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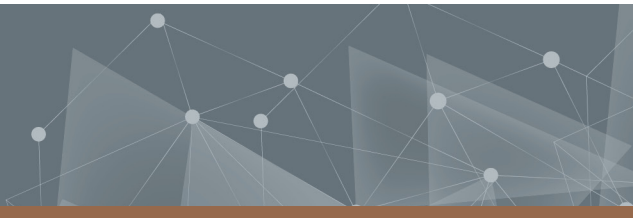

Systematic Requirements Management

Essential factors when managing requirements in major infrastructure projects

Master's thesis in Design and Construction Project Management

OLIVIA BRANDES

EMELIE CESAR

Department of Technology Management and Economics
Division of Service Management and Logistics

Chalmers University of Technology
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OLIVIA L. BRANDES
EMELIE M.J. CESAR

Report no. E2022:066
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

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OLIVIA L. BRANDES
EMELIE M.J. CESAR

Department of Technology Management and Economics
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Abstract

Introduction - One essential criteria for major infrastructure projects to be successful is to fulfill the needs and expectations of a project, which are defined as requirements. Currently, major infrastructure projects have difficulties in achieving requirements where one main reason is the increased number of requirements. Accordingly, there is a need to establish an integrated process for systematic requirements management (SRM) to fulfill the requirements. Therefore, the aim of the study was to investigate what changes are required to establish SRM in major infrastructure projects.

Method - A case study was conducted at major projects west at Skanska in Sweden. The study was based on a qualitative research consisting of 16 interviews. The interviews aimed to investigate the organisation´s current process and tools for requirements management (RM). A literature study was conducted to establish a theoretical foundation to the case study.

Empirical Study - The studied organisation has a lack of SRM within their projects, even though both design and production works systematically to some extent. Therefore, the collaboration within SRM between these project phases need to be extended. In addition, seven challenges connected to countermeasures were identified within SRM: increased number of requirements, unclear requirements, changes of requirements, lack of common structure, negative attitude, negative reputation and difficulties in documentation. Furthermore, RM tools have been identified as essential when establishing SRM.

Conclusion - To facilitate the establishment of SRM, it is important that organisations, in an early project stage, creates an integrated and common structure, including working approaches, routines and RM tools for SRM. The management has a central role to implement and maintain the common structure as well as motivate employees to understand how and why SRM should be applied. To motivate employees, it is essential to create a positive attitude, improving the understanding and establishing organisational routines. Organisations need to consider the correlation between IT, people, management and structure, and their impact on SRM. Hence, all four factors are essential when establishing an integrated process for SRM throughout all project phases, and thus achieve client satisfaction.

KEYWORDS: Requirements, Requirements management, Systematic requirements management, challenges when managing requirement, Motivation, Routines, Requirements management tools, Major infrastructure projects

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List of Abbreviations

AMA: General material- and work description

BIM360: BIM360 Autodesk Field Management

DOORS: Dynamic Object Oriented Requirements System

ITP: Inspection and test plan

QEHS: Quality, Environment, Health and Safety

RM: Requirements management

SRM: Systematic requirements management

STA: Swedish Transport Administration

VDC: Virtual design and construction

Vsaa: Our way of working

1
Introduction

The aim of the chapter is to introduce the background, and the context of the thesis. Furthermore, the chapter will present the aim and research questions as well as limitations.

1.1 Background

Major infrastructure projects are essential for the community and have the potential to create value for the society, in projects such as hospitals, roads, bridges and railways (Dahlin & Pesämaa, 2021). However, historically, major infrastructure projects have been associated with high complexity (Eriksson & Kadefors, 2017; Flyvbjerg, 2005; Masrom, Rahim, Mohamed, Chen, & Yunus, 2015). The large scale and complexity often result in difficulties in planning. Major infrastructure projects are often planned for a long duration and issues can occur due to unpredictable changes, which leads to increased time and costs (Hetemi, Mere, Nuur, & Engwall, 2017). According to Flyvbjerg (2005), both the scope and ambition level of the project can change during the project. Mohamed (2005) also mentions the complexity in major infrastructure projects, as a result of many different actors being involved.

Major infrastructure projects are often related to high costs (Flyvbjerg, 2005; Masrom et al., 2015). Budget overruns occur in nine out of ten major infrastructure projects (Garemo, Matzinger, & Palter, 2015). According to Boverket (2018), 25 percent of the project costs comes from mistakes and faults. However, the costs required to prevent mistakes are remarkably lower than the costs to correct them. According to Nagapan, Rahman, Asmi, Memon & Zin (2012), mistakes and faults in the design phase, as well as mistakes during the production, are two main causes of construction waste, an thus affect the environment negatively. Therefore, organisations need to focus on creating standardised working methods in an early stage, in order to prevent these mistakes and generate more qualitative projects (Boverket, 2018).

An essential criteria for a project's success is to fulfill the needs and expectations of a project. However, major infrastructure projects generally struggle to achieve the client's needs and expectations (Jallow, Demian, Baldwin, & Anumba, 2014). These needs and expectations are called requirements and will shape projects. To fulfill the requirements, a well implemented requirements management (RM) is essential were More, Sapre & Chawan (2011, p.1) have stated:

"*If you don't get the requirements right, your project will fail...*"

Jallow et al. (2014) have also highlighted the importance of RM and promote the benefits

of managing requirements during the entire lifespan of a project, which creates opportunities for a successful project. They empathise that a successful project needs to contain distinct requirements for quality, performance, time and budget, even if the task is difficult. Requirements can be generated and changed by different actors during an entire project (Izhar, Bhatti, Izhar, & Jadi, 2018). Therefore, it is essential to establish an RM plan to facilitate the documentation and communication of requirements between different actors.

However, there are several challenges for managing requirements, which results in a complex process for RM. One solution is therefore to establish systematic requirements management (SRM). SRM is an integrated process for RM which consider the economical, social and environmental aspects, according to Flyvbjerg (2005). Such a process does not currently exist for major infrastructure project even though it is essential (Yu & Chan, 2010). SRM facilitates for organisations to reduce faults and mistakes, which generate in less waste and more sustainable projects (Nagapan et al., 2012). Furthermore, establishing a proper SRM process in an early project phase will aid the project to fulfill the requirements, and thus the client´s needs and expectations, in the final end (Yu & Chan, 2010).

1.2 Studied organisation

One company that has discovered the need to work more systematically with RM is the contractor Skanska, especially their region: major projects west. According to Skanska, major infrastructure projects are defined by complexity and size. One reason for why major project west at Skanska has wished to work more systematically with RM is that they lately have started to engage in turnkey contracts, which have resulted in new challenges, especially to manage the increased number of requirements. Turnkey contracts means that the client gives the full responsibility to a contractor to plan and construct the client's needs (Azhar, Priyono, Solechan, Suharso, & Pramono, 2019). Another reason for establishing SRM is that major infrastructure projects are even larger today, which leads to a higher complexity when handling all requirements.

Currently, Skanska has no systematic approach, even though some methods for RM have been established. Therefore, the organisation is in need of new perspectives of how they should integrate SRM in major infrastructure projects.

1.3 Aim

The aim of the study is to investigate what changes are required to establish SRM in major infrastructure projects. In order to achieve the aim, the following research questions have been identified:

RQ1: How can the RM process in major infrastructure projects be combined with the RM plan?

The RM plan facilitates the communication between different actors of how requirements should be managed. By integrating the RM process in the RM plan, an overall

understanding can be gained of how SRM should be established. Then, it is possible to ensure that any updates or changes in requirements resulting from the RM process are documented in the RM plan.

RQ2a: What are the challenges when establishing SRM, and what is required to manage these?

RQ2b: Which functions are required in a RM tool when establishing SRM?

When establishing SRM, there are several challenges which are essential to consider at an organisational level. To manage the challenges, organisations need to sometimes do hands-on actions. Thus, there is also a need for RM tools with suitable functions that can be used to facilitate the establishment of SRM.

RQ3: What is needed to support a change towards more systematic RM?

To be able to establish a new way of working with SRM, it is important for both the organisation and its management to support the employees, and thus increase the likelihood for a positive reception of the new way of working.

1.4 Limitations

The study will be limited to major infrastructure projects and the focus will be to investigate how a SRM process can be established in early project phases in order to later be integrated throughout the entire project life cycle. By preventing mistakes in the early phase, cost can be remarkably reduced. Establishing SRM in an early phase is also assumed to facilitate the work with requirements in the following phases and thereby ensure that the final project is successful.

There are many different categories of requirements in major infrastructure projects, such as client-, environmental- and design requirements. In this study, the requirements will be approached generally and will therefore be categorised and described together. Hence, the word requirement will be used throughout the thesis to reflect any of these categories of requirements.

When analysing the correlation between the RM process and the RM plan, the focus will be on the components within the scope of the empirical study: *requirements elicitation procedure*, *roles & corresponding responsibilities*, *tools* and *approval*.

2

Theoretical Framework

The aim of this chapter is to provide a foundation in the theoretical area used as a basis to address the research questions. The chapter consists of sections addressing requirements in the construction industry, RM, SRM, challenges when managing requirements and factors that affect the SRM process.

As mentioned in the introduction, the aim of the study is to investigate what changes are required to establish SRM in major infrastructure projects. In addition, important functions for a RM tool will be investigated. Accordingly, the main themes of the theoretical framework will be RM and SRM. To achieve the aim of the study, factors affecting SRM have been synthesised within the main themes into a theoretical framework, illustrated in Figure 2.6.

2.1 Requirements in the construction industry

Requirements are used everywhere in everyday life when different conditions shall be achieved (Jallow, Baldwin, & Anumba, 2008). The key words describing requirements according to Yu & Chan (2010), are associated with the required quality, characteristics or capability of a system in order to achieve a pursuable project or product (Young, 2004; Yu & Chan, 2010). Thus, requirements describe the way a system should act (Garcia, Montes, & Martinez, 2019).

In construction projects, requirements are essential to illustrate the stakeholders' expectations on a project (More et al., 2011; Yu & Chan, 2010). In other words, requirements are used to describe what should be delivered in a construction project (Garcia et al., 2019). It is the client who has a central role to formulate the requirements for a project (Jallow et al., 2014). According to Jallow et al. (2014), requirements can be described as the client's needs and expectations. Requirements are therefore an important factor in all project phases, since they set the project's frameworks in order to fulfill requirements. In addition, More et al. (2011), highlight that it is important that requirements should be understandable by everyone.

There are several ways to categorise requirements in the construction industry. Yu & Chan (2010) have identified six different areas of requirements; *Client-, Site-, Environmental-, Regulatory-, Design-, and Construction requirements.* In addition, the authors have described other types of project requirements which are based on the client's business needs.

1. **Client requirements** - Describe the result which should satisfy the project's needs, covering the whole life cycle.
2. **Site requirements** - Describe the features and conditions of the project site.
3. **Environmental requirements** - Describe the environmental circumstances for the project area.
4. **Regulatory requirements** - Describe the legal requirements including e.g., construction, health and safety over the project life cycle.
5. **Design requirements** - Transform the client-, site- and environmental requirements to design requirements.
6. **Construction requirements** - Transform design requirements into construction requirements, including its execution.

To fulfill all types of requirements, a well implemented RM process is essential (More et al., 2011). Poor management of requirements will result in decreased quality, budget overruns and difficulties in execution (Jallow et al., 2014).

2.2 Requirements management

RM describes the elements that need to be accomplished during a project, including how to control and track requirements as well as changes to requirements (Izhar et al., 2018). This is aligned with Kumar & Kumar (2011), who state that RM is used to identify, control, and track requirements and changes to requirements during a project. In addition, Yu & Chan (2010) describe that RM ensures that the expectations and needs from the clients are achieved, and that the requirements are met in the final product. By establishing RM in a proper way, organisations could reach better business results, otherwise the project is subject of higher risk of project failure (Izhar et al., 2018).

There are several definitions of RM in the literature. Jallow et al. (2014), in their synthesis of earlier research about the process of RM within several industries, have identified the following components: *elicitation, documentation, communication, verification* and *managing change*. However, in this study the RM process is based on the following components, presented by Izhar et al. (2018): *requirements elicitation, requirements analysis, requirements specification, requirements validation, change management* and *traceability*. The process is illustrated in Figure 2.1.

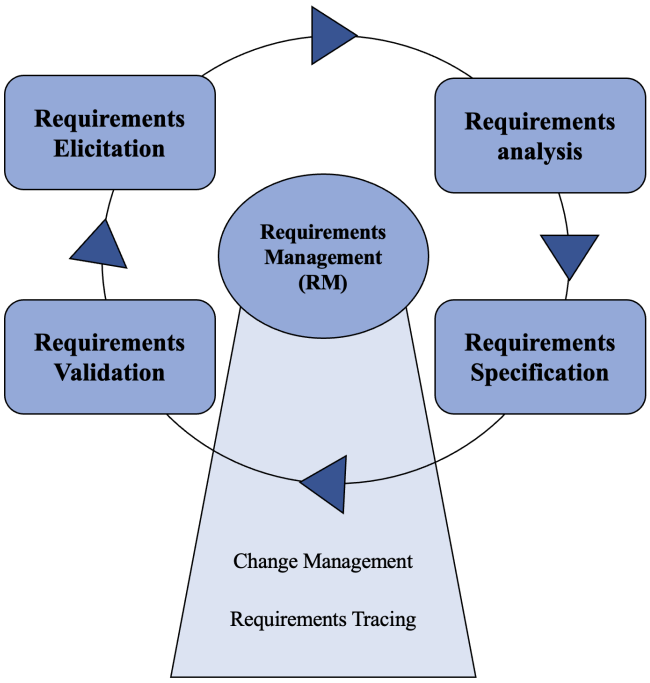

Figure 2.1: The requirements management cycle, inspired by Izhar, Bhatti, Izhar & Jadi (2018).

The basis for choosing this process is due to the underlying idea that the process of RM needs to be continuous and should occur during the entire project's life cycle (Jallow et al., 2014; Kumar & Kumar, 2011). In addition, the process for RM is iterative and refined over time (Parsanezhad, Tarandi, & Lund, 2016). The process can be defined as iterative since requirements can change or be added by different stakeholders throughout a project life cycle (Izhar et al., 2018). Hence, the process is illustrated as a continuous cycle in Figure 2.1.

Izhar et al. (2018) also stated that communication between different stakeholders is a central part to manage new requirements or changes in requirements, and it is therefore essential to establish a RM plan. The plan consists of the components, described in Figure 2.2. Figure 2.2 demonstrates the components that are essential to facilitate the documentation of requirements and the communication between different actors, when requirements are added or changed.

Project Overview	Requirement Elicitation procedure	Roles & corresponding responsibilities	Tools	Requirements traceability	Change control	Approval
Brief description of the project	Procedure to evoke, investigate and record the most important conditions	Identify roles and responsibilities for managing requirements in different tasks	Tools that will be used to fulfil requirements in terms of e.g., recording, overseeing and tracking	The process of tracking requirement during the project lifecycle	The process of managing change in requirements	An appointed role ensure and approve the documentation of requirements

Figure 2.2: Requirements management plan, inspired by Izhar, Bhatti, Izhar & Jadi (2018).

However, managing requirements is a complex process (Yu & Shen, 2013), which partly

depends on all requirements from the client. The construction industry has many challenges when managing these requirements, where one solution is to establish SRM.

2.3 Systematic requirements management

Today, managing requirements in the construction industry is a difficult task (Jallow et al., 2014). Due to the uniqueness of major infrastructure projects, there is a high need to manage and organise clear standard models for RM (Eriksson & Kadefors, 2017). Therefore, the sector needs to document and store requirements for future use, but also to aid the design- and production phase with the right information about the requirements for project success (Jallow et al., 2008). Accordingly, there is a need to establish an integrated process to manage the requirements, and thereby minimising the risk for project failure.

Currently, there is no generally accepted systematic process for RM in construction projects (Yu & Chan, 2010). According to Jallow et al. (2008), there is a strong focus on establishing frameworks for managing requirements in the design phase but those are not integrated into the following project phases at the moment. However, it is of high importance to establish a RM process that proceeds throughout the entire project (Jallow et al., 2008; Pandey & Pandey, 2012). The elements included in the process of RM, should be merged to a common SRM process throughout the entire project with the knowledge that the requirements can be adjusted or changed (Soliman-Junior, Tzortzopoulos, Balduaf, & Kagioglou, 2020). Establishing a proper systematic process for RM will reduce the cost for managing the requirements errors that will occur later in the project (Pandey & Pandey, 2012). Hence, in this study, SRM is identified as a RM process that is integrated throughout all phases in the project life cycle.

Establishing a proper SRM will ensure that the requirements are recorded and traceable, as well as integrated in the entire project life cycle (Yu & Chan, 2010). Through traceability, Yu & Chan (2010, p.6) have identified the following benefits:

- Greater confidence in meeting objectives
- Ability to access the impact of change
- Improved accountability of subordinate organisations
- Ability to track progress
- Ability to balance cost against benefits

Therefore, traceability is essential for organisations when managing requirements and should be considered as a function in RM tools.

2.3.1 Criteria and capabilities for RM tools

One way to manage the complexity of RM is to use proper and systematic tools. Hull, Jackson & Dick (2005), indicate the importance of managers having the right tools to address the RM process. RM tools help to ensure that requirements are *consistent*, *accessible* and *up-to-date* (Hoffmann, Kühn, Weber, & Bittner, 2004). Thus, RM tools aims to fulfill all requirements in a project (Izhar et al., 2018).

According to Hoffmann et al. (2004), the goal of SRM can be achieved by using RM tools in several ways such as: *adjusting attributes, specify and grouping requirements, supporting the requirements derivation to a more detailed level, keeping and adjusting attributes, facilitate relationships between requirements and design to be tracked and traced.* RM tools are used for different purposes depending on factors such as organisation size and project type (Hoffmann et al., 2004). In major organisations, same RM tools are often used in different projects due to cost savings in terms of licensing, installation and user support. Accordingly, RM tools are formulated in different ways and with different capabilities to fit the specific project. For instance, several of the RM tools are digital and implemented into softwares (McLellan, Mocko, Morkos, & Summers, 2010). One example, mentioned by Hull et al. (2005), is the digital RM tool; Dynamic Object Oriented Requirements System (DOORS). DOORS can be used to store requirements and its information in a database. The tool includes functions such as capture, trace, link, analyse and manage requirements. The tool can be used in an entire project and ensures that the project follows the specified requirements and standards (Hull et al., 2005). Furthermore, McLellan et al. (2010) mention eight capabilities for usefulness when systematically evaluating RM tools, described in Figure 2.3. These capabilities are based on the functions and features which a RM tool should include.

Capabilities	**Explanation**
Refinement	Capturing new details of the requirement and hence narrowing down the scope of the requirements.
History	The tool must ensure that the requirements life cycle is well documented. A well documented history ensures that the designer can reuse the requirements in other similar projects, which will avoid costly delays.
Satisfaction	Mapping and adapting physical design in order to fulfill the specified requirements.
Verification	Testing and evaluating the requirements. A generally evaluated method for requirements verification is using *fulfilled/not fulfilled* or *pass/fail*. The tool should also capture the correlation between different requirements.
Coupling	For evaluation, a matrix-system can be used, where 1 represent a relation between requirements, and 0 illustrates no correlation.
Prioritisation	The tool needs to grade the requirements in level of importance. Systems for prioritisation use the ranking levels *low, medium* and *high*.
Input validation	Guarantees that the information in the requirements has a certain quality and is structured before adding it to software. Additionally, the software needs to be designed with restrictions regarding access connected to the right users and requirements.
View restriction	Requirements are delegated to the right person and thus filter the requirements.

Figure 2.3: Capabilities that are needed for systematically evaluating RM tools, based on McLellan, Mocko, Morkos & Summers (2010).

Another perspective is presented by Hoffmann et al. (2004), who have designed a catalog for usefulness with various criteria for a RM tool. The purpose of the catalog is to aid organisations when selecting RM tools. The catalog covers two different perspectives, the system developers and the project administrators. The system developers perspective focuses on the core functions which are needed in a RM tool. Even though the project administration perceptive does not focus on the core functions, it is based on functions that are important for major projects. The identified criteria of what RM tools need to include from the two perspectives are presented in Figure 2.4 and Figure 2.5.

