D5.2	Improving the data security, quality and integrity continuously based on changing needs.

Table B-3: Capabilities for the data dimension

B 4 Capabilities for the integration dimension

The integration dimension evaluates the integration of hard- and software that facilitates all the systems used to carry out the organisation's business activities.

Level 0 – Non-existent The organisation has not started with Digital Transformation	
I0.1	There is no integration of systems and applications.
Level 1 - Initiating The decision is made to move toward a Digital Enterprise, and initial steps are taken	
I1.1	Efforts started to define an IT architecture.
I1.2	There are some initial application and system integrations on a user level.
Level 2 – Enabling First initiatives are implemented and form a foundation for further improvements	
I2.1	Integration of enterprise systems on a departmental level.
I2.2	There is an IT architecture design used to align the organisations IT changes to the target architecture.
I2.3	Redefining the IT architecture design to minimise the number of integrations needed.
Level 3 – Integrating Integration of initiatives across the organisation, first steps towards end-to-end connectivity	
I3.1	Integration of third-party services and supported by digital enterprise IT architecture and related tools.
I3.2	Cross-departmental integration of enterprise systems.
I3.3	Alignment of processes throughout the organisation, according to the IT architecture.
Level 4 – Optimising Initiatives are fine-tuned and further improved to increase overall performance	
I4.1	Organisation-wide integration of enterprise systems.
I4.2	Optimising end-to-end processes by leveraging the IT architecture design.
I4.3	IT architecture is capable of handling temporary and long-term growth.
Level 5 – Continuous improvement Initiatives are continuously improved, and there is full end-to-end connectivity	
I5.1	Integration throughout the whole supply chain, guaranteeing full end-to-end connectivity.
I5.2	Continuously improving the IT architecture design based on changing technologies and supply chain needs.

Table B-4: Capabilities for the integration dimension

B 5 Capabilities for the shadow IT dimension

This dimension assesses the level of shadow IT use within the organisation.

Level 0 – Non-existent The organisation has not started with Digital Transformation	
S0.1	Employees make use of non-digital solutions and tools to assist them during their work activities.
Level 1 - Initiating The decision is made to move toward a Digital Enterprise, and initial steps are taken	
S1.1	Employees develop personal digital tools to support work activities.
S1.2	The existence of digital support tools is not shared among employees.
Level 2 – Enabling First initiatives are implemented and form a foundation for further improvements	
S2.1	New digital support tools are designed in collaboration with colleagues.
S2.2	The development of digital support tools is documented and shared within a department.
Level 3 – Integrating Integration of initiatives across the organisation, first steps towards end-to-end connectivity	
S3.1	Employees and departments propose new ideas or functionalities to the IT department, which does the development.
S3.2	IT department starts with training employees and departments to develop tools according to the standards of the IT department.
S3.3	Business activities still rely on existing shadow IT solutions.
Level 4 – Optimising Initiatives are fine-tuned and further improved to increase overall performance	
S4.1	Development and implementation of new tools and functionalities are done in close cooperation between users and the IT department.
S4.2	Employees and departments finish their initial training.
Level 5 – Continuous improvement Initiatives are continuously improved, and there is full end-to-end connectivity	
S5.1	Departments can change and implement features in their systems under the supervision of the IT department.
S5.2	Employees and departments participate in regular occurring workshops to stay up-to-date on application development and the IT department's development standard.