Criteria	Explanation
Information model	Unique identification of objects in a database during its life cycle. The requirement management information model (RMI) needs to be changeable, graphically defined and requirements need to be modeled freely.
View	Enables the user to see different views of the data information.
Formatting, multimedia and external files	The expression in the RM tool should be similarly formulated to create a general expression for the users.
Change management and comments	Ability to manage change requests during a project.
Documentation of the history	The database needs to be traceable, include all changes of requirements and preserve old versions. Establish an analysis of changes to see project status.
Baselining	Saving a set of requirements in a baseline before entering a new development phase, as a version reference.
Traceability	Traceability between requirements need to be enabled in a user-friendly way in the tool.
Analysis functions	Ability to analyse requirements, including information about project status and risks. Information links in the tools will allow automatic analysis, which is cost and time effective.
Tool integration	Visible and linkable information in the tool. The RM tool needs to be integrated with other tools in the development process in order to achieve activities such as: *configuration*, *testing*, *validation* and *verification*, *communication*, *problem tracking* and *performance analysis*. Allow consistency and traceability during the whole project time.
Import	Ability to import the current requirements specification documents.
Documentation generation	The tool needs to include a document generator, using existing data, to provide both official and internal documents. The document generator and requirements data need to provide information include change history and ownership etc.
Collaborative working on the same development task	Possibility for several users to stimontansly use the same data. Additionally, a change from a user needs to automatically be real-time updated for other users.
Checking out for offline use	Having access rights, enabling to work in the tool from various working devices in different environments.
Web access	Allowing web access and occasional access to external actors, enabling collaboration and facilitated work with requirements.

Figure 2.4: Requirements from the system developer's perspective of what RM tools need to include, based on Hoffmann, Kühn, Weber & Bittner (2004)

Figure 2.4 presents 14 criteria that are essential for RM tools from the system developer´s perceptive. For instance, the criteria analysis function aid the users to analyse and gain

an overview of the requirements in terms of project status and risk while the criteria view helps the users to see different views of data (Hoffmann et al., 2004).

Criteria	Explanation
Central installation and administration of projects	The information needs to be documented at one specific place, including all changes.
Users, roles and rights	For larger and more complex projects, the user and right administration becomes more essential. The administration needs to have a central role to manage the user's account and the access rights.
Size restrictions	No upper limit for size of database and number of requirements and users, etc., to enable management of major projects.
Workflow management	Workflow management provides an administrative, organised and structured process, which will guide the users to complete the steps in the project. Moreover, it will provide consistency and standardisation of requirements. However, some users in projects where the time aspect is curious, are negative to workflows.
Extensibility	The tool must be able to meet the needs of the organisation or project and hence be adaptable.

Figure 2.5: Requirements from the project administrator´s perspective of what RM tools need to include, based on Hoffmann, Kühn, Weber & Bittner (2004).

Figure 2.5 presents 5 criteria that are essential for a RM tools from the project administrator´s perspective. For instance, the criteria extensibility enable the tool to be adaptable and fulfil the requirements and needs within the organisation (Hoffmann et al., 2004). Furthermore, even if RM tools can facilitate the implementation of SRM (Hoffmann et al., 2004), there are still problems in establishing a common systematic approach to manage requirements (Jallow et al., 2014). The next section will present some main challenges for RM in the construction industry.

2.4 Challenges when managing requirements

There are several challenges when managing requirements systematically, and the following challenges have been identified in literature:

1. Increased number and unclear requirements (Jansson, Schade, Olofsson, & Tarandi, 2010; Yang, Jieh-Haur Chen, & Huang, 2012)
2. Changes of requirements (Jallow et al., 2008; Yu & Chan, 2010)
3. No integrated process (Jallow et al., 2014)
4. Lack of documentation (Alla, Pazos, & Delaguila, 2017; Khairuddin, Sarlan, & Ahmad, 2021)

2.4.1 Increased number and unclear requirements

There is an increased number of requirements in the construction sector and according to Jallow et al. (2014), this challenge is a result of new needs and expectations from the stakeholders. The client is a stakeholder that has the power to establish the requirements for projects (Jallow et al., 2014). However, since the sector consists of many different actors, each actor may have a different perception of requirements. Hence, the actors may have different sets of requirements, which can complicate the opportunity for collaboration between different actors.

Different perceptions of requirements create difficulties in the communication between different actors, which could be a result of lack of common languages for managing requirements (Jallow et al., 2014). Therefore, requirements need to be specified and communicated clearly in order for all involved actors to understand the requirements' actual meaning (Yu & Shen, 2013). Another aspect is misinterpretations of the requirements which may occur due to lack of traceability in the design phase (Jansson et al., 2010).

Furthermore, according to Yang et al. (2012), there is a lack of clear definition of requirements. Unclear statements of the requirements can result in project failure (Garcia et al., 2019). Another issue is the difficulty to understand the requirements in the documents, since generally a natural language is used (McLellan et al., 2010). To understand the requirements, is it of high importance to take time and prioritise the work with the requirements when gathering and organising them (Yu & Chan, 2010).

2.4.2 Changes of requirements

Requirements vary between different projects, but also during the project phases, in both detail and precision (Jallow et al., 2014). Requirements can be seen as dynamic, nevertheless the requirements will change in the long run as the understanding improves (Young, 2004). The changes can also occur due to altered stakeholder needs, technical-, environmental- , business, laws- and regulation changes (Jallow et al., 2014; Yu & Chan, 2010). Changes of requirements can lead to delays and increased costs for the project, and can therefore be identified as an challenge (Jallow et al., 2008; Jallow et al., 2014). Therefore, Young (2004), has stated that it is of high importance to establish a process for requirements changes. The change of requirements needs to be documented and updated, and before altering a requirement it has to be approved in an approval process.

An essential factor for the RM process is to manage a system to validate that the current plan and time schedule are updated and traceable. Traceability is an essential factor for managing requirements and the effect of requirement changes, since it explains and tracks requirements during the project life cycle (Jallow et al., 2014). However, after interpreting the requirements in the design phase, the focus on requirements is shaded and the clients' wishes are more prioritised, which may result in changes of requirements (Jallow et al., 2008). One solution to manage this challenge, is to, at an early stage, document and store the requirements properly in a central repository.

2.4.3 Lack of integrated process

Currently, there is no integrated process for RM throughout the entire project life cycle in the construction sector (Jallow et al., 2014). According to Jallow et al. (2008), the management of requirements today is considered to be a front-end-task. Most focus for the designer and the client is to identify and capture the requirements, which are inadequately documented and then used as a basis for the rest of the project.

During the different project phases, the requirements need to be fulfilled before continuing to the next phase. According to Yang et al. (2012), 40 percent of the requirements in a project need to be reformulated and changed today. Another issue is that the requirements from the initial phase are not always updated during the project, and are not aligned with the requirements changes (Jallow et al., 2014). Therefore, Jallow et al. (2008), emphasise the importance of an integrated system and explain that RM needs to be correlated with all activities in every project phase, and accordingly permeate the entire process. In addition, by tackling the issues already in the initial project stage, the consequences will be reduced in the later project phases.

2.4.4 Lack of documentation

One challenge mentioned by Khairuddin et al. (2021), is the lack of documentation for requirements. The challenge is related to the changes of requirements during a project which should be updated in documents. Lack of documentation generates current requirement specifications, which are not reflecting the initial requirements. Therefore, establishing standardised documentation of requirements is an essential part for project success (Alla et al., 2017).

The documentation of changes of requirements is important, nevertheless, the stakeholders do not always read these documents, which results in an unawareness of its content (Khairuddin et al., 2021). The requirements specification is a component in the RM process (Izhar et al., 2018), where the documents about requirements are created in order to assure understandability, correctness, completeness, and consistency (Khairuddin et al., 2021). When establishing requirement specifications, the information needs to be presented to the stakeholders, and ensure that the most important requirements are identified for a specific project (Khairuddin et al., 2021).

2.5 Factors affecting the SRM process

SRM is a process which needs to be integrated in the entire project. In organisations, it is essential to have the right process (Liker, 2004). The definition of a process is according to Chen (2001, p.70): *"... a specific ordering of work activities across time and space, with a beginning, an end, and clearly identified inputs and outputs: a structure for action"*. According to O'Neill & Sohal (1999), it is required to understand an entire process and its impact on an organisation to gain an overall understanding of the effect of actions that occur in different parts of the process.

Environmental factors may have a high impact on the change of an organisation, and also affect its processes (Kettinger & Grover, 1995), thus, the *context of the organisation*

has a huge impact on the characteristics of the process and the opportunity to change. There are also internal factors that may affect a process: *IT, People, Management* and *Structure*.

2.5.1 Organisational context and client satisfaction

The organisational context is, according to Kettinger & Grover (1995), fundamental for what type of change that will occur. The context is influenced by environmental factors, for instance client's power and economic conditions, and will shape a strategy to address change, such as establishment of SRM.

In major infrastructure projects, the client has the power to set the conditions after its needs and expectations; needs and expectations that are established in terms of requirements (Jallow et al., 2014). During recent years, the number of requirements from the client has increased in the construction sector which puts higher pressure on the contractor to fulfill the needs and expectations of the client. Infrastructure projects have high costs related to mistakes and faults (Boverket, 2018). Thus, organisations need to establish a systematic method in order to prevent mistakes and deliver high quality projects (Boverket, 2018). Currently, there is no systematic process for RM (Yu & Chan, 2010). By designing a strategy, which considers environmental factors, will create a foundation to establish a SRM process. Establishing proper SRM will result in minimised costs, more qualitative projects and fulfilment of the client's requirements, which generate in client satisfaction.

2.5.2 IT

Implementing a strategy that is aligned with the IT in an organisation has contributed to cost reduction, higher quality and improved decision making (Lakatos, Bercea, Bacali, & Moldovan, 2015). IT has the capacity to change processes in an organisation (Kettinger & Grover, 1995). Furthermore, IT tools contribute to knowledge- and information sharing and facilitate communication between people, and most of these interactions in IT tools are documented within organisations. One IT tool that can facilitates knowledge- and information sharing is a database (Rafaeli & Raban, 2005), which can document the information and knowledge in order for employees to retrieve the data later on. However, O'Neill & Sohal (1999) state that IT tools can not be used to change an organisation's culture or strategy.

2.5.3 People

People are important in any organisational process, and are influenced by values, skills and behaviors (Kettinger, Teng, & Guha, 1997). Implementing SRM will cause changes within an organisation. According to Jørgensen, Owen & Neus (2009), the three most challenging factors when implementing a new process are:

1. Changing attitude and mindset
2. Corporate culture
3. Underestimated the complexity of the process

In order to manage the change process, the *knowledge, attitude* and *motivation* of the employees need to be considered and prioritised.

2.5.3.1 Knowledge

Knowledge is important for the employees to understand why the change should be done. According to Washington & Hacker (2005), people who understand the change of an organisation are more likely to have a positive attitude towards the change. Another perspective, mentioned by Markova (2006), is that the organisation always strives to gather and create new knowledge for a better outcome of the change.

2.5.3.2 Attitude

Negative attitude from the employees is one factor that can negatively affect the organisational change initiatives (Andrew, 2017). For a successful change in an organisation, it is essential that it is embedded and accepted by the people in the organisation, at all levels (Sushil & Agnihotri, 1999).

2.5.3.3 Motivation

Motivation is another crucial aspect in organisational changes (Radojević, Stankovic, & Rajin, 2020). According to Phan, Pham, Tran, Le, Nguyen & Nguyen (2020), motivation is useful when supporting employees to be more effective, creative and qualitative in their work. Marisa & Yusof (2012) state that motivation enhances chances to achieve goals, both for individuals and within organisations.

2.5.4 Management

For a project to be successful, the project managers play an essential role (Phan et al., 2020). They have the responsibility to systematically set strategies and plans for a specific project. The managers should have the following tasks in a change process, which are inspired by Ionescua, & Dragomiroiua (2014):

- Provide information about the change by communicating with the employees
- Support employees with the right tools
- Train the employees to be able to adapt a new change
- Be involved, work, and support the employee in the new change

An important part of the project manager's role is to act as a leader and motivate the employees (Marisa & Yusof, 2012). To motivate employees, the project manager needs to have skills in terms of; communication skills, ability to obtain feedback, provide rewards, involvement and delegation of assignments. In addition, Phan et al. (2020) have stated that an unmotivated project manager in the construction industry has a negative effect on the quality and productivity of the project. This is aligned with Marisa & Yusof (2012), who stated that an unmotivated manager will lead to an unmotivated employee.

2.5.5 Structure

The structure has, according to Kettinger & Grover (1995), high impact on projects. According to George (2020), it is important that every project has the right organisational

structure, which is especially important to support the implementation of a new process. Structure includes factors such as *teamwork, coordination and control* .

2.5.5.1 Teams

Teams are a central part of organisations and it is essential that people collaborate and act for a common purpose (Kozlowski & Ilgen, 2006). The characteristics of a team are, for instance, high expertise and rapid response. The effectiveness of teams is based on how the organisation structure is designed (Kozlowski & Ilgen, 2006). Therefore, a proper structure of working approaches increases the collaboration between the employees in an organisation.

2.5.5.2 Coordination and control

Coordination and control can be applied in an organisation by using organisational routines, since routines makes it easier to monitor, measure and compare. Comparing and controlling are aligned, since improved control facilitates the comparison of results (Becker, Salvatore, & Zirpol, 2005). Routines simplify for the employees by creating a common understanding, and hence the coordination will be facilitated.

2.6 Synthesis the theoretical themes

The main themes that have been considered in this chapter are SRM, organisational context, IT, people, management and structure. Together, these main themes have a potential impact on client satisfaction. Inspired by Kettinger et al. (1997), a theoretical framework has been synthesised, illustrated in Figure 2.6.

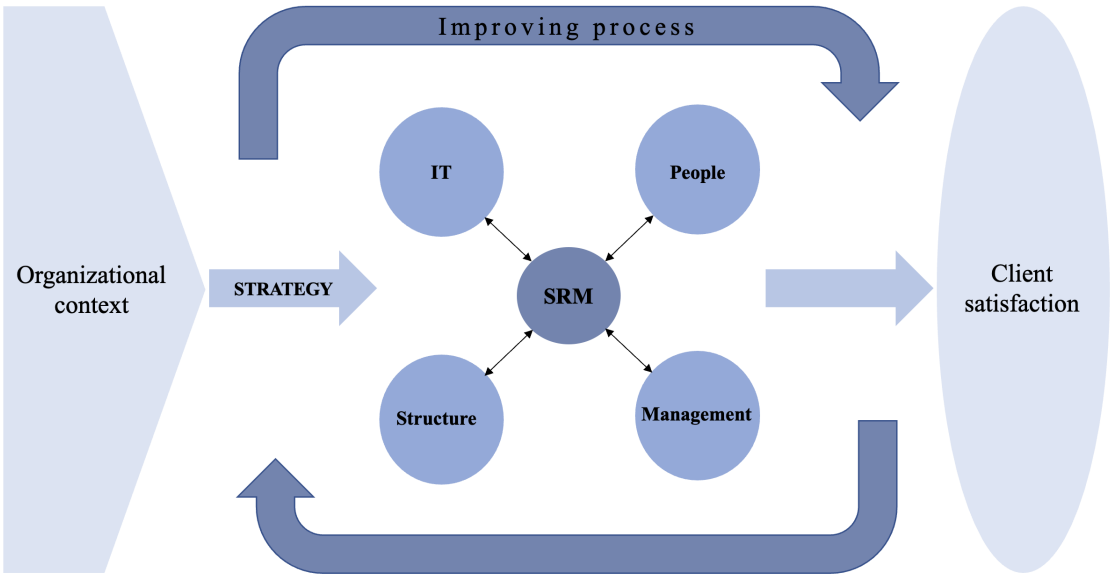

Figure 2.6: Illustrates a theoretical framework inspired by Kettinger, Teng & Guha (1997).

Figure 2.6 demonstrates how organisations should understand the entire change process and its impact on the organisation when establishing SRM. The change is an improving

process, where organisations should consider both input and output, as well as adapt to new changes that may occur. The input consists of the organisational context, influenced by environmental factors, which results in a strategy to address SRM. In addition, the figure demonstrates how the factors IT, people, management and structure affect SRM, which together with environmental factors need to be considered in the improving process. Thus, organisations can establish a proper SRM, and thereby generate the output in terms of client satisfaction.

To be able to establish a new way of working with SRM it is essential to create employee motivation. Motivation can be useful when describing human behaviors (Barg, Ruparathna, Mendis, & Hewage, 2014; Marisa & Yusof, 2012) and according to Marisa & Yusof (2012, p.166), motivation aims to achieve goals and states: *"Motivation is embodied in the psychological processes to ask for direction, give direction, and enhance the behavior to do something in order to achieve goals"*. Therefore, motivation is essential by providing clear goals and directions in an change such as SRM.

There are several significant factors for improving motivation, which are according to Mansfield & Odeh (1991):

- Employees' attitude
- Achievement challenges
- Participation

Firstly, to motivate employees in organisations it is essential to impact the workmen and supervisors *attitude* by creating a trusting, understanding and cooperative organisational environment (Mansfield & Odeh, 1991). The establishment of this environment needs to start in an early phase of employment, with the aim to offer high support to new employees. Other important factors for improved motivation of the employees is to establish training programs, provide information about the organisation, and encourage knowledge gaining activities. Another way to motivate employees is to implement organisational routines (Nelson & Winter, 1982).

Routines specify how employees should perform their job, which is central for organisations to function properly (Nelson & Winter, 1982). By using organisational routines, organisations are able to store organisational knowledge and experience of how to perform different tasks (Nelson & Winter, 1982). Organisational routines are also used to improve the understanding about behavior and change in organisations (Becker et al., 2005). Organisational routines in general, simplify for people to create teams to commonly achieve a specific goal (Wolthuis, Hubers, Veen, & Vries, 2022). Consequently, organisational routines affect how people interact between each other and how the collaboration proceeds, as well as have the potential to change culture and mindset.

The second significant factor for improving motivation is *achievement challenges*, which is the most powerful motivator (Mansfield & Odeh, 1991). Achievement describes that the assignment should be adapted to the skill of employees, for them to be transformed into achievers. In addition, challenges need to be an integrated part of the employees work tasks. Construction projects are often associated as long term projects where the requirements change during the project lifetime, which can result in unmotivated employees. However, Mansfield & Odeh (1991) highlighted the importance of scheduling the

work in different phases with smaller tasks designed to achieve short term goals.

The third factor for improving motivation is *participation*. Creating an environment where the employees feel invited to participate, will result in a feeling of importance and value, and thus, a higher level of commitment (Mansfield & Odeh, 1991). Another benefit with participation is that it facilitates implementation of e.g. policies in organisations, since the employees have an opportunity to be a part in the development of the policies.

3
Methodology

The aim of the chapter is to present the method, underlying the study. Firstly, the chapter describes the case study including information about the interview approach and the data analysis. Furthermore, the chapter provides information about the method used for the literature study. In addition, the chapter will discuss the research quality as well as the ethical aspects considered in this study.

3.1 Case study

A case study will be conducted at Skanska, specifically at the department of major infrastructure projects west. The department is responsible for the major infrastructure projects within Skanska west, which include projects with a budget of more than 100 million SEK (personal communication, April 1, 2022) . Major projects in the infrastructure industry are often complex and financially extensive, resulting in substantial requirements. A contributing factor to the increased number of requirements on Skanska, is increased pressure from society, in areas such as the environment, quality and health and safety. This has resulted in higher demands from the client. Therefore, Skanska is in great need of systematically managing these requirements.

Skanska is one of the world's leading construction and project development companies and has started to engage in turnkey contracts in major infrastructure projects. With these prerequisites, the case study at Skanska will investigate how SRM can be established in major infrastructure projects. The case study is focusing on three major turnkey contract projects in region west in Sweden. The case study will examine the current working approach, routines, process and tools for RM, as well as challenges and countermeasures for managing requirements.

3.1.1 Research strategy

The case study will be based on a qualitative approach consisting of interviews in the method. The choice of method is based on the fact that there is currently no designed process for SRM within Skanska.

The qualitative research strategy focuses on words rather than the quantitative data (Bryman & Bell, 2015). Moreover, the research strategy generates the perspectives of the respondents and the consideration of their opinions and valuation as a central part. Thus, the understanding of the respondents' perspective through high involvement is essential. According to Bryman & Bell (2015), qualitative research has an approach of being open for changes in the structure of the research over time, rather than seeing the

method as constant and invariable. The following six main steps for qualitative research, inspired by Bryman & Bell (2015), have been conducted during the interview phase:

1. Create general research questions with opportunities for changes
2. Choose relevant location and respondents
3. Collect relevant data, with detailed original ideas about construction of interviews and theory, e.g. time aspect for interviews and opportunity for recording
4. Analyse and interpret data, e.g. by coding the result
5. Create a more detailed research question and gathering more data if needed
6. Ensure that the result is valid and reliable

Currently, there is a lack of research within SRM in major infrastructure projects. Therefore, the qualitative approach generates the possibility to be open minded for changes in the structure of the research, when new perspectives arise.

3.1.2 Interviews

During the interview phase, semi-structured interviews were mainly used which included a question schedule with predecided questions, and the possibility to have a varied order of questions (Bryman & Bell, 2015). Another characteristic of semi-structured interviews is more general formulation of interview questions, which provides space for follow-up questions. A flexible structure creates an opportunity to identify the most critical aspects based on the respondent's knowledge and experience (Bryman & Bell, 2015). Thus, the respondents were able to answer the questions about RM and also give additional input. The focus was to identify Skanska's current working approach, routines, process and tools for RM, as well as challenges and countermeasures for managing requirements.

At the start of the case study, the interview form *unstructured interview* was used during the inspirations interviews. The unstructured interviews were used in order to receive inspiration and more general information before setting up the thesis delimitation. According to Bryman & Bell (2015), an interview template with listed themes or more general questions are used in this type of interview form. Furthermore, the interview questions are asked informally with varied order.

3.1.2.1 Sampling of respondents

The respondents for the interviews work at Skanska and have knowledge about RM in major infrastructure projects.

The respondents of the unstructured interviews were selected based on experience in RM, especially in SRM. The majority of the respondents had a vision to implement a more systematic process for RM. The interviews were recorded and then transcribed. Table 3.1 presents the selected respondents.

Table 3.1: *Selected respondents for the inspiration interviews, with job description, date, location and duration.*

Job description	Date	Location	Duration
Department manager	2022-02-15	Head office, Gårda	120 min
Project manager	2022-02-16	Head office, Gårda	90 min
Phd- QA/risk and Technical adviser	2022-02-15	Microsoft Teams	50 min
Function manager	2022-02-23	Microsoft Teams	60 min
Coordinating project manager	2022-02-23	Microsoft Teams	60 min

The respondents in the semi-structured interviews were actors involved in different projects at major project west at Skanska with experience of RM. The respondents were chosen to reflect the contractor's perspective, aiming to gain knowledge of how they manage requirements in the design- and production phase. Table 3.2 presents the interviews with information about job description, project, date, location and duration.

The studied projects where; Hisingsbron, Hamnbanan, Ängelholm-Maria and European Spallation Source (ESS). The first three projects are turnkey contracts. The respondent from project ESS was chosen due to the respondent's knowledge about SRM in major infrastructure projects. The same reasoning applies for choosing the respondent from major projects region west. The majority of the interviews were conducted on site on the different projects. All interviews were recorded after approval by the respondents and were transcribed later.

Table 3.2: *Selected respondents for the interviews, with job description, project, date, location and duration.*

Job description	Project	Date	Location	Duration
Quality coordinator	Hisingsbron	2022-03-08	On project site	86 min
Quality manager	ESS	2022-03-07	Microsoft Teams	77 min
Unspecified	Major projects west	2022-03-10	Microsoft Teams	117 min
Project leader	Hamnbanan	2022-03-14	On site	60 min
QEHS manager	Hamnbanan	2022-03-14	On site	60 min
Technical expert	Hamnbanan	2022-03-15	Microsoft Teams	57 min
Quality coordinator	Hamnbanan	2022-03-17	On site	57 min
Project leader	Ängelholm-Maria	2022-03-22	On site	71 min
Asst. Project leader	Ängelholm-Maria	2022-03-22	On site	59 min
Quality coordinator	Ängelholm-Maria	2022-03-22	On site	97 min
Project manager	Ängelholm-Maria	2022-03-23	On site	52 min

3.1.2.2 Interview template

The interview template was created based on the literature study and the aim of the report, presented in Appendix A - Template for interview questions. The interviews were focusing on the current working approach, routines, process and tools for RM that are used in major infrastructure projects. Moreover, due to different projects and background of the respondents, questions regarding the respondent's personal opinion about challenges and countermeasures for RM were formulated. For the unstructured interviews, no template was formulated in order to gain a wider perspective about SRM.

3.1.2.3 Interview process

The majority of the interviews were performed on the project site. Due to geographic distance and lack of time for some of the respondents, six interviews were performed digitally. Conducting online interviews was timesaving, aligned with Bryman (2013). However, according to Bell, Bryman & Harley (2019), interviews on site are able to provide better connections between the interviewer and the respondent.

The interviews started with general questions about the respondent which is usual for qualitative research (Bryman & Bell, 2015). According to Ahrne & Svensson (2011), it is important to make the respondent comfortable and provide a safe environment to express personal opinions. Furthermore, the background information about the respondent is also important for the perception of the context of the answers from the respondent (Bryman & Bell, 2015). Open questions were also used during the interviews. These types of questions are beneficial when exploring new areas, such as SRM (Bryman & Bell, 2015).

If the questions were perceived as unclear, they were always reformulated, which is essential according to Ahrne & Svensson (2011). Moreover, an important aspect during the interviews was to always be interested, structured and show the respondent curiosity about the subject (Bryman & Bell, 2015; Kvale, 1996). The interviews always ended with the respondents being asked if they had anything more to add.

3.1.2.4 Analysis of qualitative data

An essential approach for analysing qualitative data to use grounded theory (Bell et al., 2019; Bryman, 2013). Grounded theory is based on an iterative process of analysing data, which implies that the process of collecting and analysing data is parallel (Bryman, 2013), and has inspired the data analysis in the study. Grounded theory consists of different tools, where coding has been used in this study.

Coding is used to name and break down the data in different categories (Bell et al., 2019; Bryman, 2013; Silverman, 2006). In this study the following categories have been used:

- Current RM tools
- Current process for RM
- Current routines and working approach for RM
- Knowledge
- Motivation
- Database for RM
- Challenges

- Countermeasures

Coding was performed during the whole data collection and is described as tentative, instead of fixed, since indicators in the data are constantly being compared. These indicators can be referred to actions or events and are examined and coded by mentioned categories. The coding phase was conducted in an early stage, which is aligned with Bryman (2013), who advocated that a continuous process for coding is essential to gain a better understanding of the collected data and the theoretical sampling process.

3.1.3 Trustworthiness

To ensure quality of the research the concept trustworthiness was used. The concept is based on four criteria: *credibility, transferability, dependability* and *confirmability* (Bryman & Bell, 2015), which have been considered to address the trustworthiness of the study. The performed actions to address these four criteria are as follows:

- **Credibility:** Achieved in the study by sending the result to the supervisor at Skanska for approval in order to confirm the accuracy.
- **Transferability:** The information gathered from the interviews was described in the result with a general approach to make it applicable for all types of major infrastructure projects.
- **Dependability:** The method for the interviews was described in detail together with information about selected respondents and research questions. The information was continuously reviewed by the supervisor.
- **Confirmability:** The interviews were conducted in good faith without personal values affecting the result.

3.1.4 Ethical aspects

To establish an ethical study it is essential to refer to voluntariness, integrity, confidentiality and anonymity for respondents involved in the study. Figure 3.1 presents how the ethical aspects, inspired by Bell et al. (2019), Bryman (2013), and Silverman (2006), have been used during the interviews.

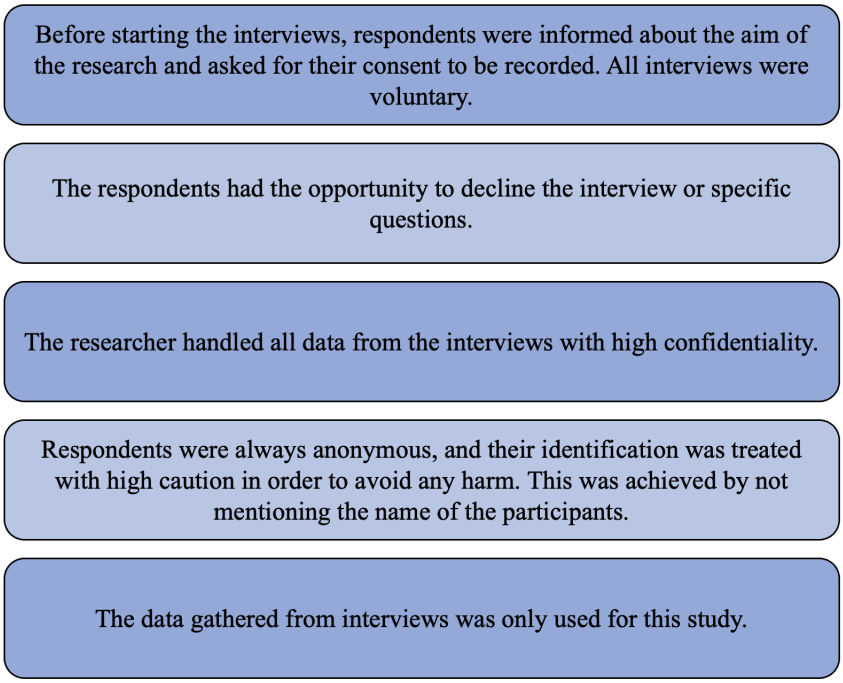

Figure 3.1: Ethical aspects considered during the interview phase, inspired by Bell, Bryman & Harley (2019), Bryman (2013), and Silverman (2006).

3.2 Literature study

A literature study was conducted to establish a theoretical foundation to the case study. According to Silverman (2006), the literature study should pinpoint the reason for doing the study and provide information about the previous research within the topic. The literature study consists of articles and books to gain an overall understanding about the theme. Before starting the empirical research, general information about SRM was collected. The overall purpose with the initial literature study was to create a base of knowledge before the inspirations interviews.

For the literature study, keywords were used to direct the literature research. The purpose with keywords is to simplify for the researcher to find relevant literature, since it is hard to identify a specific topic with a general title (Silverman, 2006). During the literature study, new knowledge was added, which resulted in keywords being added and altered.

The following key words were, but not limited to:

- Requirements
- Requirements management
- Systematic requirements management
- Challenges when managing requirements
- Motivation
- Routines
- Requirements management tools
- Major infrastructure projects

The databases used to identify scientific articles within SRM were Google scholar, Chalmers Library and ResearchGate. Requirement in general is a popular term, which resulted in a huge amount of references. Therefore, it was essential for the researcher to identify the most important theme for the research which should constitute the base of the study. By studying several articles, new references emerged.

One approach to ensure validity in the literature study is to select several articles from different authors and assure that the selected sources are peer reviewed (Bell et al., 2019). During the literature review the researchers focused on finding primary sources instead of secondary sources.

4
Case Setting

The aim of the chapter is to provide information about the studied organisation with project descriptions within: Hisingsbron, Hamnbanan and Ängelholm-Maria. In addition, the organisation's management system and quality forum will be described.

4.1 Project description

The case study will investigate three different turnkey contracts within major project west at Skanska. Major projects west is a region within the business unit Infrastructure, including approximately 120 employees. Major projects are identified at Skanska as infrastructure projects with a budget of over 100 million SEK (personal communication, April 1, 2022). The three projects are: Hisingsbron, Hamnbanan and Ängelholm-Maria. The presented information is gathered from interviews, dialogues with employees, internal documents from Skanska and from the organisation's web page as well as information gathered from the project European Spallation Source (ESS).

4.1.1 Project Hisingsbron

Major projects west were assigned by the city of Gothenburg to construct Hisingsbron in a joint venture with MT Højgaard AS (Skanska, 2022b). Project Hisingsbron started in 2016 and the bridge has a total length of 1380 meters over Göta Älv, between the mainland and Hisingen in Gothenburg (Skanska, 2022b). The width of the bridge is 40 metres and the bridge opened for pedestrians, bicycles, cars and buses in may 2021, and for trams in the middle of august 2021. Project Hisingsbron is currently in the transition phase, where one mainly performs inspections.

4.1.2 Project Hamnbanan

Major projects west were assigned by Swedish Transport Administration (STA) to construct Hamnbanan (Skanska, 2022a). Hamnbanan is used to transport goods to and from the harbour of Gothenburg by railway. The distance is currently single-tracked and to increase its capacity, 1.9 kilometres will be reconstructed to double track, where parts of the distance will include a tunnel (Skanska, 2022a). The project started in the autumn of 2019, and is expected to be finished in 2024.

Project Hamnbanan is currently in the final stage of the design phase, and in the middle of production, where focus is shifting from ground- and foundation works towards concrete works. Thus, nearly half of the project volume is finished. Even though the design phase soon is finished, there will be a need for design management during the production phase

to, for instance, manage changes and revisions of requirements. During the design phase, the project receives help from the external consultant WSP.

4.1.3 Project Ängelholm-Maria

STA has given Skanska the assignment to build Ängelholm-Maria (Skanska, 2020). The project consists of a 24 kilometres double-track railway at the West Coast Line, including 19 railway bridges and two iron bridges. As a result of the large distance that the project is covering, the organisation has decided to divide the project into different subareas. Completed subareas will be sent to the client for approval, who can then send back potential comments and require revisions.

The design phase started at Ängelholm-Maria during autumn 2020. The design management has been working in a collaboration with the external consultant, AFRY and Skanska Technology. Currently, 80 percent of the project is completed, and presently both design and production are ongoing. The project is planned to be finished by May 2024 (Skanska, 2020).

4.2 Management system

Skanska's management system, *Our way of working* (Vsaa), includes the common working approach for Skanska Sweden, and is used to lead the organisation towards developed projects and production.

According to internal documents at Skanska, the management system describes how the organisation should manage its operations. Vsaa is a tool for the top management to ensure that the organisation's operations are conducted in accordance with the established routines, as well as a support for the employees in their daily work. The management system has different focuses, such as quality, environment and working environment. Furthermore, Skanska is using Vsaa to facilitate for the organisation to adapt their values, which is the basis for how the organisation should act and how to make decisions. The purpose of Vsaa is to establish a common starting point for the way of working.

Vsaa contains, among other things, working methods that ensure that the requirements set by laws and authorities, the Skanska Group and ISO certification are being followed. Vsaa is certified in quality (ISO 9001), environment (ISO 14001) and working environment (ISO 45001).

According to internal documents, the main benefit of using Vsaa is to ensure security, safety and support in daily work. The documents also include information on how Vsaa is updated, and describe the best working methods based on the employee's experience. Vsaa includes tools, such as checklists, agendas, templates and links to digital tools.

4.3 Quality forum

During the latest years, there has been much focus on environment and work environment, according to R13. These are two areas organised in Quality, Environment, Health

and Safety (QEHS). However, the respondent experiences that quality has not been prioritised, but that the organisation now has realised the need of prioritising quality. One reason for why there should be higher focus on quality is especially that if Skanska cannot fulfill the requirements towards the client, then unnecessary costs will occur.

The number of requirements has been increased by the client, which has resulted in a need for Skanska to manage requirements in a systematic way. How the magnitude of requirements should be managed is discussed in a group called *Quality forum*. In that forum, the employees have the opportunity to change the current working method for managing requirements, and exchange their thoughts and experiences gained within different projects. In that way, the organisation can develop their way of working with SRM.

The quality forum had a discussion about SRM where the following illustrative quote was stated: *"We do not understand why it is so difficult, it should not be..."*

5
Empirical Study

The aim of the chapter is to present the result based on interviews from turnkey contract projects at major projects in the region west at Skanska. The projects are: Hisingsbron, Hamnbanan and Ängelholm-Maria, and some perspectives will also be considered from the project ESS.

5.1 Systematic requirements management

Within major infrastructure projects, there is a tremendous need to verify and document performed work (R8). R9 describes that, currently, there is a lack of sufficient knowledge of the contractors, clients and consultants to manage the increasingly more complex infrastructure projects in society. Hence, these projects require more control to systematically ensure that all requirements are fulfilled. Nevertheless, R8 explained that most employees perform the work steps by experience and practice today, but there is a lack of approach of how the documentation should be systematically accomplished. The respondent mentioned, however, that in those occasions when documentation actually is performed, the responsibility for the work is clearly defined at start, as well as how the documentation should be done.

When the contractor should transmit a project, the execution must be correct, but they also need to prove the correctness towards the client. The correctness of the work towards the client is proved by verifying that the requirements are fulfilled, which according to R2, is done by SRM. If the contractor is not systematic when managing requirements, a discussion can occur at the transmission regarding if the requirements actually are fulfilled. Hence, SRM is considered as crucial for the contractor to prove that their work is correctly performed.

SRM is often associated with quality requirements (R8). The question is what quality actually implies, and the respondent described it as generating the right product, i.e. the contractor delivers the right product to the client. However, the respondent describes that the documentation and management of the quality requirements have been worse lately, since the focus has been in other areas. Some of these areas are purchase, work environment and environment, especially due to specific occasions. According to the respondent, the development in society is a basis for how and what organisations choose to prioritise and focus on.

Another reason for Skanska to establish SRM is that it is important to not lose against their competitors, i.e. it would be bad if the competitors find a solution before Skanska (R8). The respondent believes that the current knowledge about SRM and IT maturity

is enough to establish SRM.

5.1.1 Difficult and important requirements

Several respondents experienced it most difficult to manage requirements in the beginning of a project. R11 mentions the difficulties in transferring all requirements from the contract to the construction document. R5 does also agree and describes that RM is easier the longer a project proceeds. According to the respondent, it is difficult to establish a common structure for a project, since both the conditions and the direction of the project must be known.

The respondents provided various examples on which requirements are most difficult to work with. According to R5, there are difficulties in interpreting and identifying the requirements from AMA-standards, technical description and general regulations, which the organisation must improve in order to ensure that no requirements are missing. R11 mentions that environmental requirements are difficult to use since there is a lack of instructions for how the requirements should be fulfilled, and thus environmental requirements are open for interpretation. Table 5.1 presents the requirements considered by the respondents to be most difficult to work with in a project.

Table 5.1: *The respondents opinions about the most difficult requirements in a project.*

Respondent	**Difficult requirements**
R1	Requirements in standards, which are then referred to different standards
R6	Technical requirements
R5	Interpretation of AMA-standards, technical description and general regulations
R10, R11	Environmental requirements
R9	Security requirements
R2, R10	Unclear requirements

The answers from the respondents regarding the most important requirements were various. R7 believes that the most important requirements are those who generate increased maintenance costs or result in not fulfilling the warranty inspection, which cause unnecessary costs. Nevertheless, R4 experienced difficulties in identifying the most important requirements. R3 states that all requirements are important and ends: *"is not possible to prioritise... everything must be done and finished"*. R9 believes that the most difficult requirements can also be considered as the most important requirements.

5.1.2 Knowledge

Many respondents share the perception that Skanska currently possesses the required knowledge to establish a process for SRM (R3, R5, R6, R7, R9). However, according to R3, it is a new concept that has not been used very long, which has resulted in a lack of structure for SRM in the organisation. Therefore, the organisation needs to structure and coordinate the existing competencies. R7 and R11 also agree that SRM could be

improved. In addition, R6 experienced that there is enough knowledge within the organisation but that there is a need of resources in terms of employees to extend SRM.

Respondent R1 experiences the current knowledge within SRM as varying. According to the respondent, employee's such as the production managers and project managers possess the knowledge and experience of RM, but it is not always those who work with RM in practice. Instead, these assignments are delegated to less experienced persons, which can result in requirements being missed, particularly when they are identified. The respondent advocates that more experienced persons, such as a production managers, should be involved in the most important periods, especially when the requirements are identified and in the summation of inspection programs. According to R11, there is varying knowledge and experience in RM in the production, especially among supervisors. Thus, it is essential to increase the knowledge and experience in the production in order to achieve an integrated SRM through all project phases.