Table B-5: Capabilities for the shadow IT dimension

Appendix C – Validation Research Statements & Questions

Maturity levels
The maturity levels are sufficient to represent all stages of Digital Transformation engagement. (Sufficiency)
There is no overlap between the descriptions of the maturity levels. (Accuracy)
Capabilities are correctly assigned to their respective maturity level. (Accuracy)
Would you add any maturity levels? If so, please explain which and why?
Would you update the maturity level description? If so, please explain which and why?
Do you have anything to add about the maturity levels, which is not covered in the questions above?
Dimensions
The dimensions are relevant to assess the IT architecture of an organisation. (Relevance)
The dimensions cover all areas involved in the assessment of the IT architecture of an organisation. (Comprehensiveness)
There is no overlap between the distinct dimensions. (Mutual Exclusion)
Capabilities are correctly assigned to their respective dimensions. (Accuracy)
Would you add any dimensions? If so, please explain which and why?
Would you remove any dimensions? If so, please explain which and why?
Do you have anything to add about the dimensions, which is not covered in the questions above?
Understandability
The maturity levels are understandable.
The dimensions are understandable.
The assessment guidelines are understandable.
Could the ITA-MM be made more understandable? If so, please explain how?
Do you have anything to add about the understandability of the ITA-MM, which is not covered in the questions above?
Ease of use
The assessment tables are easy to use.
Could the ITA-MM be made easier to use? If so, please explain how?
ITA-MM is intended as a self-assessment tool without an external assessor requirement. Would you be able to do an assessment by yourself in the future? Why or why not?
Do you have anything to add about the ease of use of the ITA-MM, which is not covered in the questions above?
Usefulness
The ITA-MM is useful for assessing the IT architecture of the organisation.
The ITA-MM helps to better understand how to improve the IT architecture.
Could the ITA-MM be made more useful or practical? If so, please explain how?
Would the ITA-MM have been of added value in a recent project? If so, please elaborate how? If not, please elaborate why?
Would you use the ITA-MM for a future improvement project? If so, please elaborate why? If not, please elaborate why?
Do you have anything to add about the practicality of the ITA-MM, which is not covered in the questions above?
ITA-MM Roadmap
The goal and purpose of each roadmap step are clear (Understandability).
The roadmap is easy to use (Ease of use).
The roadmap is useful to formulate and execute improvement initiatives (Usefulness).
Would you suggest any updates or improvements related to the roadmap? If so, please explain what and why?
Would the roadmap have been of added value in a recent project? If so, please elaborate how? If not, please elaborate why?
Would you use the roadmap for a future improvement project? If so, please elaborate why? If not, please elaborate why?
Do you have anything to add about the roadmap or one of the nine steps, which is not covered in the questions above?

Table C-1: Validation research statements and questions

Appendix D – Transcription Validation Surveys

D 1 Maturity Levels

Interviewee	A	B	C	D	E
The maturity levels are sufficient to represent all stages of Digital Transformation engagement. (Sufficiency)	4	5	5	5	5
There is no overlap between the descriptions of the maturity levels. (Accuracy)	3	4	4	3	3
Capabilities are correctly assigned to their respective maturity level. (Accuracy)	4	5	4	5	4
Would you add any maturity levels? If so, please explain which and why?	No	No	I personally would not add any maturity levels, as the current levels already allow a clear distinction and provide a great number of details.	No, it is already quite extensive.	No, more levels make it too complex.
Would you update the maturity level description? If so, please explain which and why?	I think the descriptions could be a bit more exact.	No	I would not. In my opinion, the current level descriptions cover a complete range from start to end.	In my opinion, levels 4 and 5 do have some overlap; not sure if there is a fundamental difference?	If you read them independently, 3 seems more sophisticated than 4. Also, it is possible for organisations to work on multiple initiatives on different levels. This way you have to scale all initiatives for the entire organisation on 1 level.
Do you have anything to add about the maturity levels, which is not covered in the questions above?	No	It is very interesting to read through the levels, recognise your department's current level, and then read step by step what improvements could be made.	Currently, the focus is on digital transformation. However, I believe that the current setup and maturity levels could also be used for a broader range of activities. E.g., the evaluation tasks and processes currently performed by a team that does not specifically require a digital transformation.	No	No