R8 expresses that there is a tendency of individuals to postpone tasks, such as systematic documentation, which could be avoided by continuous control. It was only R10 who considered the employees to have little knowledge of SRM, who expressed that employees are unaware of SRM and stated: *"I think people are unaware that they miss it since they have never done it, and then they do not know that they may need it"*.

In addition, respondent R8 describes that the number of requirements has increased in recent years, which put higher pressure on the role responsible for the documentation and administration of RM. Even though digitisation facilitates documentation and administrative work, only one role within RM is not enough since the requirements and corresponding work steps are extensive.

5.1.2.1 SRM requires new competence

It is essential that the organisation possess the right knowledge about SRM to facilitate the work (R12). According to R12, there is a lack of knowledge about SRM, which often results in that the requirements are not applicable in the production, and in turn leads to rework. Associated with lack of time, this problem can also result in that the people in the production need to find the solutions and correct the drawing when there is time pressure. Thus, the production sometimes lacks confidence in the people designing the construction documents. R12 believes that the planning manager needs to have experience from production to create better order and structure in the construction documents, which should result in more effective projects.

The empirical study indicates that several respondents share the opinion of the importance of identifying requirements in an early stage. According to R1, SRM should be extended by identifying the requirements in the beginning of a project. This can be achieved by creating an excel list. One role that could identify these requirements and gather them into a list of requirements is a contract engineer. It is, however, important to remember that the identification of requirements is time consuming, even though it is essential for a project (R1). R6 also illuminates the importance of a role that identifies and checks requirements as well as delegates the requirements to different disciplines, and suggests that the role could be a project requirement manager. The work assignment

could be facilitated with a database.

In addition, it is essential to identify requirements in an early stage of the project (R9, R13, R11). For instance, R9 advocates that it is the key requirements that should be identified in the beginning, as well as what is required to manage those. Moreover, it is important to have a systematic approach for how they will be managed during the entire project (R11). The respondent also advocates that major projects at Skanska need to map the requirements and establish a structure for how the requirements should be delegated to each discipline. If this is accomplished, it is possible for the organisation to establish routines for the management of requirements.

Some characteristics that are essential to increase SRM are proper literacy and a sense of order when managing requirements, which generally lacks today (R2). Another needed personality type is a person who plans and is able to manage the identification of all requirements, as well as can ensure that the requirements are being fulfilled (R8). In addition, individuals are needed with high competence within their area of knowledge and who is able to cooperate with other people. R9 pinpoints the importance of having key individuals that are both competent within an area of knowledge but also are able to lead their organisations to establish SRM. Accordingly, a mix of leaders and experts is needed, who aids the organisation to increase SRM. Therefore, R9 believes that the management of projects have a great responsibility to know their employees, know their strengths and weaknesses, and are able to adapt and distribute the right assignment to the right employee.

At project ESS, there was an established department with the assignment to review the construction documents and formulate job descriptions, which describe how the work should be performed and which requirements should be controlled (R2). The department functioned as a support team to the production managers within SRM and was established due to the high technical advancement within the project. This type of department could, according to R2, be used in similar major infrastructure projects where more advanced IT is required. In contradiction, R6 highlights that solely one group managing the requirements can imply some risks, and describes: *"... the risk is that it will remain in the group, which is not good either. Then, the group needs to know everything about all requirements instead of the individuals".*

5.1.2.2 Support function

Within major infrastructure projects at Skanska there is a support function in terms of QEHS. R9 has experienced that the support function often is not prioritised and the organisation needs to examine how it should be structured to be able to manage all requirements.

Currently, the production manager has the responsibility for the execution of requirements and the communication towards the client. The client often has specialists within several areas, which has resulted in an even more extensive coordination of requirements, and thus greater responsibility for the production manager, especially in complex major infrastructure projects. Hence, the project of R9 has investigated the possibility of restructuring, and to eventually establish a support manager or a more overall role to

unburden the communication towards the client.

There is currently no common work approach within different projects or roles at Skanska (R12). For instance, roles within the support function have various meanings in different projects, which e.g. is the case for quality due to the fact that there are several different focus areas within quality. At present, some employees within the support are not located close to the production and act e.g. as digital managers. They introduce new tools, but do not support the employees in how they should use them. However, at project Ängelholm-Maria, when questions occur within RM, their support ensures the right knowledge about the requirements, read AMA-standards as well as specify the requirement and insert it into an inspection list. Skanska is currently trying to find a structure for how a project should be structured and to have a common work approach within the organisation for support functions.

R8 emphasises the importance of having a support function at the projects. It is required that a group or person with enough knowledge and understanding within SRM can inspire, control and follow the work of the employees within the area. The group needs to agree on the working approach in order to motivate others to perform what has been decided. Thus, a positive performance culture is created, which is based on strong leadership.

Additionally, R12 pinpoints the importance of having a resource located on site who acts as a support to motivate the employees within SRM. The support function needs to be present during the entire project to aid with questions within the area. If there is a lack of support when a question arises, there is a risk that the employees lose interest and return to old habits and work manners. Thus, the work with SRM requires prioritisation of time and work, which results in a need of enough resources in the support function. Currently, there is some support at Skanska concerning working approaches and tools within SRM, however, there are not enough resources. According to R12, there is especially a need for more resources and time to aid the production on site with SRM and to answer questions in more detail.

5.1.3 Challenges for SRM

When SRM is applied, it is essential to have a fair ambition level (R6). Generally, the respondent experiences that Skanska often sets a too high ambition level, which is difficult to manage, and thus the work manner has reverted to the old one.

5.1.3.1 Increased number and unclear requirements

Today, the number of requirements in major infrastructure projects are extensive (R8, R9, R11, R12). Therefore, it is a challenge for the organisation to ensure that all requirements are collected and followed. Hence, it is essential to create a system to manage the requirements during the entire project until it is handed over to the client.

The current mindset when managing the amount of requirements, is that *"yes but it will be well in the end"* - R8. However, this attitude is costly for Skanska since it can result in the end product not fulfilling all requirements or the right quality. It is essential

to already, in the tender phase, identify all requirements in the construction documents but also ensure that the organisation understands what is important for the society, end product and Skanska (R8, R11). This can be achieved by increasing resources during the entire design phase when interpreting all requirements and gathering them into construction documents (R11). According to R12, it is also important to identify the focus area of the client early and what is most important for them, since this can vary between different clients. R9 emphasises that it is important to clearly formulate the description of the working steps in detail and its connection to the different requirements. This ensures that the employees understand how the requirements should be fulfilled and that they feel safe in the execution of the work steps being correctly performed.

Several respondents consider that it is often unclear what the requirements from the client means (R1, R6, R8, R10). One reason for unclear requirements is that many of the requirements in the tender document from the client, often are referred to other documents and standards, which in turn are referred further (R1, R6). Thus, the contractor needs to put in a lot of time and resources to interpret all the requirements, and the risk of missing requirements also increases. This was prioritised at project ESS where they put more time on formulating detailed construction documents and job descriptions, which also facilitated the fulfillment of the requirements in the production (R1). In order for this prioritisation to occur in other projects, an early collaboration between the design and production is required when identifying requirements. In addition, R10 experienced that several of the requirements in the tender document are unclear since they are general and not adapted to a specific project. One reason is that the clients have not prioritised sorting out irrelevant requirements.

Another way to manage unclear requirements is to make a profound work with requirements in an early stage in the project. Thus, the contractor and the client can together ensure that all information is understandable, and that both parties agree on what applies from the project start. Another aspect, mentioned by R8, is that when Skanska has submitted a tender, it is the contract that applies, and the organisation can not reserve for changes. Therefore, it is important to ask all questions from Skanska to the client before the tender is submitted, to ensure that both parties understand what the project includes. The respondent also mentions that sometimes, there is a possibility to attend tender meetings together with the client to discuss questions that have aroused, alternatively ask questions in a procurement system.

5.1.3.2 Changes of requirements

Changes of requirements in later stages of a project are, according to R1, costly and require increased work for the organisation. R12 expresses that Skanska does not have endless resources to solve different situations along a project due to changes decided by the client. Nevertheless, if a change occurs in an early stage of a project, the consequences will not be as extensive, especially in terms of costs and time (R2). R10 describes that it would have been facilitated if the client was not allowed to change a requirement when the design starts.

One solution to minimise changes of requirements is to identify the requirements in the beginning of a project (R12). The respondent says *"... even if the client can be change-*

able and get impulses, it is essential to hold onto the original structure". The respondent pinpoints that Skanska has the responsibility for the execution and must be able to motivate all changes along the project towards the inspectors. Another solution to avoid changes, is that the contractor and client establish a plan in an early project phase where the contractor understands how they can fulfill the client's needs.

Another solution is to lock changes of requirements in an early phase (R8, R12). This requires more time and resources in the early stages to receive better understanding about the requirements, better quality in the construction documents, as well as a better insight in the prerequisites, and how requirements should be fulfilled. The respondent stated that the ambition need to be: *"Now we are entirely sure which requirements we shall fulfill and how we will fulfill them, now no one can change anything if it is not required."* Nevertheless, R12, highlights the importance of collaboration, and an effort to accommodate the client's needs during a project, to maintain a good relationship towards the client. However, one reason for the changes of the requirements could be that both the contractor and the client gain a greater comprehension of the requirements and its consequences during a project (R9).

In a dream world, where no changes of requirements occur during a project, the production and the design should collaborate systematically and provide relevant calculations, budgets, and time plans, which also are supplied with resources (R8). The collaboration would generate clear and understandable manuals, provided to those who will execute the work. This design- and production team is usually called the product delivery group, which is a new term within Skanska. Earlier, the design and production were separated from each other and the new term arose when Skanska realised that the production had valuable input to the design. However, there is still a challenge in achieving this structure since the design is not always finished when the production starts. There are benefits with the design working closer to the production in order to increase SRM, to both be sure of collecting all requirements but also to ensure the constructability (R12).

5.1.3.3 Lack of common structure

In the organisation, there is a lack of understanding of the reasons for establishing SRM as well as its practical meaning. R12 expresses *"... we do not always know why".* Therefore, there is a need for clearer ground rules and explanations of what is expected by the employees when the organisation shall work systematically with RM (R12). The organisation should formulate a framework for the basis of SRM, which includes clarifying the definition of SRM to increase the understanding (R3, R12). Moreover, the organisation needs to put more resources to work with SRM (R3, R11, R12). It is essential, according to R11, to understand that time will be saved in the long run if they use SRM, and contribute to successful projects.

It is important to establish a common structure in an early stage to increase SRM (R11, R13). The collaboration between design and production also needs to be improved, by creating a joint structure and plan from the beginning (R13). If the organisation does not have any structure, where leaders control if the employees have fulfilled the requirements or not, then the employees will stop to follow up on e.g. checklists. Therefore, the organisation needs to have a structured system for SRM, where all involved parties align

on the importance of SRM.

However, Skanska works actively to set up a common structure for the way they work (R11, R12). According to R12, the overall goal should be to work uniformly and states: *"We are in the position that we now want to see everyone work in the same direction"*. R11 advocates that regardless of which client or consultant Skanska are collaborating with, the organisation should have a common structure for SRM. Furthermore, R3 and R12 have highlighted the importance of Skanska deciding on common tools in their work with SRM. It is also essential to clearly define what different working steps should include and why. R5 explained that Skanska has discussed the opportunities to use common tools during the entire project. However, since there are different prerequisites for each discipline, it can be a challenge to have common tools for all tasks in the entire organisation (R5, R9). Another challenge is that projects differ between each other, which makes it difficult to create a harmonised way of working with SRM for the entire organisation. However, R9 highlights that the organisation needs to consider the whole picture, and adapt routines and work approaches for the right department and organisation level. Major infrastructure projects include many actors, which make it difficult to control that everyone has the same working approach. Hence, a process or routines for how the organisation should manage the requirements need to be systematically performed. Therefore, the organisation has created the management system, Vsaa, which can be considered as a sort of routine, to inform how the organisation will operate.

5.1.3.4 Negative reputation and negative attitude

Today there are few discussions about RM, which results in a challenge to increase the usage of SRM (R3). Furthermore, R10 believes that SRM has a negative reputation amongst the majority of the employees. The respondent stated: "*It has got the wrong name and a negative reputation*", and as soon as SRM is mentioned, colleagues stop listening. Therefore, the respondent supposed that SRM is in need of a new name to change the current attitude towards the concept and hence motivate employees to work with SRM. During a Quality forum meeting in the spring of 2022, various proposals arose for a new name for SRM, presented in Appendix B - New name for systematic requirements management.

Negative attitude is another challenge in the construction industry (R8, R9). R1 believes that RM is not always prioritised and not considered serious, where the employees take lightly on requirements. R8 pinpoints the importance that the organisation has the right attitude to increase the work with SRM. One way to improve the attitude, and thus making the employees understand the importance of SRM, is to establish goals. Another way is to analyse the deviations and connect them to costs in order to increase the interest for SRM (R1).

Currently, there is a mentality amongst the employees that they are credited if they are solving a problem that has already aroused, instead of working proactively (R8). According to the respondent, there is a norm in society to rather act directly than to plan for what to do. One reason could be that the current technology enables us to be constantly connected and that we do not have to plan in advance. This behaviour is probably one reason for the peoples' mindset and how people act at work. The respondent stated: *"We are not used to planning, because we have not done that earlier"*. Therefore, it is essential

that Skanska is aware of this, and try to change the current mindset (R8).

One important mission as a manager is to ensure that all employees in the organisation work uniformly, and hence, change the current attitude towards new working approaches (R3, R8). R8 highlights the importance of having the right tools in order to enable a change. Currently, one goal in the organisation is to digitise all documentation within SRM. However, there are some challenges to reach this goal, since there is an aversion towards changing habits (R12). Even though digital tools are designed to look like the current working approach, the respondent believes that the employees would rather work with physical supporting tools, since changing the way of working is believed to be time consuming and difficult. The majority of employees that are most negative towards digital tools, according to the respondent, are supervisors in the ages of 50-60 that rather are using paper based templates.

5.1.3.5 Difficulties in documentation

One challenge within major infrastructure projects to increase SRM is the lack of information about the conditions of the ground. R5 describes that it is hard to systematise and document areas that lack information, which result in rapid decisions and unconsidered solutions. Therefore, it is easier to systematise areas that already have enough information. R8 states that major infrastructure projects are not using clear boundaries between different working stages, which result in high degrees of freedom for the different disciplines. The respondent emphasises: *"...we have a starting- and end-point, but we have no hindrance to start the work with concrete, even though the macadam is not documented"*. However, the respondent believes that this mindset has been created by the organisation itself, which makes it difficult to design SRM.

Major infrastructure projects are complex and include many working steps, which creates challenges in documentation. R2 pinpoints that ESS used *systematic completions*, where they divided the project in different areas and executed inspections for each project area during the entire project. This was performed together with the client in order to avoid a full inspection once the project was finalised. The disadvantages with systematic completions was the high number of inspections. However, it enabled the contractor to find faults earlier that could be taken into account for the next inspection area. Important to remember, is that these inspections are included in the structure of a project, and that there are control measures, for instance the checklist, that ensures that they are properly documented. The purpose of SRM is according to R2, that it should be easy to inspect, and then approve the work.

5.2 Process for requirements management

The following section presents the current working approach, routines, process and tools for RM at project Hisingsbron, Hamnbanan and Ängelholm-Maria. As a result of different expertise and experiences within the respondent group, the description of Hisingsbron will only cover the production phase, while Hamnbanan and Ängelholm-Maria will cover both the design and production phase.

5.2.1 Project Hisingsbron

The RM process for project Hisingsbron covered the production phase. The production used a set of documents from the design management, including drawings, technical descriptions and general directions. There was no list with identified requirements created.

The first step in the production was to establish *Inspection and Test Plans* (ITP). ITP is created in different disciplines for each work stage. The purpose of ITP is to describe the requirements valid for each work stage as well as which ones to be verified. Checklists were created based on the ITP to ensure that the requirements were validated, either digital or paper based. The respective discipline manager creates the ITP as well as checklists, with support from the support function if necessary.

The presented process of RM is systematically performed in some disciplines, even though further improvements could be done in the installation discipline due to lack of resources (R1). One employee at the project has established a structure for how the organisation should build steel bridges in the future, and how RM should be documented based on a folder structure. The response to the question about established routines for RM was not clear. However, there seems to be a lack of routines for how to use checklists and ITP.

5.2.1.1 Current requirements management tools

One current working method for RM that is used at the project is, for instance, digital checklists (R1). The respondent highlights the importance of working methods to firstly, identify requirements and then secondly, verify them. At Hisingsbron, it is clearly stated which role has responsibility for each requirement (R1). Each discipline knows which requirements they are responsible for, which then are checked against an ITP. Yet, there are difficulties in distributing the requirements to different disciplines in a systematic way, where one reason could be that requirements apply to more than one discipline.

At Hisingsbron, both paper based and digital checklists are used. Digital checklists are established using *BIM360 Autodesk Field Management* (BIM360). At this project, it is only the disciplines ground and concrete that are using digital checklists. Other disciplines have chosen to use paper based checklists, which according to R1 is aligned with Vsaa.

5.2.1.2 Current process for requirements management

Figure 5.1 presents the overall RM process at project Hisingsbron (only the production), and the different digital tools, departments and roles in the respective steps. Furthermore, the figure presents the respondents' perceptions if the RM process is systematically performed.

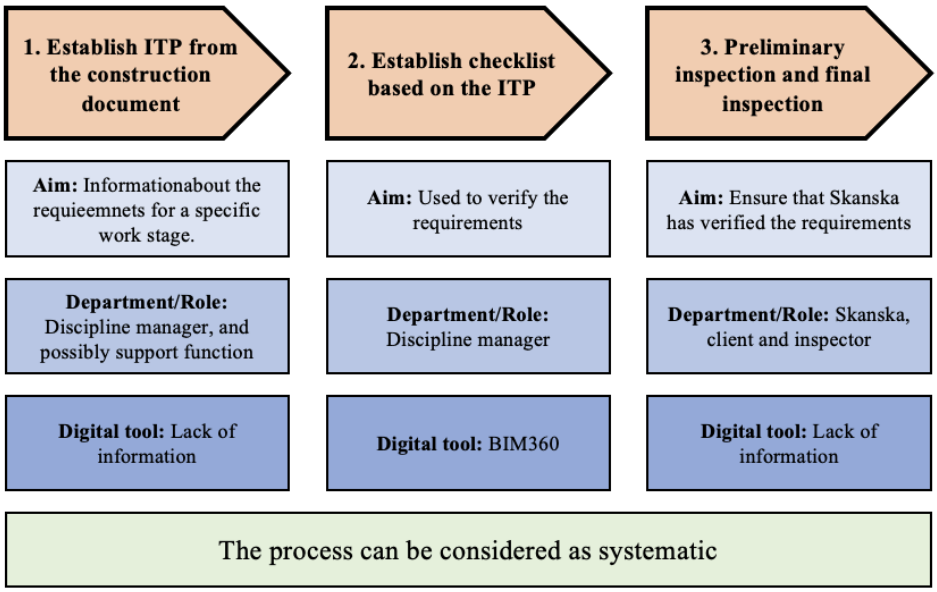

Figure 5.1: The current RM process at project Hisingsbron.

5.2.2 Project Hamnbanan

At project Hamnbanan, the RM process started with the design management identifying the requirements from the tender document. The requirements constitute the foundation of construction documents. The design phase has been managed in collaboration with an external consultant. The consultant has the overall responsibility to ensure that requirements have been fulfilled. However, Skanska is involved in the planning and support to ensure that all actions are taken, after which the consultant writes a certificate that a certain document has met a specific requirement. When the construction documents were established, these were sent to the design management at Skanska for consultation and review to ensure that they complied with the requirements in the tender document. This circulation of comments process can be seen as a routine to ensure that the requirements are properly designed (R7). Approved documents were then sent to the client, and an arrival check and review comments were sent to Skanska and then to the external consultant. The RM process in the design phase is, according to R7, relatively systematically performed.

From the construction document, job planning, ITP and inspection programs, including self-inspections, were established for the production. QEHS has the responsibility to review job planning and ensure that the identified quality requirements have been met. R7 states that job planning is a great working approach since the steps are based on the requirements from the documents that are translated to the production. The inspection program is created for different steps in different disciplines, which is later reflected in the project specific checklists. These checklists are used by supervisors during the entire production phase to verify that the requirements are fulfilled. Two respondents believe that the RM process at this project is partly systematic (R7, R8). For instance, the collection of final documentation, as well as samplings which are performed to ensure that the requirements are fulfilled, can be seen as actions that are systematically performed

(R7). On the other hand, the respondent states that SRM is not established through the entire project.

Furthermore, according to R3, the current RM process is not systematic, where one reason could be the project's complexity where many surprises under the ground have been revealed. This has led to the project needing to focus on short term measures. However, R5 is of the perception that the project is eager to work more systematically to ensure that the requirements are fulfilled. The project has made some effort to increase the work with SRM, for instance by establishing an excel list in the beginning of the project (R3). The excel list contains the identified requirements, responsibilities, timing and prioritisation. However, there is a lack of information if the list is currently used or not (R5). On the other hand, knowledge transfer will be performed in an attempt to increase the focus on SRM within the project. In such a transfer, an employee with experience from Hisingsbron, which has been working with similar tasks, will facilitate the session.

Hamnbanan is working with routines, for instance, education in how to build. The education can include sessions in which the new supervisor is informed about the environment, including environmental requirements, what needs to be performed, and how to implement it in their work. Another perspective on SRM, was that employees' knowledge has a higher impact on how different working methods are used. The selection of working methods can therefore differ depending on personality and knowledge. At Hamnbanan, it is clear which discipline is responsible for the different requirements (R6). However, the respondent perceives that there is a lack of understanding for which roles are responsible for each requirement. Nevertheless, there is a wish to improve this, even if the respondent is unsure how to realise it. In the production, R7 is of the opinion that it is clear which role is assigned and responsible for each requirement.

Project Hamnbanan is using preliminary inspections. These inspections are managed by both Skanska, a third-party-reviewer, the client and sometimes a specialist within a specific discipline based on need. During the inspection, Skanska has the opportunity to demonstrate that they have done everything properly, and that the client approves the outcome. The purpose with preliminary inspections is to develop a structure for how Skanska will, for instance, document, collect and manage deviations, as well as find an appropriate level that satisfies the client's needs. Additionally, the preliminary inspections are performed to review areas that are not visible in the future. R7 wishes to increase the number of preliminary inspections, and states that resource constraints from the clients, and cost from the contractor, could be limiting factors.

Today, there is a role within the project that functions as a bridge between design and production, which facilitates the collaboration between the two project phases (R5). Moreover, the design management and the employees from production have performed several meetings during the autumn 2019, with the purpose to align their way of working.

5.2.2.1 Current requirements management tools

At project Hamnbanan, BIM360 is used mainly in the production since the program is currently not adjusted for the design management (R6). However, there is a desire from the design management to implement tools to facilitate the process of RM. For instance,

a database is of interest in order to categorise requirements (R7). Furthermore, BIM360 is used as a communication tool between design and production. The tool can be used to manage questions regarding, for example, misinterpretations and lack of requirements, which can be sent from the production to the design management for correction.

For this project, requirements were identified and categorised in an excel list, which took approximately three months to create. The purpose was to facilitate for employees to filtrate and categorise requirements for each discipline. However, the usage of the list today is relatively low. One disadvantage with the excel list is the lack of time aspect, which is a functionality that digital tools need to include (R4). The time aspect means that each requirement needs to be connected to a project phase, in order to facilitate long term planning, even though the requirements will be managed in the production phase.

In the production, checklists are used to verify the requirements. These checklists can be either digital or paper based. In this project, the ground discipline used a paper based checklist, and the concrete discipline used a digital checklist designed in BIM360. There are, however, some supervisors, especially elders, that prefer paper checklists. Nevertheless, R5 pinpoints benefits with digital checklists such as time saving and facilitation by having all documentation collected in the same place. Furthermore, R3 expresses that occasionally, requirements may be contradicted and then the design management and production need to evaluate its implication. On these occasions, the project usually uses ask-answer-logs. There is also a similar ask-answer-system towards the client and the project also uses implementation meetings.

5.2.2.2 Current process for requirements management

Figure 5.2 presents the overall process for RM in project Hamnbanan for design and production, as well as the digital tools and roles represented in each step in the process. In addition, the figure illustrates the respondents' experience regarding whether the process for RM is systematic or not.

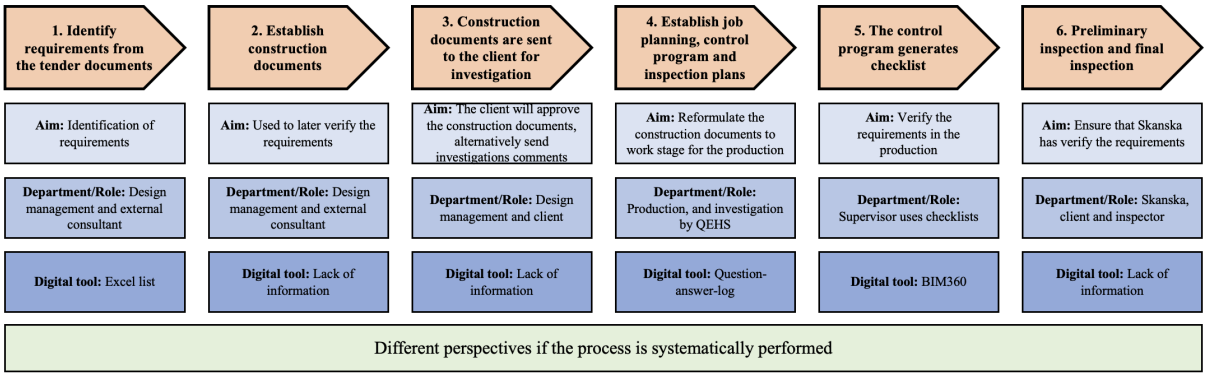

Figure 5.2: The current RM process at project Hamnbanan.

5.2.3 Project Ängelholm-Maria

At project Ängelholm-Maria, the RM process started with the design management identifying the requirements from the tender document which composed the basis for the

construction documents. In this project, Skanska used an external consultant to both clarify the requirements and also establish the construction documents, which are based on product requirements. As Hamnbanan, Ängelholm-Maria also has a circulation for comment process with the external consultant to ensure constructability and that all requirements are identified in the construction documents. When Skanska had approved the construction documents, they were sent to the client for investigation in an acceptance control. To ensure quality, self-controls, and internal inspections were used in the design phase, which were based on the completed construction documents and were accomplished throughout the project. The self-controls were used to ensure that the requirements were fulfilled.

Based on the construction documents, job descriptions, and inspection programs for the production were established. Inspection programs provided the basis for checklists for each work step. These checklists are used by the supervisors to verify requirements and should be controlled during the entire production phase. From the tender document, a project plan was also created, which later was decomposed into routines. The project plan was based on the project plan of Hamnbanan, since both have the same client and similarities between the projects. However, today it is ascertained that the individuals at the client had various levels of participation and involvement within RM in each project. At Ängelholm-Maria the client has high involvement, which resulted in higher demand on the project plan. Thus, the project plan for Ängelholm-Maria needed to be revised five times after feedback from the client, which was time consuming. Most of the feedback from the client included reformulating keywords that the client considered more suitable for the project plan, but which, according to R9, had the same meaning. This was experienced as ineffective, even if the respondent agreed that certain questioning generally result in a better end product.

The opinions differ between respondents on whether the RM process at Ängelholm-Maria is systematically performed. According to R12, the process is partly systematically performed, and some respondents consider the RM process in the design phase as systematic. However, other respondents opine that the process is not always systematically performed since there are areas which are not possible to control. Occasionally, Skanska needs to rely on the external consultant to do everything correctly since there is not always time to review the work. Thus, the SRM in Skanska is based on the RM being hundred percent systematic in another organisation. However, some respondents explain that the project strives to have a more strict SRM henceforth.

The production uses Vsaa for RM. The management system is functioning well, even though the design management have clarified some parts to make it more intelligible for the production, which then was adapted to a routine for the employees (R11). Another respondent explains that Vsaa is based on routines. An additional perspective from the respondents, is that people from different business units work with, for instance, checklists in various ways. Hence, the design of the checklists is varying depending on the person who has responsibility for them.

The project has design meetings with the client every month during the design phase in terms of technical meetings. At these meetings, there is an opportunity to, when necessary, e.g. discuss different changes of requirements. One reason for using these technical

meetings is mainly due to the large size of the project. The meetings are systematically designed according to R11. Currently, the project is also implementing quality inspections to ensure that the self-controls are done and to verify the phase of the project. The quality inspections aims to systematically discover possibly repetitive deviations which need to be remediated before forthcoming works. However, since the inspections are still in the test phase, the respondent is not able to express whether the quality inspection works properly or not. At Ängelholm-Maria, there is a employee that to some extent has the responsibility to systemise the working approach, which is the same person who is responsible for the quality inspections. Another intention with these quality inspections is to create security for the employees that their work is properly performed, and to have it verified.

Furthermore, there is a clear work specification in the project plan with information of what should be performed at the project, which roles there are and the expectations of every role in the production (R5). R10 also experienced that the responsibility of the requirements is clearly distributed, even though there are occasions when it is unclear. R9 has mixed perception whether the requirements are clearly distributed among the roles in the production. The respondent experiences a problem in that the supervisor has a high amount of requirements, and thus there is a risk that requirements are missed. R12 agrees and expresses that there is a clear matrix of responsibility for which requirements a specific role should be responsible for, even though many lack knowledge about the actual meaning of the working role´s responsibility. One area of improvement could be to give a more clear area of responsibility to the support function, QEHS. Currently, the support function has a certain area of responsibility, even though it is not formally stated. The support function has the responsibility to introduce tools, working approaches and introduction material to support the production, but it is not required to actually be performed.

Moreover, there have been challenges for the part-project managers to understand the invitation to tender from the client, since many of the requirements were indistinct and contradictory. Hence, the design management was delayed, which resulted in a pressure on the production since they had less time to prepare the work.

The project is currently in a period where the design management has provided the production with construction documents, which has resulted in a need of support in questions regarding details. R11 describes that one part-project manager currently is positioned close to the production to support them when they are reading construction documents and need to find the right information. The respondent mentioned that several of the employees in the design management have a background within production. Thus, there is a proper collaboration between the design and production.

5.2.3.1 Current requirements management tools

At project Ängelholm-Maria, there are no digital tools for RM in the design. R9 mentions, however, that they are using tools such as different ask-answer-systems. One ask-answer-system is APRICON, which is being used to manage questions between Skanska and their external planning manager, with weekly follow ups.

In addition, the project is using a quite new ask-answer-system from 2018, named JIRA, which was used at project ESS. The system functions as a chat between the client and the contractor and it is possible to specify who the question should be assigned to. Thus, when questions arise from the external planning manager, the chat can be used to receive answers on questions from the client that Skanska is not able to answer. The benefit with the chat is that it functions as a basis for documentation of the decisions which have been made. According to R11, the ask-answer-system functions but, many questions have arisen. At present, there have been 1200 questions from the planning manager and 600-700 questions from Skanska to the client. One conclusion according to the respondent is : *"If the tender documents had been more clear, there would not have been as many questions..."*

The production uses BIM360 for documentation of self-controls. The digital tool makes it possible to check each work step in various checklists. However, the collaboration between design and the production would have been facilitated if the design management also were using BIM360 (R10). One reason is that the project has an external consultant for the establishment of construction documents, and they are using its own system. According to R10, if the consultant should use a specific digital tool it needs to be required in the contact. However, the respondent does not experience this as necessarily as long as the consultant does the work correctly and is able to show that the requirements are met.

5.2.3.2 Current process for requirements management

Figure 5.3 presents the overall process for RM in project Ängelholm-Maria for design and production, as well as the digital tools and roles represented in each step in the process. In addition, the figure illustrates the respondents' experience regarding whether the process for RM is systematic or not.

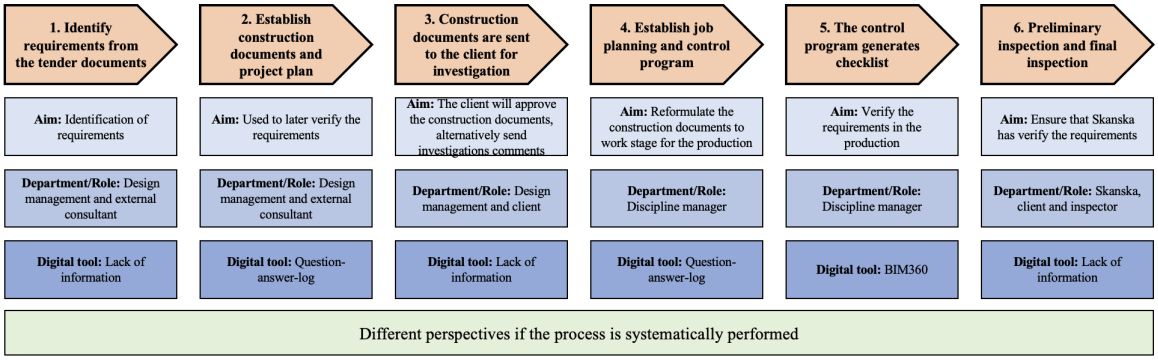

Figure 5.3: The current RM process at project Ängelholm-Maria.

5.3 Development of requirements management tools

There are different perceptions about how current RM tools can be further developed. R3 gave two different suggestions. Firstly, to manage the requirements in an excel list including a smart column system in order to verify the requirements, functions to connect requirements for a specific role, and ensure that only a few people have access to perform

changes. Secondly, to use the document management system APRICON. APRICON includes modules for visual planning and design through *Virtual design and construction* (VDC). At present, the model is used as a tool to conduct design meetings. The principle is based on that many employees gather in one room, with clear questions and answers, and ensure to align on different issues. This results in that everyone is conscious about who has delivered the information as well as when and how it has been done. This principle could probably be used for RM (R3). However, it is important to create the right conditions, where everyone involved dares to express their opinions. This means that the client needs to have courage to approve without waiting for the inspector. According to the respondent, it is only now that Skanska has begun to consider how APRICON can be used for RM.

In the current digital tools, there is a lack of functionality for managing the time aspect for when requirements need to be managed. According to R3, APRICON incorporates these functions, as well as gives a note when different steps should be managed during the project time. Nevertheless, the program requires that the project has a properly outlined time plan where every step is connected to set the time of completion, that there is knowledge about how to translate requirements into actions, and what it takes to do the work.

Several departments within Skanska are looking at which software and tools that are needed for managing the requirements in the production (R12). However, it is important to remember that all new tools come with a learning period and it is crucial for implementation in order to get the employees to understand the value of it. It is common that people are sceptical towards new tools, and consider the current one to work fine. According to R12, it is more common for young employees to express scepticism towards new tools and programs. One reason for this could be that they rather want to move forward with the projects and create instead of learning how to use the new tools. This eagerness to produce is not always beneficial towards the implementation.

5.3.1 BIM360

BIM360 is a digital RM tool that major projects at Skanska have implemented. R12 describes the tool as a large database in which there are possibilities to create templates for every step of a specific stage, from beginning to end. The purpose of the tool is to create a way for the employees to follow up on activities, comment, and sign off activities after completion. The documentation is then summarised in the joint platform.

For BIM360, there is room for development in functionality to create better BIM-models with more information about requirements. An example of this was highlighted by R12, who expressed a wish to include more information, for example about what is stated in AMA and quality of the production, in the BIM-model. The information about checklists should also be included in the model, to visualise which requirements have been fulfilled with e.g. green colour. The respondent said: *"If one could get a model containing all information, that would be the best"*. In that way, everyone will be aware about the latest updates regarding SRM. In addition, R2 also expresses how a 3D-model with different colours could be used to visualise how the work with SRM is proceeding. For instance, yellow could mean that a part of the construction in the model is completed and green

when that stage has been controlled by the client. In that way, the 3D-model could be used to illustrate which parts of the construction that are approved, given that the respondent believes that it could be connected to systematic completion. If so, the organisation could increase the usage of digital tools within the RM process. R1 suggests that all final documentation together with the client could be done through a model in the future. If connected to a joint SharePoint, the information flow could be even more optimised.

As a response to the question if other software than BIM360 could be used, R5 replies that it is not needed. The respondent believes that it would not be valuable to change a system which requires a learning period and new way of working, since BIM360 works fine.

5.3.2 Database for requirements

The majority of the respondents wish to create a database to manage requirements to facilitate documentation management. R6 stated: *"It would be like a dream come true"*. Another advantage with having a database is, according to R7, that the system highlights which requirements are applicable for a specific project. By that, the risk for the organisation to miss a crucial requirement also decreases. To create a requirements repository where Skanska can identify the most important requirements at an early stage would, according to R7: "*make it substantially easier to take correct actions, rather than fix it afterwards which drives a lot of cost*".

R1 spots a challenge that standards are connected in several levels, which makes the interpretation of the requirements in the standards difficult and sometimes necessary to involve several different peoples' opinions. This situation often results in that the contractor and the client have different opinions about what needs to be done to fulfill the requirement. This challenge could be mitigated with the use of a joint database between client and contractor. The respondent states that if the actors together summarise all requirements, they are then aligned on what the requirements' definitions are and how that translates into actions. Putting all requirements into a database should take a couple of days to perform, according to R1. What requires the most time is, however, to agree on the definition of requirements. The respondent sums up with the statement:
But if it is in our agreement to do it, then there should be nothing to discuss?

In contradiction to R1, R6 states that creating a database is a time consuming task to identify, manage and validate all requirements during the whole project. Furthermore, it is also a complex task, due to all the references and cross-references to different standards.

5.3.2.1 Designing of a database to manage requirements

There are many suggestions for how a potential database for managing requirements could be designed. If Skanska establishes a database, it is important that it does not get too large, according to R2. Focus should instead be on user friendliness, and to achieve this, the most important requirements need to be identified. To facilitate this, R7 believes it could be beneficial if the client prioritises amongst the requirements for the project. Doing so, Skanska could then prioritise between the requirements themselves and add

other perspectives, such as Vsaa, economical and technical aspects.

Moreover, R10 mentions that a database should be visually adapted to increase user friendliness. The respondent suggests that the database should be designed as a large board where post-it notes should illustrate different demands in a project. The post-it-notes could easily be moved around between different disciplines and roles, making the approach understandable and manageable for all parties. On the other hand, the system also needs to be sufficiently advanced to incorporate all necessary information for the responsible.

The respondents have identified several important functions within a database. A search function is desired to be able to search for different AMA codes and specific phrases in the RM platform (R2). In addition, a filter function could make it easier to sort between the requirements and get an overview of requirements belonging to a specific discipline or role, together with the connected standard and document. R2 also expresses a wish to have a function to categorise requirements in the database. Furthermore, R6 states that the database could be used to follow up on fulfillment of requirements and R7 means that the database should have the function to document information connected to the requirements.

The responsibility and ownership of the database was another function highlighted by R7. The respondent believes that it would have been beneficial if the client themselves could establish a database to manage requirements, where they outline the requirements that should be fulfilled in the contract. Anyhow, the database to manage requirements will be valuable for both parties, since it will make it transparent which requirements that should be achieved. This perception is also shared with R10, who expresses that the client should manage the database, and that it should be available for both parties. Additionally, a joint database would make it easier to align on changes, additions and removals of requirements that are done throughout the project, and thus function as a single source of truth.

One example of a database is DOORS, which is used to manage requirements by STA. During the tender phase, the database is used to create the tender document sent to the contractor. The majority of the respondents at Skanska had heard of the tool before, but few had ever used it. There seems to be uncertainty if the system is used by STA or not, since none of the projects in scope for this thesis used DOORS. However, STA should have assigned Hamnbanan a DOORS database for specific requirements for the railway, but that never happened.