Table D-1: Transcription validation survey maturity levels

D 2 Dimensions

Interviewee	A	B	C	D	E
The dimensions are relevant to assess the IT architecture of an organisation. (Relevance)	5	5	5	5	5
The dimensions cover all areas involved in the assessment of the IT architecture of an organisation. (Comprehensiveness)	4	3	5	5	2
There is no overlap between the distinct dimensions. (Mutual Exclusion)	2	3	4	4	4
Capabilities are correctly assigned to their respective dimensions. (Accuracy)	4	4	5	5	4
Would you add any dimensions? If so, please explain which and why?	No	Improvements could not be made if you have the right people. So, an HR-related dimension could cover that.	I would not add any dimensions to prevent overlap. The current dimensions might have some overlap but are linked to each other very well. The current dimensions seem to cover all aspects involved and provide a lot of insights.	No	As discussed, human capital. It is always about human, process, and technology.
Would you remove any dimensions? If so, please explain which and why?	I would not remove any dimensions since that would result in the loss of important information	No, because this would result in the loss of relevant aspects.	I would not, for the same reason as given in the previous answer. The current dimensions might have some overlap but are linked to each other very well. The current dimensions seem to cover all aspects involved and provide a lot of insights. Removing a dimension could result in not having a complete overview of the situation.	No, I think that all dimensions are relevant.	No
Do you have anything to add about the dimensions which is not covered in the questions above?	No	No	I do not.	During the development, it was sometimes hard to distinguish when something was about data or technology. However, this version of the model put it quite right.	No

Table D-2: Transcription validation survey dimensions

D 3 Understandability

Interviewee	A	B	C	D	E
The maturity levels are understandable.	4	5	5	5	4
The dimensions are understandable.	3	5	5	5	4
The assessment guidelines are understandable.	4	5	4	5	4
Could the ITA-MM be made more understandable? If so, please explain how?	Sometimes it is not clear which maturity level a certain process is. Some better definitions on the levels would probably help.	No	I think the ITA-MM is very clear and understandable. However, the dimensions might allow for some interpretation and personal opinions. Therefore, further definition and guidance on these dimensions could help to prevent misconceptions.	No	You could visualise it in a picture. It is a lot of text for organisations. If it is too complex, they will not use it. Also, an online tool could help organisations. Simple questions to determine the level, and they will get a result.
Do you have anything to add about the understandability of the ITA-MM, which is not covered in the questions above?	No	No	The ITA-MM could be completed with a small introduction and argumentation/justification for the levels and dimensions to make the model even more clear than it already is.	No	No

Table D-3: Transcription validation survey understandability

D 4 Ease of Use

Interviewee	A	B	C	D	E
The assessment tables are easy to use.	4	4	4	3	4
Could the ITA-MM be made easier to use? If so, please explain how?	Some other format would probably help to increase the ease of use.	No	Currently, the scoring table does allow for interpretation of the aspects that are being scored. Due to misconception, someone might think they meet the level requirements, while that is not the case. The score form could, for example, be extended with a column that allows you to tick off the subjects that are applicable or met. Adding additional columns would allow for a four-six eye principle and cross-checks.	In my opinion, it is too extensive/complex for straightforward use. I think a form, like this questionnaire, which takes you step by step, is a nice improvement.	See earlier response about online tooling.
ITA-MM is intended as a self-assessment tool without an external assessor requirement. Would you be able to do an assessment by yourself in the future? Why or why not?	Yes, besides the previous comments, it should be easy to use.	Yes, because of the clear and recognizable descriptions.	Yes, I would. The provided amount of definitions and details would allow me to do an assessment.	See the previous answer. The choices are not that hard to make, but some guiding by different tooling could be helpful.	I understand the tool, but I doubt it if I would assess the level perfectly right. It should be very clear that it is not important whether you assess your position perfectly right, but it is an indication for future steps.
Do you have anything to add about the ease of use of the ITA-MM, which is not covered in the questions above?	No	No	I believe when someone is involved in a digital transformation, they should also take the time to read through a model like this that supports that transformation. The current model will then speak for itself.	No	No