5.4 Motivation

Changing employees' habits could be perceived as challenging (R8). It is important to understand that it requires a lot of engagement and time to change habits and ways of working, in order to establish a new routine. One way to create new routines is to motivate people towards wanting to change the established way of working. The respondent continues stating that motivation could be created when employees get appreciated, and potentially awarded, for their work. Managers should follow up on the implementation of

new routines, to show appreciation towards their team and highlight that their work will make a difference. If new routines are implemented, motivation is a key success factor to make them stick long term (R8).

5.4.1 Performance culture

Positive performance culture is one way to motivate people to increase SRM (R8). According to the respondent, positive performance means that the organisation needs to create an environment where the employees feel proud and get challenged, as well as create the right conditions and resources to execute their work. This will hopefully result in that the employees will take their own initiatives and put more effort into their work than is expected, as well as an ambition to develop themselves and increase their knowledge-base. However, it is important to have a balanced approach, and not push the employees too hard.

Furthermore, one way to establish a positive performance culture is to celebrate project achievement with rewards, for instance a cake. In order to reach the set target, it is essential to ensure that the employees understand how to reach the goal, who is responsible, and what the path looks like. One way could be, according to R12, to stepwise introduce the new way of working and the tools, and always encourage and support the usage. In addition, the respondent states that it is essential to show how the new routine has generated a positive result. If the employees understand the value of the new working approach, they will become more positive and motivated to continue working with the implementation.

5.4.2 Management system

There are different perceptions if Skanska has a systematic way to perform changes in their management system, Vsaa. R8 believes that the organisation does not actively work to find the optimal way to use Vsaa or to benchmark against their own employees. This results in the employees having difficulties to take part in changes and exchange experiences and knowledge. Furthermore, the interaction between employees and Vsaa is not properly performed, and needs to be improved. The respondent also states that there are many employees today that do not prioritise reading in Vsaa, which is believed to be a consequence of personality and interest. Therefore, a new mindset is needed.

There are different suggestions of how the organisation can increase interest in and use of Vsaa (R8). One way is to establish Vsaa of the week or Vsaa of the month, which aims to enlighten the employees about various subjects or best practices for different working approaches. In that way, the employees will hopefully be inspired, and thereby absorb information more easily. However, it is important that the Vsaa of the week or month is driven by an appropriate person to increase the interest amongst the employees. Furthermore, the occasions need to be short and not take too much time and effort from the employees. The respondent stated: *"We invite you to a bun, and then we take 15 minutes to talk about Vsaa"*

Another way to update the management system to be more inspiring is by requesting the employees to send in improvements and suggestions of new working approaches. Addition-

ally, the respondent states that today's information society makes it difficult for people to absorb information through plain text, and they need to receive it orally. Therefore, one suggestion is to establish a Vsaa podcast that will hopefully increase the interest and inspire the employees to work with Vsaa.

There are different perceptions if Skanska are using Vsaa in their work with RM. R2 believes that project ESS used Vsaa in their way of working with SRM. However, the respondent is unsure if the management system is used in other projects, where one reason could be the time aspect and the priority to start working. According to R12, Vsaa is the basis for how the organisation works. R11 states that the project Ängelholm-Maria works with Vsaa, even though some adjustments have been made to make it more adapted to the production.

According to R8, there are three different answers if the organisation is using Vsaa for managing requirements or not: *Yes, No* and *I do not know*. Yes, since the respondent believes that it is used in some cases. No, since the organisation may miss aspects, or have countermeasures. I do not know, since the organisation does not have a systematic way to communicate updates in Vsaa. R10 is not using the management system for RM, but stated that if a question arises, the answer will probably be found in Vsaa. If the organisation should work solely with the guidelines in Vsaa, R13 believes that Skanska would have a proper systematic approach when managing requirements.

6
Analysis

The aim of this chapter is to answer the research questions. Firstly, the chapter will provide the reader comprehension of how the three studied projects currently use the RM process and how this can be integrated in a RM plan. Secondly, the chapter will present the identified challenges and its countermeasures when establishing SRM. The chapter will also investigate the main functions needed in a RM tool. Thirdly, the chapter will investigate what is needed to support a change toward more systematic RM.

6.1 RQ1: How can the RM process in major infrastructure projects be combined with the RM plan?

Seven components have been identified by Izhar et al. (2018) for a RM plan. However, only the following four components will be analysed:

1. Requirements elicitation procedure: evoke, investigate, and record the most important requirements
2. Roles and corresponding responsibilities: ensure that a role has responsibility for each requirement
3. Tools: used to fulfill requirements
4. Approval: appoint a role to ensure documentation of requirements

The reason for not analysing *project overview* and *requirements traceability*, is because they have not been included in the scope of the empirical study. Furthermore, *Change control* is about managing changes of requirements, and will be analysed in detail in RQ2a. However, the majority of the respondents state that the process for managing requirements changes is well designed. The challenge is that requirements change during the project, which affects the RM process.

Figure 6.1 illustrates the three projects and their activities in the RM process in relation to the four components from the RM plan.

	Requirement Elicitation Procedure	Roles & Corresponding Responsibility	Tools	Approval
Hisningsbron	**Design:** Lack of information. **Production:** Creating inspection program (including self-control and checklist), ITP, checklists and job planning	Clear which requirements every role has responsibility for. But not always clear between the disciplines.	**Design:** Lack of information. **Production:** BIM360, e.g., digital checklists	**Role**: Lack of role to ensure documentation of requirements. **Design:** Lack of information. **Production:** The documentation is overall systematically performed but can be improved.
Hamnbanan	**Design:** External consultant identify requirements from the tender document, then create construction documents. Approved by Skanska and client. **Production:** Creating job planning, ITP, inspection program (including self-control and checklist)	Clear which requirements every discipline has responsibility for. Different perspectives about the responsibility for requirements regarding the work role.	**Design:** Excel-list to identify & categories requirements. Overall, more RM tools are needed. **Production:** BIM360, e.g., digital checklists **Other:** BIM360 and ask-question-log.	**Role**: Lack of role to ensure documentation of requirements. **Design:** Different perceptions if the documentation is systematically performed. **Production:** Different perceptions if the documentation is systematically performed.
Ängelholm-Maria	**Design:** Consultants identify requirements from the tender document, then create construction documents. Approved by Skanska and client. Self-control to ensure quality and verify the requirements. **Production:** Job planning, inspection program (ink. self-control).	Different perspectives about the responsibility for requirements regarding the work role.	**Design:** Lack of tools for managing requirements. **Production:** BIM360, e.g., digital checklists **Other**: Ask-answer-log	**Role**: Lack of role to ensure documentation of requirements. Initiative have been implemented. **Design:** Different perspectives if the documentation is systematically performed. **Production:** Different perspectives if the documentation is systematically performed.

Figure 6.1: Activities, roles and tools in the RM process for the three different projects combined with the four critical components of the RM plan.

Requirements Elicitation Procedure

Requirements elicitation procedure in the RM plan is correlated with *requirements elicitation* in the RM process. The result shows that Hamnbanan and Ängelholm-Maria, have the same procedure for requirements elicitation in the design phase, where both projects have an external consultant for managing the requirements. The consultant has the responsibility to identify and categorise the requirements into a construction document. Kumar & Kumar (2011) also mentioned that a RM process should include identifying requirements.

Izhar et al. (2018), have described that the *requirements elicitation procedure* should evoke, investigate, and record the most important requirements. Currently, Skanska does not identify the most important requirements in an early stage, even though many of the respondents have mentioned the benefits and ambition to execute it. One respondent has mentioned that this can be achieved by establishing a database for requirements, in terms of a storage centre.

In the production phase, the result shows that the activities are the same in all three projects; *Creating job planning, ITP, control program (including self-control and checklist).*

Role and Corresponding Responsibility

The *role and corresponding responsibility* for managing the requirements is another component in the RM plan (Izhar et al., 2018). Izhar et al. (2018) state that it is essential to identify roles and the responsibility for requirements. However, the empirical findings indicate that there are different perspectives regarding if the responsibility for the re-

quirements are clearly distributed among the roles. At Hisingsbron, it is clearly stated which roles are responsible for each requirement. One respondent from Hamnbanan has mentioned that the role and responsibility for requirements is not clearly defined. The respondents at Ängelholm-Maria have different perceptions if the responsibilities for the requirements are clearly distributed among the roles, where the majority of the respondents have the opinion that it is clearly stated. One respondent has stated that the responsibility matrix in the project plan has a strict explanation of the responsibility of different roles. However, the respondents have noticed that there is a lack of understanding of what the responsibility of the role actually means.

The perception of clarity regarding the responsibility of requirements for the disciplines differ between the studied projects. At Hamnbanan, the impression of one respondent is that the clearness of responsibility for specific requirements in each discipline is a result of employees' experience. One respondent at Hisingsbron mentioned that although the responsibility of requirements generally is clear for each discipline, sometimes there could be unclarity. The reason for unclarity is because the same requirement can belong to several disciplines.

Tools
In the design phase, there is a lack of digital tools for Hamnbanan and Ängelholm-Maria. Accordingly, it can be stated that the employees are in need of digital tools to manage requirements. This is aligned with Hull et al. (2005), who stated that digital tools are essential in the RM process. Nevertheless, an initiative has been conducted at Hamnbanan in an early project stage, to identify and categorise requirements in an excel list. However, the impression given by the respondents is that the excel list is not currently used.

Hamnbanan and Ängelholm-Maria are both using answer-ask-logs between the design- and production phase. At Ängelholm-Maria, a relatively new system is used, which enables Skanska to ask questions directly to the client in a chat. The chat generates the opportunity for Skanska to specify which role the question should be assigned to. Another benefit with the system is that it provides a basis for the documentation of decisions.

Izhar et al. (2018) stated that RM tools ensure that the requirements are met and recorded during the entire project. Figure 6.1, illustrates that all projects use BIM360 in the production phase, for example when verifying requirements by using checklists. However, not all disciplines use digital checklists. There are several reasons for using a paper checklist, where one perspective is that older employees prefer this type of working approach.

Approval
To establish SRM, the RM process needs to be integrated in the entire project (Jallow et al., 2008). Furthermore, Eriksson & Kadefors (2017) state that the requirements need to be clearly managed and organised. This can be achieved by ensuring that the requirements are well documented (Jallow et al., 2008). According to empirical findings, the aim of SRM is to facilitate the inspection and approval of requirements documentation. Figure 6.1, shows that there are different perceptions on whether or not the RM process is systematically performed at the studied organisation. To achieve a proper SRM it is essential that it is integrated in the entire project life cycle (Jallow et al., 2008). At

Hisingsbron, the RM process in the production phase is relatively systematic, but could be improved by e.g. providing more resources. One respondent at Hamnbanan consider the RM process in the design phase to be quite systematic. However, the perceptions about whether the overall RM process is systematically performed differ between the respondents. One respondent presumes that it is partly systematic, and provides examples of systematic working approaches such as validation of samplings. Contrary, two respondents do not agree, and express that the RM process in the project is not systematically performed. One reason is that the projects had many surprises which resulted in quick decisions and the time to work systematically has been unprioritised. For Ängelholm-Maria, the managing of requirements in the design phase can be seen as quite systematic according to several respondents. However, one respondent describes the difficulties to ensure and control that all requirements are validated. In this case, Skanska needs to rely on the consultant being systematic when identifying all the requirements.

Overall, the respondents in the three projects wish to be more systematic when managing requirements. One initiative at Ängelholm-Maria is to use quality inspections to ensure that the self-controls are being accomplished for every discipline and discover repeated deviations to avoid the same mistakes. Another initiative at Ängelholm-Maria is that the project has appointed a specific role, which has the responsibility to systematically design the work tasks within RM. The role should provide security to the employees, that the work is correctly performed. This is aligned with Ionescua et al. (2014), who describes how the manager should be involved and support the employees in a change, such as SRM. Another initiative is that an employee at Hisingsbron, has designed a structure for how the organisation can systematically construct a steel bridge in the future. The structure includes how the RM will be documented based on a folder structure. As mentioned before, Hamnbanan has at an early stage, established an excel list to identify and categorise requirements, which is another SRM initiative.

The last component in the RM plan is to appoint a role to ensure and approve the documentation of requirements (Izhar et al., 2018). One role who has the essential responsibility to systematically set plans for a specific project, is the project manager (Phan et al., 2020). However, for the three studied projects, there is a lack of roles that have the responsibility to ensure the right documentation. In a certain way, the initiative of having a role responsible for the systematic design of the working tasks, is one example of a role that can ensure approved documentation of requirements.

6.2 RQ2a: What are the challenges when establishing SRM, and what is required to manage these?

Managing requirements is a complex process (Yu & Shen, 2013), and there are several challenges when managing requirements systematically. Accordingly, the section will present the identified challenges and countermeasures from both the theoretical background and the empirical study, which are illustrated in Appendix C - Identified challenges and countermeasures.

By analysing Appendix C, the majority of the identified challenges confirms the existing research: *increased number of requirements, unclear requirements* and *changes of requirements*. However, some of the challenges have similarities and can emerge into the same challenge: lack of common structure and lack of integrated process as well as lack of documentation and difficulties in documentation. In this study, these will be analysed as the same challenge and be described as *lack of common structure* and *lack of documentation*. Two challenges not focused in earlier research in relation to SRM are addressed in the empirical study; negative reputation and negative attitude. These challenges can be seen as a contribution from the study, and will be described as *negative attitude and reputation*.

Increased number of requirements
Both empirical study and Jallow et al. (2014) have identified the increased number of requirements as a challenge. However, the identified theory has a lack of information on how to manage this challenge, and hence there is no mentioned countermeasure. Contrary, the result has mentioned several countermeasures. Overall, it seems to be essential to manage the requirements at an early stage of a project, with the aim to understand and identify all requirements, in order to fulfill the client's expectations and focus areas. This can be achieved by providing more resources in the design phase.

Unclear requirements
There are both similarities and differences between the theory and empirical study for countermeasures of managing unclear requirements. The following similarities could be found: *specify requirements*, *prioritise RM* and *clear and understandable requirements*. Specify requirements is mentioned in the result as an activity that the client should have responsibility for when formulating the tender document. In addition, the client should adapt the requirements to a specific project, which is not always done according to the empirical study. Yu & Shen (2013) mention the importance of specifying and communicating the requirements clearly, which is aligned with the result. Prioritising RM is another similarity between theory and empirical study, which, according to the studied organisation, can be achieved by increased time and resources. Lastly, clear and understandable requirements are essential for both the contractor and client. The contribution from the studied organisation is aligned with Jallow et al. (2014), highlighting the importance of a common language, and Yang et al. (2012), mentioning clear definitions to understand the requirements. Another option to increase the understanding of requirements is to ask possible questions about the requirements to the client before the tender is given. Thus, the understanding of the actual meaning of the requirements can be increased, which Yu & Shen (2013) mention as an essential factor to manage the unclear requirements.

Another countermeasure only mentioned in the empirical study is the importance of increasing the collaboration in an early stage between design and production when identifying requirements. In addition, the result mentions that the consultant or the in-house designer needs to have the right knowledge within both design and production.

Changes of requirements
Change management is, according to Izhar et al. (2018), a component in the RM plan as well as a component in the RM process. Therefore, change management can be seen as essential within SRM. However, both literature and empirical result have mentioned changes of requirements as a challenge, but with different countermeasures.

Young (2004) indicates that establishing a process for managing requirements changes is a countermeasure. However, as mentioned earlier, Skanska has a well designed process for managing requirements changes. Instead, the result focuses on how to minimise the risk for requirements changes. One approach is to, in collaboration with the client, establish a common plan in an early stage of the project, to ensure client satisfaction. This may be aligned with Jallow et al. (2014), who mention the importance of documenting and storing requirements in a central repository in an early project stage. Another aspect mentioned by Young (2004), is that requirements changes are well documented, updated and traceable.

One important factor to minimise the risk of unnecessary changes is, according to Young (2004), to establish an approval process before changing a requirement. The empirical study mentioned that the requirements should be locked for changes from the client before Skanska has started the design phase, which minimises the risk of unnecessary changes.

Lack of common structure
SRM is defined as a RM process that is integrated throughout all phases in the project life cycle. The data collected support Jallow et al. (2014) on the importance of establishing a RM process where all components are integrated into every project phase. This can, according to empirical findings, be achieved by establishing common processes, tools and routines.

Another countermeasure is to increase the collaboration between design and production, where they establish a common plan to structure and coordinate the requirements. A common plan will hopefully ensure that requirements are fulfilled before entering the following phase, which is a countermeasure mentioned by Jallow et al. (2008). To create a better plan and structure for SRM, it is essential to establish a common definition, ensure that the employees understand the aim and prioritise the work with SRM. The managers also need to control and show interest for the employees in their work with SRM.

Lack of documentation
Requirement documentation is, according to Izhar et al. (2018), one component in the RM process. Alla et al. (2017) mention how establishing standardised documentation of requirements is a countermeasure for lack of documentation. The empirical study indicates that there are some difficulties in documentation, where one reason could be that the sector does not have a clear start and end between different working steps. One

solution could be to establish systematic completion.

Young (2004) and Khairuddin et al. (2021) mention the importance of documenting changes in requirements. However, the client does not always read these documents which result in an unawareness of the content (Khairuddin et al., 2021). One countermeasure, according to Young (2004), is to update and document changes of requirements, which Khairuddin et al. (2021) state are even more important if the client should read the documentation. In addition, the most important requirements need to be identified for a specific project in an early stage. This could be done when establishing requirements specification, which is a component in the RM process (Khairuddin et al., 2021).

Negative attitude and reputation
Interviewees mentioned additional challenges for SRM to be *negative reputation* and *negative attitude*. Negative reputation can be improved by defining a new name, or increasing the conversation and interest about SRM. Hence, the employees need to be motivated to change their attitude towards SRM. One way to improve the negative attitude is to increase the employee's understanding about SRM, which could be done by increasing the conversation. Another way to improve the attitude to SRM, is to analyse the deviations in terms of costs or establish goals. The empirical study indicates that the employees are not always used to planning in their daily life. Thus, employees act when the problem has occurred, which is not aligned with SRM. Therefore, one countermeasure is to change the current mindset and highlight the importance of planning in an early stage.

Further investigations
From Appendix C it could be stated that several of the countermeasures could act as countermeasures for more than one challenge. Some examples are: *increase the understanding of SRM, create a common language for requirements* and *create a common definition for SRM*, which could be connected to having more clearly defined requirements. As mentioned before, the requirements need to be identified in an early stage of the project together with the client, to create clear and understandable requirements. Thus, the client and the contractor are able to have the same perspective of the requirements' meaning. To achieve intelligible requirements it is important to deposit time and prioritise the work with RM. In addition, there needs to be a clearly appointed start and end of every working step to ensure that the requirements are fulfilled before continuing to the next project phase. The requirements also need to be updated throughout the entire project. Another correlation between different countermeasures is the importance of having a common structure with standard RM tools in the organisation. This facilitates the work and can improve the attitude towards SRM.

6.3 RQ2b: Which functions are required in a RM tool when establishing SRM?

Both theoretical and empirical data point to RM tools as a main prerequisite when establishing SRM. RM tools can be used to ensure that the requirements are consistent, accessible and up-to-date (Hoffmann et al., 2004). RM tools can be used in different ways, with different capabilities Hoffmann et al. (2004), which depends on organisational size or project type. Several of the RM tools are digital, and the empirical study indicates that respondents have different perceptions of which functions a digital tool should include. The organisation has done some effort to implement a digital tool for managing requirements in terms of an excel list with identified requirements for a specific project. However, there seem to be a lack of proper tools that are simple to use.

In addition, the majority of the respondents have suggested that a digital tool in terms of a database with all requirements would be beneficial for both the design and production. A database would both clarify the requirements for a project and facilitate the documentation of requirements. One respondent mentioned *"It would be like a dream come true"* if a database was implemented. When implementing a new RM tool, it is important, according to the studied organisation, to consider that it will take time for the employees to adapt and learn the new working method. It is important that the employees understand the aim of the new tool, and why they should adapt. However, it is essential to remember that an IT tool cannot be used to change an organisational culture or strategy (O'Neill & Sohal, 1999).

Functions for RM tools
The section presents the most important functions which should be included in RM tools, according to empirical study and literature, illustrated in Figure 6.2. The figure illustrates the criteria from Hoffmann et al. (2004) and the capabilities from McLellan et al. (2010), which will be referred to as functions in this analysis. By combining the two, most of the functions mentioned in the empirical study can be achieved. Only one function from the empirical study could not be matched with the theory, which is search-function to track requirements. However, McLellan et al. (2010) and Hoffmann et al. (2004) mention six additional functions that are not identified in the empirical study, see Figure 6.2. Moreover, the figure presents the renamed functions in terms of *common functions*.

Functions for RM tools			
Common Functions	**Empirical findings**	**Literature – Critera**	**Literature - Capabilities**
Traceability	Traceability of requirements	Traceability – Developer´s perspective	
Search-function	Search-function to track requirements		
Specified work role	Connect requitements to work role		View restriction
Access restriction	Few people who have access to change in the system	Users, roles, and rights – Administrators perspective	Input validation
Time aspect	Systematically management of the time aspect for the requitements	Analysis function – Developer´s perspective	
Technical advance	Elementarily designed system, but sufficiently technical advance to manage the requitements	Extensibility - Administrators perspective	
Visuality	Visually adapted system	View – Developer´s perspective	Satisfaction
Categorisation	Categorisation of requirements		Coupling
Identify and compile requirements	Function to identify and compile all requitements for a project	Information model – Developer´s perspective Import – Developer´s perspective	Refinement
Validate and check requirements	Opportunity to validate and check requitements		Verification
Document validated requirements	Opportunity to document validated requitements	Documentation of the history – Developer´s perspective Baselining – Developer´s perspective	History
Formatting, multimedia, and external files		Formatting, multimedia and external files - Developer´s perspective	
Tool integration		Tool integration – Developer´s perspective	
Web access		Web Access – Developer´s perspective	
Central installation and administration		Central installation and administration of projects - Administrators perspective	
Workflow management		Workflow management - Administrators perspective	
Prioritisation			Prioritisation

Figure 6.2: Functions that are needed for RM tools.

Most important functions

Figure 6.2 illustrates that there are four functions that have been mentioned by both studied organisation and the theories Hoffmann et al. (2004) and McLellan et al. (2010): *access restriction, visuality, identify and compile requirements* and *document validated requirements*. In the analysis, these functions have been identified as the most important functions for a RM tool.

The first function, access restriction, describes that only a few roles should be able to make changes in the system for requirements. According to Hoffmann et al. (2004), there needs to be an administrative role that controls the user accounts and the access rights, which is more essential in larger and complex projects. Furthermore McLellan et al. (2010), describe that there should be restrictions concerning the access of requirements for different users. McLellan et al. (2010) also mentioned the importance of having requirements that are certain, qualitative and structured, before being added to the digital tool.

Secondly, the system should also have a function to visualise the requirements order to facilitate the usage. One respondent suggested that a database should be designed as a board including post-it-notes to illustrate the different requirements in a specific project. By using the method, the task will be easier and more visual since the post-it-notes can be transferred between different disciplines and roles. This suggestion is aligned with McLellan et al. (2010), who state that to achieve requirements, they could be mapped and adapted to physical design. Furthermore, Hoffmann et al. (2004) describe that the system should enable the users to see data information in various views.

The third function for a digital tool is identify and compile requirements. Employees within the studied organisation mentioned how the requirements within a project need to be clearly identified and compiled. This is aligned with Hoffmann et al. (2004), who describe how a system should identify the requirements in a database during its life cycle, but also that the system needs to be changeable. The function will also facilitate importing the current requirements specification documents. This is a component in the RM process which ensures that the requirements are understandable, correct, consistent and completed (Khairuddin et al., 2021). This is supported by McLellan et al. (2010), who mentioned that requirements should be refined and formulated in detail with a more narrow scope.

Lastly, the fourth important function is document validated requirements. Hoffmann et al. (2004), advocate that a database should be traceable and include all changes of requirements. This is supported by McLellan et al. (2010), who emphasise the importance of documenting all requirements during a project. In addition, Hoffmann et al. (2004), mention the importance of having a baseline for requirements that could be used as version reference, before entering a new development phase.

Important functions

There are six functions that have been mentioned by both studied organisation and one of the two theories (Hoffmann et al., 2004; McLellan et al., 2010): *traceability, specified work role, time aspect, technical advance, categorisation* and *validate and check requirements.* In the analysis, these functions have been identified as important functions for a RM tool.

The function, traceability of requirements, is important to facilitate the usage of the system. According to Yu & Chan (2010), traceability generates the ability to track the progress and ensure that the requirements are integrated in the entire project life cycle. Another function for RM tools is the ability to connect requirements to roles. In addition, one respondent has mentioned that digital tools currently lack the time aspect for when the requirements need to be considered during a project. The planning and consideration of the time aspect are essential in the beginning of projects, even if the requirements will be validated in the production phase. Hoffmann et al. (2004) highlight the importance of the ability to analyse requirements, where requirements information should automatically be linked to the status and risks in a project. Accordingly, the time aspect is an important function in both the empirical study and for Hoffmann et al. (2004).

Moreover, the increased number of requirements have resulted in the need of a function to categorise requirements, which will also facilitate the SRM process according to empirical

findings. McLellan et al. (2010) have suggested a matrix-system for evaluating requirements and to categorise the requirements and their correlation. Requirement validation, which is a component in the RM process, is another function needed in a RM tool. Thus, the tool need a function to check the requirement when it is fulfilled, and according to McLellan et al. (2010) this can be done by illustrating the requirements as e.g. *fulfilled/ not fulfilled*.

Less important functions
There are seven functions identified solely by either employees, McLellan et al. (2010), or Hoffmann et al. (2004). These functions are: *tool integration, web access, central installation and administration of projects, workflow management, formatting, multimedia and external files, prioritisation* and *search-function*. In the analysis, these functions have been identified as less important functions for a RM tool.

The function, tool integration, implies that a RM tool should be commonly integrated throughout an entire project as well as integrated into other tools. In addition, the tool should link information between different activities and thus enable traceability. The function is aligned with the aim of SRM, which is to establish a RM process that is integrated in all phases throughout the project life cycle. Another function aligned with the aim of SRM is workflow management, which enhances a structured process and standardisation of requirements. The function provides the basis for a digital database to function, and could also be connected to the countermeasures presented in Appendix C, regarding having clear boundaries for when a working step should start and end. Accordingly, it would enable the structure of completing a working step before continuing to the next step, which also would facilitate the documentation of requirements. Central installation and administration of projects is another function which provides the basis of a digital database, since it describes how information should be documented in one specific place. The fourth function is web access, enabling access to external actors, and would facilitate the work with requirements, and the collaboration between client and contractor. Formatting, multimedia and external files, describes how the RM tools should have similarly formulated expressions. This is aligned with the countermeasure, common structure, which advocates the need of a common working approach. Another function mentioned by McLellan et al. (2010) and the empirical study is the ability to prioritise requirements. According to McLellan et al. (2010), the digital tool needs to ensure that the requirements can be graded in terms of level of importance. This is supported by one respondent, who stated that it would be beneficial if Skanska, in an early stage of the project, identified the most important requirements in a database. Lastly, search-function can track requirements, which can be essential when managing the increased number of requirements. It would provide traceability, which can be connected to the function traceability.

Further investigation
The analysis has identified functions that can be considered as most important, important or less important in a RM tool. However, it is essential to always consider the employee's opinion of which function they consider as important in a RM tool, since they will apply the new way of working. This is aligned with Mansfield & Odeh (1991), who advocate the importance of involving the employees in the new tool to improve motivation. If the employees are not feeling involved, there is a risk for a negative attitude towards

SRM. Therefore, all functions that have been mentioned by the organisation should be considered as important since they have been valued by the employees. Thus, when establishing new RM tools, organisations always need to support and involve the employees to increase the opportunity for a successful change process.

Furthermore, empirical findings present that clients and contractors often have different perceptions about requirements. One potential reason is the difficulty of different standards being connected to each other, which often result in different perceptions of requirements. This problem can be overcome by establishing a database. One suggestion, mentioned by a respondent, is that the database should be designed by the client where they, already in the contract, identify and collect all requirements that should be fulfilled. By this, the collaboration between the contractor and the client will be facilitated, since the requirements are clearly defined. In addition, one important function described by Hoffmann et al. (2004), web access, also indicates how a common platform where both actors have the access, will facilitate the collaboration.

Another perspective mentioned in the empirical study is the time aspect of creating a database. One respondent stated that creating a database will take approximately one day, and that the main issue concerns the client and contractor agreeing on the definition of the requirements. In contradiction, another respondent believed that designing a database is an overwhelming task, which includes identifying, managing and validating all requirements during the entire project. The different perspectives of the time aspect for creating a database implies that the scope of the work connected to establishing a database for requirements is unclear. This issue may also concern the management of activities within SRM, making it difficult for organisations to plan the work steps. Furthermore, since a database has been identified as essential to facilitate the establishment of SRM, it is important for organisations to investigate the time aspect to creating a database. By doing that, organisations can compare the time aspect with profitability for a database.

Moreover, BIM360 is a digital tool that is used at Hisingsbron, Hamnbanan and Ängelholm-Maria and ensures that the employees have the opportunity to check, validate and document requirements when they have been fulfilled. These functions can be found in Figure 6.2. This indicates that BIM360 may have potential to continue being a RM tool in the organisation, which also is advantageous since it is already an established RM tool. However, since the analysis has identified additional functions which are not identified in BIM360, the organisation may need to complement with other RM tools.

6.4 RQ3: What is needed to support a change towards more systematic RM?

Both theoretical and empirical data have identified motivation as essential to support a change towards more systematic RM. Motivation is important in a change process towards SRM, and can, according to Phan et al. (2020), support the employees to be more effective, creative and qualitative in their work. Moreover, Marisa & Yusof (2012) stated that motivation supports achieving goals, and the empirical study emphasises that by setting understandable goals for the employees, they will be motivated to more easily

adapt to SRM.

Goal setting is a central part of motivation, and it is essential to always celebrate project achievements with rewards, so that employees within the organisation feel appreciated, and understand that their work is important. This is aligned with Mansfield & Odeh (1991), who stated the importance of an environment where the employees participate in the change process, which will result in employees feeling valued and more committed to the change. Another crucial aspect when setting goals, according to the empirical study, is that the employees should understand how to reach the goals with SRM, as well as who is responsible for reaching the goal. It is also important that the employees have the goals integrated in their daily work related to the change initiative to a relevant level (Mansfield & Odeh, 1991). This has been a difficulty for Skanska, where one respondent highlights that the organisation often sets a too high ambition level when establishing goals for a new working approach. A too high ambition level can lead to the employees reverting to old habits since the change feels overwhelming and not possible to accomplish. Therefore, organisations need to establish a stepwise change, and thus successively achieve the goal. This is aligned with Izhar et al. (2018), who define the process for managing requirements as iterative. SRM could be implemented iteratively in organisations by creating pilot projects, where the result and experiences from the employees are evaluated. The new perspectives should be managed in an iterative process, to facilitate the implementation in following projects.

The empirical study has identified that changing the employees' habits is a challenging task for organisations, which requires high involvement and time. Barg et al. (2014) and Marisa & Yusof (2012) have stated that motivation can be one factor to explain human behaviours, and according to the empirical study, one way to control the employees' behaviours is to establish organisational routines. One respondent mentions that by creating routines, organisations can motivate the employees to establish a long term change for SRM that is integrated into organisations. Routines are essential to improve the understanding about behaviours and change in an organisation (Becker et al., 2005). Both Nelson & Winter (1982) and the empirical findings point to routines as essential when creating employee motivation. Another positive aspect with routines is that organisations can ensure that the employees understand how they should perform their tasks (Nelson & Winter, 1982). Aligned with establishment of goals, the positive result generated from routines should also be presented for the employees in order to increase the understanding of the value of the new routine. Accordingly, the employees will be more motivated to continue the work with the new routine, and thus have a more positive attitude towards SRM.

Attitude and knowledge

One identified challenge when establishing SRM, is that employees have a negative attitude towards the working approach. Therefore, it is important to motivate the employees, by creating a trusting, understanding and cooperative organisational environment, in order to change the attitude (Mansfield & Odeh, 1991). Both Mansfield & Odeh (1991) and Washington & Hacker (2005) have highlighted the importance of supporting the employees in order to increase the knowledge and understanding of why the organisation should apply SRM. At present, Skanska possesses the right knowledge for establishing SRM, even though it seems that the organisation lacks understanding of the reasons for why

SRM should be established. Therefore, the organisation needs to increase information about the reasons, since the understanding can generate a more positive attitude towards the change (Washington & Hacker, 2005).

One way for organisations to increase the information about why SRM should be implemented within the organisation is to enlighten the benefits with the concept and how it would affect the daily work. Thus, it is essential for organisations to demonstrate how SRM should be established. For instance, organisations can establish meetings to discuss SRM and provide information on how SRM should be applied. The meetings should be time effective and increase interest within the concept. Another way to increase interest is by creating a new name for SRM. A new name will hopefully generate a more positive attitude of the employee who will associate the concept with something new.

Support function
One group of employees that can increase the knowledge about SRM is a support function. According to one respondent, a support function is essential to motivate the employees within SRM. Furthermore, it is essential to support the usage of SRM, and stepwise introduce the new way of working and new tools. Today, Skanska uses support functions in their major infrastructure projects, even though one respondent experienced that the organisation does not prioritise the support function sufficiently. The support functions are in need of more resources to possess the right knowledge and understanding of SRM, in order to inspire and control the employees. In addition, even though some common working approaches have been established within support functions, the organisation is in need of a common structure for all support functions in every project within the region. Currently, Skanska has, to some extent, started to find a common structure for how their support function should be designed, which has been highlighted by George (2020) as essential to facilitate the implementation of a change.

One successful factor for a support function is that the function needs to be involved during the entire project to facilitate for the employees by answering questions regarding SRM. This is aligned with Ionescua et al. (2014), who has emphasised the importance of always being involved and supporting the employees within a change. If there is a lack of support for the employees when questions arise, there is a risk that the employees lose motivation and return to old habits. By establishing routines for SRM, the assignment of the support function will be facilitated since all the employees in the organisation by habit perform SRM in projects. In addition, the routines will increase the understanding and the knowledge of how SRM should be performed, and a more positive attitude can be created towards the new way of working. Thus, motivation can be identified as a main factor to support the change towards a more systematic RM.

7
Discussion

This thesis investigated what changes are required in major infrastructure projects to establish SRM. The findings from the empirical study facilitated the identification of challenges and countermeasures for SRM. By conducting interviews with experienced employees, the thesis aimed to fill a gap in finding additional inputs of important functions for RM tools, challenges and countermeasures of SRM as well as what is needed to support SRM.

Based on the analysis, several identified challenges and countermeasures have been identified, some of which have not yet been explored in the theoretical background (negative attitude and negative reputation). These challenges have been merged to one, since they have fundamental similarities. Some of the perceived challenges and countermeasures seem to be connected, such as lack of common structure and lack of integrated process. In addition, there may be correlations between the challenges and the environmental factors, which are reasons for why SRM should be established.

Client power and economical conditions are two environmental factors which have resulted in a need for SRM. Due to increased number of requirements, the pressure and demand from the client has increased. Thus, the client set the conditions for the project, which is formulated in terms of requirements (Jallow et al., 2014). Another consequence of the increased number of requirements is that the contractor and client have different perceptions about requirements (Jallow et al., 2014). Therefore, Yu & Shen (2013) advocate the importance of having specified and clearly defined requirements for all actors, to attain a common understanding. One solution to overcome the challenge is to identify and prioritise RM in an early phase. Increased number of requirements may therefore be a main challenge to consider. In addition, establishing SRM will minimise the cost for the projects in terms of preventing mistakes before they have occurred. Considering these two environmental factors, and creating a strategy for establishing a well-performed SRM process will hopefully increase client satisfaction.

One potential cause for an inadequate established SRM is lack of common structure. George (2020) has identified that structure is especially important when establishing a new process. A common structure would provide a basis for how the organisation should use SRM and RM tools. Currently, there is no integrated system for RM in the studied organisation, and there is no common structure for how to apply SRM, even though there are similarities in working approaches and methods at the studied projects. One important task for the manager is to support the employees and provide the right tools for the change (Ionescua et al., 2014). Providing the right tools is not achieved by the managers today, since the organisation lacks a common tool for RM that is integrated throughout the entire projects. Hence, it is essential to provide sufficient and right resources to es-

tablish SRM. Another challenge is that the employees at the studied organisation do not understand the actual meaning of SRM. Therefore, there is a need to define what SRM is for the organisation.

IT, management, people and structure are factors which have been identified in the theoretical framework to possibly affect SRM. The study has identified that these factors are correlated to each other and do have an impact on SRM. Accordingly, these factors are important to consider since they both can aid organisations to overcome the identified challenges as well as impact the outcome, in terms of client satisfaction, see Figure 7.1. The thesis also indicates that environmental factors and identified challenges are connected, since they both are reasons for why SRM should be implemented. Without the challenges, there would not be a need for SRM, and thus the change process would not be required. The identified main challenge, increased number of requirements, is a main reason for SRM being established, and is therefore positioned under organisational context in the figure, together with the environmental factors. In addition, motivation has been identified as a main factor to support the change towards SRM.

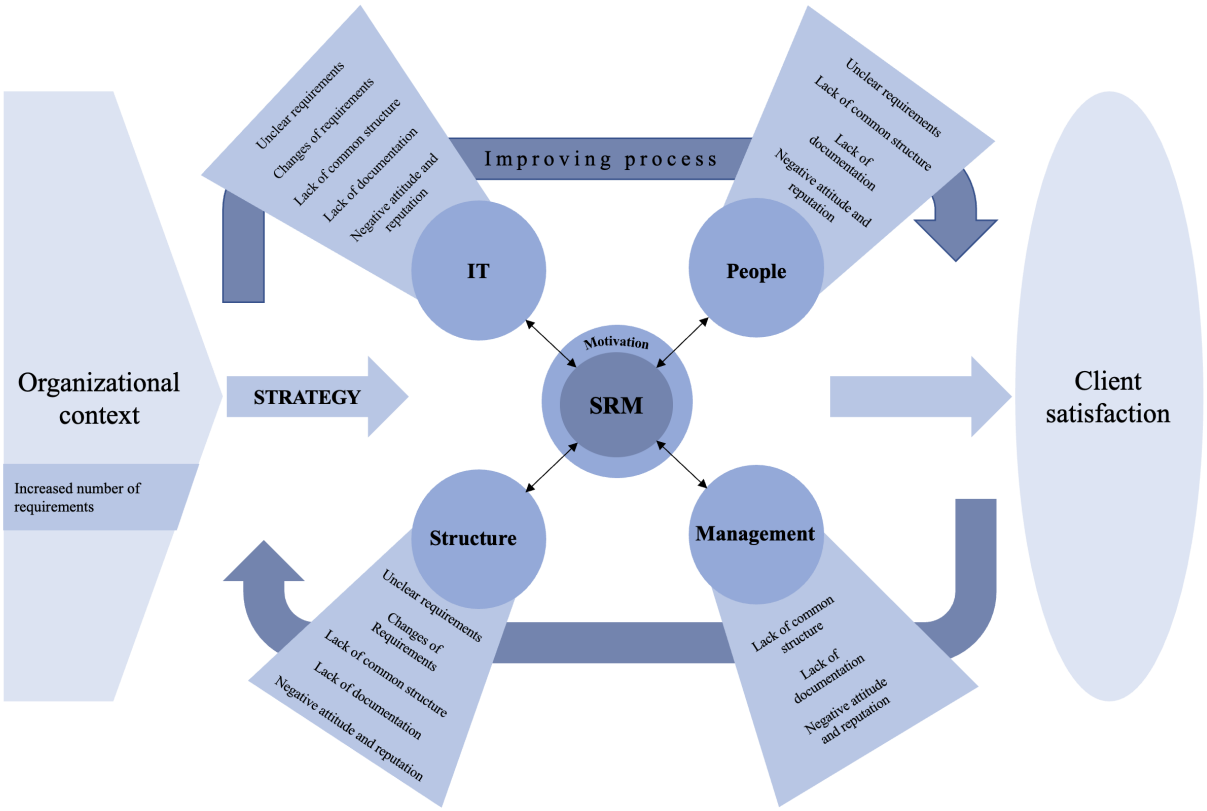

Figure 7.1: The identified challenges in relation to IT, people, management and structure.