Table D-4: Transcription validation survey ease of use

D 5 Usefulness

Interviewee	A	B	C	D	E
The ITA-MM is useful for assessing the IT architecture of the organisation.	4	5	5	5	3
The ITA-MM helps to better understand how to improve the IT architecture.	4	5	5	5	4
Could the ITA-MM be made more useful or practical? If so, please explain how?	No	No	The ITA-MM could be made more useful or practical by making it an online model/tool. For example, when it comes to digital transformations, you would obviously like to limit the amount of hard copy forms etc. Online accessibility could also add to the ease of use of the model.	See previous. Probably split up the list in some different parts with the help of form tooling, i.e..	No
Would the ITA-MM have been of added value in a recent project? If so, please elaborate how?	Yes, it would have helped during recent projects.	Yes, instead of taking a problem and creating a solution that is not improving the maturity level, you could think of a better solution that fixes the issue and improves the department.	Yes, it would. It could have been of great value to assess our calculation model and determine the next steps towards a new or improved solution.	Sure, in the current transformation of my team and tooling.	Yes, by constructing a recently made digitisation scan.
Would you use the ITA-MM for a future improvement project? If so, please elaborate why? If not, please elaborate why?	Yes, I think it could be useful to show what progress a project could make.	Yes, for the same reason mentioned above	Yes, I would. However, it certainly depends on the impact of a project. It will not be of use if a project itself or its impact is very small. However, for larger projects requiring multiple disciplines, the ITA-MM helps to provide a clear overview for all stakeholders involved. In my opinion, this will benefit the understanding and follow-up of the project.	Yes, see previous.	Possibly, but it is important to cover all aspects that influence digital transition and transformation of companies
Do you have anything to add about the practicality of the ITA-MM that is not covered in the questions above?	No	No	I do not.	No	It is much text and up to the interpretation of the user.

Table D-5: Transcription validation survey usefulness

D 6 ITA-MM Roadmap

Interviewee	A	B	C	D	E
The goal and purpose of each roadmap step are clear (Understandability).	4	4	5	5	5
The roadmap is easy to use (Ease of use).	4	4	4	4	4
The roadmap is useful to formulate and execute improvement initiatives (Usefulness).	4	4	5	5	4
Would you suggest any updates or improvements related to the roadmap and/or the nine steps? If so, please explain what and why?	Yes, as mentioned earlier, another format could also help here.	There could be some timeframe related guidelines added. For example, a guideline on how much time each phase and a complete iteration take.	Personally, I would consider switching the first two steps of the roadmap. My personal experience is that in order to create awareness and support, you should first define a clear scope.	Again, it is quite a lot of text and information to absorb when you look at it the first time, I suppose. So, how can we reduce the amount of information presented at once?	No
Would the roadmap have been of added value in a recent project? If so, please elaborate how? If not, please elaborate why?	Yes, we could use it in projects we are currently working on. The whole organisation is changing, and this is a nice way to track the changes.	Yes, instead of going from an idea to a solution in one step, you can guide yourself and the team in a more professional way.	Yes, it would have. The method provides you with a clear overview of steps to take in a process. Without any kind of guidance like this method, it is easy to forget or skip steps that could be important or beneficial for your project.	In building the IT roadmap for ADIL, we have started right away instead of taking the previous steps as maturity assessment and scope definition etc. If we did, it would have saved us a lot of rework	No, for me, as it is a standard way of working for me. Many companies use (partly) this approach but are not aware of it.
Would you use the roadmap for a future improvement project? If so, please elaborate why? If not, please elaborate why?	See above.	Yes, for reasons mentioned above.	Yes, I would, as it would provide the team and me with a detailed guide through the improvement process. It is something that can be shared with all stakeholders and clearly shows what is part and expected of a project.	Yes, for the reasons I mentioned earlier.	Yes, I would use a roadmap of some form.
Do you have anything to add about the roadmap or one of the nine steps, which is not covered in the questions above?	No	No	I do not.	No	No

Table D-6: Transcription validation survey ITA-MM roadmap