7.1 RM tools

RM tools have been identified in the thesis as essential when establishing SRM, where BIM360 has been considered as a main tool for the studied organisation. Identify and compile requirements is a fundamental function for an RM tool, which is not a function

for BIM360. Therefore, the organisation may consider other RM tools to complement BIM360 to facilitate SRM. One digital tool that includes this function is a database for requirements. A database is also seen as beneficial by the studied organisation. Thus, one suggestion is to use an equivalent or correlative digital RM tool to complement BIM360. The employees' opinions are important when establishing new RM tools, and therefore the functions traceability, specified work role, time aspect, technical advance, categorisation and document validated requirements are additional functions, which have been considered by both theory and empirical study. By considering the employees opinions, the organisation can create a more positive attitude towards SRM. Therefore, search-function also needs to be considered as important function since it has been mentioned in the empirical study. As it is the people who in the end apply SRM, their opinions are of high value for a successful establishment.

Even though several employees are positive towards RM tools, the result indicates that there are some employees who are sceptical about implementing new tools. Therefore, it is essential, according to Sushil & Agnihotri (1999), to ensure that the people, at all levels in an organisation, accept the change. One reason is that a new digital tool would imply adjusting to new working methods. Another potential reason for why employees are sceptical is the behaviour to only focusing on the executing of the work, instead of prioritising time to learn new tools.

7.2 Motivation

One main identified factor that is needed to support a change towards a more systematic RM is to increase motivation. There are many different approaches to motivate employees, especially, organisations should focus on creating a positive attitude, improving the understanding of SRM and establishing organisational routines. Motivation can be used to support employees in their work (Phan et al., 2020), as well as to inform how the requirements should be achieved. The people have the power to decide if they will apply SRM and RM tools. Therefore, the managers have an essential role in motivating the employees and facilitate the understanding of how to apply SRM (Marisa & Yusof, 2012). To motivate the employees they need to be controlled, praised and rewarded. One approach for how the managers should motivate the employees, is to set up goals and later show appreciation and celebrate success when the goals are achieved. Consequently, this thesis believes that goal setting has the potential to increase both the managers' and employees' understanding as well as interest for SRM, and thus increase the motivation.

It is of high importance that the organisation establish a positive attitude towards SRM to increase motivation. One factor to consider to improve the attitude towards SRM, is, according to the empirical study, to change the current mindset regarding planning. Currently, there is no habit of planning among the employees, only a behaviour of solving a problem once it occurs. The empirical study also describes that this habit is connected to managers' role of only praising employees when they solve a problem and not for preventing it from happening. If the employees are not supported correctly in their application, they will not be motivated to apply SRM. A support function has been identified as essential to support the employees during the entire project within SRM, and thus increase the motivation.

Another approach to change the current mindset of SRM, is to provide understanding of the reasons why SRM should be established (Washington & Hacker, 2005). According to the empirical study, it is essential that the employees understand the value of the new working method, since it increases motivation. In addition, the mindset of SRM can be improved by establishing routines (Wolthuis et al., 2022). By having clear routines and right knowledge, the employees can more easily understand how SRM should be applied, and thus, the motivation and attitude towards SRM can be improved.

Establishing organisational routines within SRM should be considered already in an early project phase to facilitate the motivation of employees. The routines need to be formulated for a specific purpose and organisation level. Routines within SRM would contribute to a more common understanding of how to apply SRM in organisations and affect the correlated interaction between employees. Establishing routines also improves the motivation of employees (Nelson & Winter, 1982), since routines can be used to control them (Kozlowski & Ilgen, 2006). For instance, the managers need to control the employees in their work with documentation, since the employees easily regress to old habits if they are not controlled.

The management system within the studied organisation is based on routines for how the organisation should work. It seems to be unclear whether the employees are using the information described in the management system, where reasons could be due to personality and experiences. Some people are not interested in reading about routines or updates in a management system, and thus the information should be communicated in a new way. Therefore, the managers have an essential role to communicate SRM in an understandable way (Marisa & Yusof, 2012). Since all employees are not interested in reading text, the managers may consider other communication methods, such as verbally, where one example is to share knowledge - and information through a podcast. Another approach to increase the interest and usage of a management system is to implement regular meetings with the employees to inform about updates and working methods mentioned in the management system. By using this type of meetings, the interest will increase and hopefully generate a more positive attitude towards SRM. Ionescua et al. (2014), have stated that one important manager skill is to inform about SRM by communicating with the employees, which can be achieved by applying these regular meetings to SRM.

7.3 Future research

SRM is a complex subject which results in a tremendous study. In addition, the subject needs to be prioritised in major infrastructure projects caused by the increased number of requirements, which have resulted in a need of managing requirements systematically. To narrow the scope of the study, this thesis mainly has focused on which changes are required to establish SRM, generating in increased project success, and thus client satisfaction. Due to the complex subject, other changes will probably be required, outside the scope of the research questions.

Additionally, the study has identified that SRM should be an integrated process through-

out an entire project. The study has determined that it is essential to extend the collaboration within SRM between the project phases in an early stage. Therefore, future studies could focus on how to increase the collaboration within SRM. The study has also identified the challenges for major infrastructure projects to understand and manage the requirements from the client, resulting in unnecessary mistakes and faults. Therefore, future research could investigate how the collaboration between the client and the contractor should be performed in an early stage within SRM. In addition, this study has considered IT, management, people and structure as factors that affect the SRM process. Thus, future research may identify additional factors that can affect the process.

A wide array of functions that are needed in a digital RM tool exist, and an interesting area for further research would be to explore which type of RM tool that should be used to facilitate SRM. Furthermore, the thesis has identified six main challenges of SRM and their countermeasures. However, further research could investigate additional challenges and correlated countermeasures that may exist.

In addition, this thesis is based on only one case company, including interviews from three major infrastructure projects. Hence, future studies may consider other companies and projects when evaluating what changes are required for SRM. This thesis has aimed to take a first, small step, in order to identify potential changes that are required in an organisation, which utilise the establishment of SRM for project success. However, in order to gain an expanded and more detailed perspective, more research is needed.

8

Conclusion

SRM is essential to prevent mistakes and faults in major infrastructure projects. By prioritising time and resources to identify the requirements in an early stage will facilitate SRM, and hence result in client satisfaction. In order for an organisation to increase their work with SRM, three research questions have been investigated to identify what needs to be changed when establishing SRM.

Firstly, the four components within an RM plan have been investigated: *requirements elicitation procedure, role and corresponding responsibility, tools* and *approval*. By combining the RM plan with the RM process, there are some areas that need to be considered by organisations to achieve a successful establishment of SRM. The study presents that organisations need to identify the most important requirements in an early stage to facilitate the documentation. Organisations also need to distribute roles and corresponding responsibility for requirements and make sure that the meaning of the responsibility is clearly defined. Furthermore, RM tools are important to facilitate SRM, therefore organisations should ensure that the employees have the right RM tools, which also need to be integrated in the entire organisation within all project phases. The study has identified that to increase SRM, the collaboration between design and production needs to be extended, which is essential to achieve an integrated RM process, and thus SRM. In addition, organisations also need to appoint a role that is responsible for the management of requirements.

Secondly, the study has identified that the challenges are reasons for establishing SRM, where one of the main challenges is the increased number of requirements. One successful factor for an organisation to apply SRM, is to manage all the identified challenges already in an early stage to facilitate the understanding and identification of requirements. Unclear requirements can be overcome by formulating clear and detailed requirements which are commonly perceived by all actors. The contractor and the client should establish a common plan, and enable lock for changes before the design phase. However, if there are prerequisites for requirement changes, an approval process is required. In addition, a common structure and definition is fundamental to establish SRM in order to increase the understanding. By increasing the understanding, the motivation toward SRM can be improved.

The study also indicates that RM tools are necessary when establishing SRM. Therefore, the most important functions in an RM tool have been identified: *access restrictions, visuality, identify and compile requirements* and *document validated requirements*. To motivate people to use the RM tools, the functions: *traceability, specified work role, time aspects, technical advance, categorisation, validate and check requirements* and *search-function* have also been considered as important, as they have been identified as essential

by the employees in the studied organisation. Hence, it is important to consider the employees' opinions when establishing new RM tools to create a positive attitude towards the new way of working. Some of the identified functions can be found in BIM360, even if there are some countermeasures. Therefore, BIM360 needs to either be developed or complemented with other RM tools, such as a database.

Thirdly, the study has indicated that one main approach to support a change towards more systematic RM is to create employee motivation. Motivation can be achieved by setting clear goals, creating organisational routines as well as increasing the attitude and knowledge of SRM. To minimise the risk for employees to regress to old habits within RM, one way is to establish clear goals for SRM. By establishing clear goals, the employees understand what should be achieved within SRM. Additionally, it is important to celebrate success and show appreciation when the goals are achieved to create a more positive attitude towards SRM. Furthermore, organisations also need to establish organisational routines in an early stage of the project to facilitate the understanding of how SRM should be performed to improve motivation. It is also important that the employees understand why SRM should be applied to create a positive attitude, and thus generate motivated employees. Organisations need to supply and prioritise support functions, which needs to be involved during the entire project to aid the employees within SRM. All these criteria are essential to increase employee motivation.

IT, people, management and *structure* are four factors that affect the SRM process, and the study has specified that these factors are correlated. In addition, the identified challenges, together with environmental factors, can be connected to the reasons why these four factors and SRM are needed. To establish SRM, a common organisational structure is required, including clear working approaches, routines and digital RM tools. The management has a central role to implement and maintain a structure, including establishing RM tools and facilitating the applicability and understanding of how the employees should use SRM. In addition, a skilled management will contribute to motivate people to understand the reasons why establishing SRM and its RM tools. To motivate the employees, it is essential to create a positive attitude, improving the understanding of SRM and establishing organisational routines. Hence, all four factors are essential when establishing an integrated process for SRM throughout all project phases, and thus achieve client satisfaction. Accordingly, the thesis has facilitated the understanding of the reasons for why SRM should be applied within organisations, but also how organisations can establish SRM.

In conclusion, when establishing SRM it is essential that organisations, in an early stage, prioritises resources to create a common structure for how organisations should work with SRM and its RM tools. In addition, the management need to motivate all people, and facilitate the understanding for how SRM should be applied, in order to have an integrated RM process throughout an entire project. Accordingly, the study provides essential factors that need to be considered when establishing SRM in major infrastructure projects: these factors have been identified as changes which generate qualitative and successful projects.

9
Recommendations

The study has identified that challenges combined with the four factors, IT, people, management and structure need to be considered to facilitate SRM. Based on the identified challenges and the four factors, the following recommendations for organisations within major infrastructure projects have been formulated.

A short term recommendation is to create a common structure for SRM within the entire organisation. The common structure should include a clear definition of SRM, a proper RM process and common working approaches, routines and RM tools, which would facilitate the understanding of how SRM should be applied. In addition, organisations need to communicate the purpose of SRM and the reasons for why SRM should be applied to increase the employee's knowledge. Moreover, organisations and their management always need to motivate and support the employees in the establishment of SRM to create a positive attitude. If the employees are not motivated, they will not understand why and how SRM and the RM tools should be applied. Therefore, the following short term recommendations have been formulated to motivate the employees within SRM and avoid the risk of reverting to old habits (see Figure 9.1).

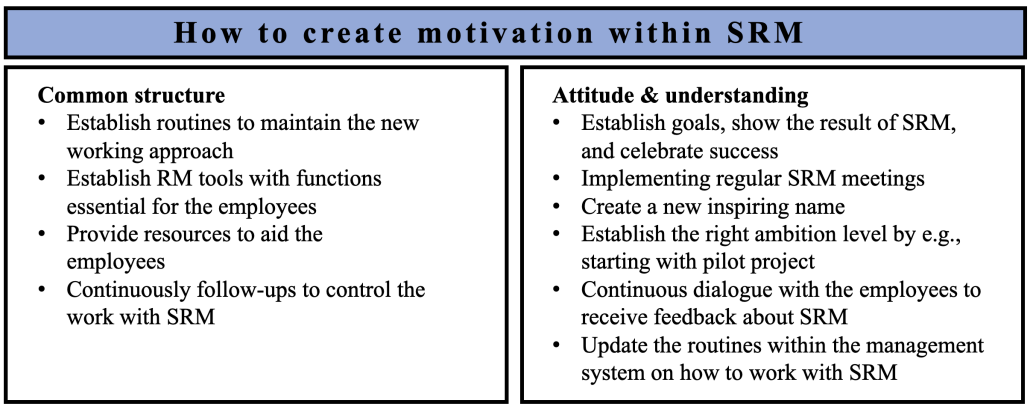

Figure 9.1: Short term recommendations for organisations to motivate employees.

A long term recommendation is to address SRM as an improving process, which is affected by IT, people, management and structure. Thus, it is important to both consider the input and the output, in terms of environmental factors, challenges, factors to extend SRM and client satisfaction, when establishing SRM. In addition, the process for SRM should be iterative where organisations need to be eager to gain new perspectives about the concept and adapt to new changes that may occur within the input and output to always improve SRM.

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Appendix A

Template for interview questions

Before the interview starts, the respondents are informed about the aim of the study and asked for permission to record the interviews.

General questions

1. Background about the respondent
    a. Role and current project

Requirements management (RM)

1. Usage of RM in daily work
    a. Differences within RM today, compared to a few years ago
2. Most difficult/easiest project phase to work with requirements
3. The current RM at specific projects, including:
    a. Working approach
    b. Current process
    c. Routines
    d. RM tools
    e. Following-up questions to investigate if a-d are systematically performed, including benefits and challenges with systematic requirements management within the asked areas
4. Usage of the management system
5. Challenges in RM within the projects
6. Changes of requirement from the client during the project
    a. The current requirements change process
7. Applicability of requirements
    a. Clarity in the formulation of requirements
8. Clarity of the responsibility concerning requirements and corresponding role

Opportunities within systematic requirements management (SRM)

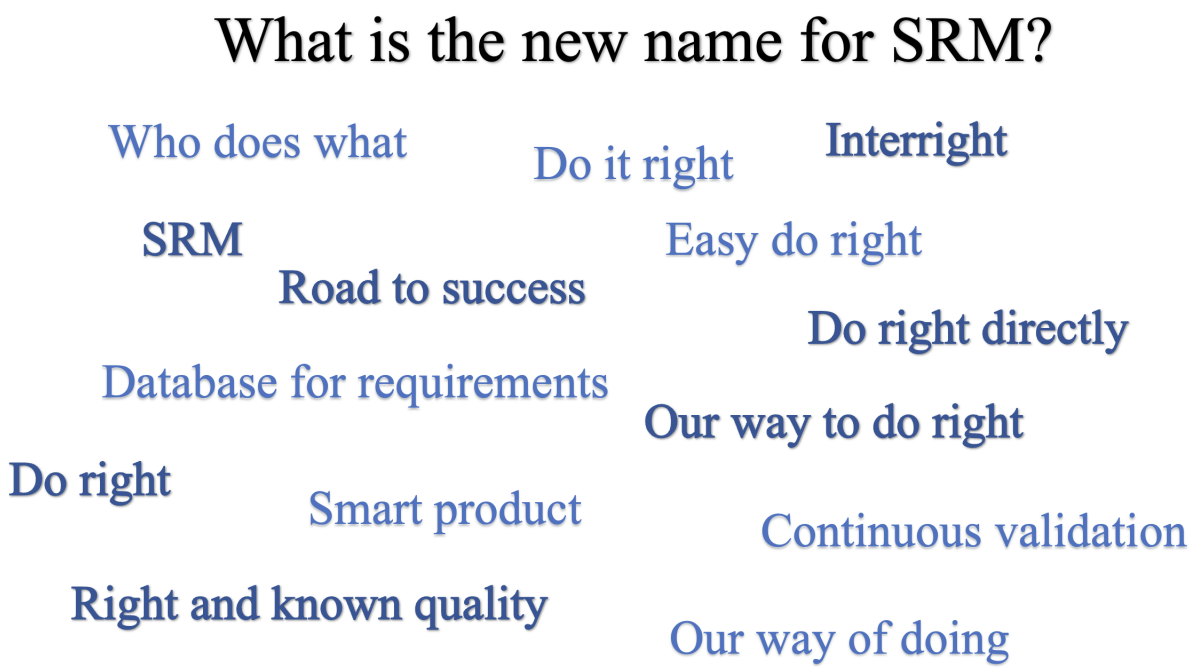
1. Current benefits with SRM and what should be preserved
2. Required changes
3. Current knowledge and required competencies
4. Most challenging requirements
5. The need to identify important requirements in the design phase

Others

1. Opportunity to add additional perspectives

Appendix B

New name for systematic requirements management



Appendix C

Identified challenges and countermeasures

Challenges	Countermeasures Empirical findings	Countermeasures Literature
Increased number of requirements	**Early stage** • Establish SRM to ensure that all requirements are identified and later verified • Identify all requirements in the tender phase • Provide more resources in the design phase to interpret requirements, and then define the requirements in the construction document **Knowledge** • Ensure that the contractor understand the clients' requirements and its focus areas • The job description needs to include the specific requirements that are applied for respectively working step • Increase the knowledge about inspection program and its design	
Unclear requirements	**Specification** • The client should specify the requirements in the tender document, and the requirements should be adapted to a specific project • Identify the requirements in detail • Ensure that the requirements can be measurable • The design management needs to establish detailed and clear ITP templates to facilitate for the production **Prioritisation** • The work with RM should be prioritised, in term of resources and time, when identifying and formulating the requirement • Increase the collaboration in an early stage between the design and production when identifying the requirements **Knowledge** • Ensure that the client and the contractor understand the requirements, and are agreed, in an early stage of the project • Ask possibly questions about requirements before signing the contract • Ensure that the in-house-design/consultant have the right knowledge within both design and production	• Prioritise to work with the requirements when gathering, organising, and checking them **Specification** • Requirements need to be specified and communicated clearly • Create a clear definition of requirements • Create a common language **Knowledge** • Increase the understanding of the actual meaning of requirements
Changes of requirements	• Lock changes of requirements from the client when the contractor has started their design phase • Minimise the risk for changes of requirement, by establish a common plan in an early stage of the project between the client and the contractor to ensure clients satisfaction • Increase time and resources in an early stage to establish better construction documents, and ensure that the requirements are managed during the entire project	**System for changes** • Establish a process for requirements changes • Before a requirement changes, it must be approved in an approval process **Documentation** • Ensure that requirements are well documented, updated, and traceable • In an early stage, document, and store requirements in a central repository

Challenges	Countermeasures Empirical findings	Countermeasures Literature
Lack of common structure	**Knowledge** • Ensure that the employees understand the aim of SRM and its meaning • Establish a common definition of SRM **Structure** • Establish common processes, tools, and routines for SRM that will be used in the entire project • Establish a better structure and coordination of requirements in an early stage of the project • Establish a clear structure, where the managers control and show interest for the employees in their work with SRM **Early stage** • Increase the collaboration between design and production where they establish a common plan in an early stage • Prioritise the work with SRM, i.e., in the time plan and resources	
		• Ensure that the requirements are fulfilled before continuing to the next project phase • Ensure that the requirements are updated throughout the entire project • Establish an integrated system where RM is correlated with all activates in every project phase
Lack of documentation		• Ensure that the most important requirements are identified for a specific project **Documentation** • Establish standardised documentation of requirements • Ensure that the client reads all type of documentation • Document and update changes in requirements
	• Establish clear start and end between different working steps to improve the documentation • Establish systematic completion	
Negative attitude and reputation	• Define a new name for SRM • Present SRM in a new and interesting way to motivate employees • Increase the conversation about SRM in organisations	
	Knowledge • Increase the employees understanding about SRM, and the reason to adapt **Motivation** • Establish goals • Analyse deviations e.g., in terms of costs • Change the mindset of the employees regarding planning • Ensure that employees have the right tools to work with SRM	

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
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