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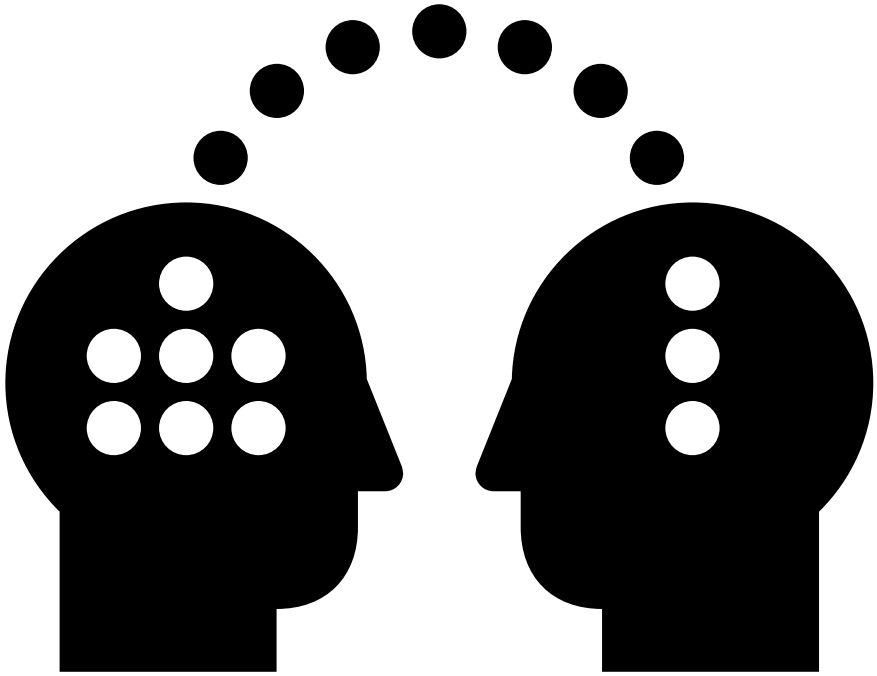

Knowledge Transfer for Handovers of Complex Infrastructure Projects

Master's thesis in Design and Construction Project Management

MADELEINE JOHANSSON

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS

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Report no. E2022:139
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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MADELEINE JOHANSSON

Department of Technology Management and Economics
Chalmers University of Technology

ABSTRACT

The handover process is an important process at the end of a project and implies next to the delivery of the product, the handover of documentation, guidelines as well as knowledge. The transfer of knowledge in the handover process is a challenge in ordinary construction projects but becomes even more challenging in complex infrastructure projects. The size and complexity of these projects, result in a large amount of documentation that is managed and transferred from the project to the receiving organizations. Moreover, construction knowledge is often tacit, which is retained by the individuals and organizations involved in the construction project, and finally is lost once the project is completed.

Not much has been published about the handover process in relation to knowledge transfer. In project management literature, there are publications about the close-out phase in construction projects, which is the last phase in the project lifecycle. However, there has rarely been anything published about how complex infrastructure projects should be handed over in relation to knowledge transfer. Therefore, this topic is relevant to be studied.

The purpose of the thesis is to investigate how knowledge is managed, stored and transferred from the project to the receiving organizations. The thesis aims to map challenges related to knowledge transfer for handovers, and to produce improvement proposals that the Swedish Transport Administration (STA) and other public clients can benefit from.

The aim of the thesis was fulfilled through a qualitative research approach by conducting 18 semi-structured interviews with representatives from STA with experiences of handovers of complex infrastructure projects. Moreover, a literature study was conducted to map the current practices, opportunities, and challenges with knowledge transfer for handovers of complex infrastructure projects. Further, different applied and conceptual models for learning and knowledge transfer were investigated.

The results showed that the main challenges are organizational and communication challenges in the handover process. Further, the findings show that explicit knowledge is handled relatively well in the process, but that tacit knowledge is more difficult and has challenges. Furthermore, the main possible improvements that were identified are maintaining competence from the project to the receiving organizations, by changing the organizational structure and conducting education. Finally, this thesis has created a foundation for further research of knowledge transfer for project handovers, and especially of complex infrastructure projects.

Key words: Knowledge management, knowledge transfer, explicit knowledge, tacit knowledge, project handover, project close-out, complex infrastructure projects, construction.

Kunskapsöverföring vid överlämnande av komplexa infrastrukturprojekt

MADELEINE JOHANSSON

Institutionen för teknikens ekonomi och organisation
Chalmers tekniska högskola

SAMMANFATTNING

Överlämningsprocessen är en viktig process i slutet av ett projekt och innebär utöver leveransen av produkten, överlämnande av dokumentation, riktlinjer och kunskap. Kunskapsöverföringen i överlämningsprocessen är en utmaning i vanliga byggprojekt, men blir ännu mer utmanande i komplexa infrastrukturprojekt. Storleken och komplexiteten på dessa projekt resulterar i en stor mängd dokumentation som hanteras och överförs från projektet till mottagande organisationer. Dessutom är kunskapen inom byggsektorn ofta tyst, som besitts av individer och organisationer som är involverade i byggprojektet, samt går förlorad när projektet är klart.

Det har inte publicerats mycket litteratur om överlämningsprocessen i relation till kunskapsöverföring. I projektledningslitteratur finns publikationer om avslutningsfasen i byggprojekt, som är den sista fasen i projektets livscykel. Det har dock knappt publicerats något om hur komplexa infrastrukturprojekt ska lämnas över i förhållande till kunskapsöverföring. Därmed är detta ämne relevant att studera.

Syftet med examensarbetet är att undersöka hur kunskap hanteras, lagras och överförs från projektet till mottagande organisationer. Examenarbetets mål är att kartlägga utmaningar relaterade till kunskapsöverföring vid överlämnande, samt att ta fram förbättringsförslag som Trafikverket och andra offentliga beställare kan dra nytta av.

Målet med examensarbetet uppfylldes genom en kvalitativ forskningsmetod genom att utföra 18 semistrukturerade intervjuer med representanter från Trafikverket med erfarenheter av överlämnande av komplexa infrastrukturprojekt. Vidare genomfördes en litteraturstudie för att kartlägga nuvarande praxis, möjligheter och utmaningar med kunskapsöverföring vid överlämnande av komplexa infrastrukturprojekt. Vidare undersöktes olika tillämpade och konceptuella modeller för lärande och kunskapsöverföring.

Resultaten visade att de främsta utmaningarna är organisatoriska och kommunikationsmässiga utmaningar i överlämningsprocessen. Vidare visar resultaten att explicit kunskap hanteras relativt väl i processen, men att tyst kunskap är svårare och har utmaningar. De viktigaste tänkbara förbättringarna som identifierades är att upprätthålla kompetensen från projektet till mottagande organisationer, genom att förändra organisationsstrukturen och genomföra utbildningar. Slutligen har examensarbetet skapat en grund för vidare forskning om kunskapsöverföring vid projektöverlämnande, framför allt av komplexa infrastrukturprojekt.

Nyckelord: Kunskapshantering, kunskapsöverföring, explicit kunskap, tyst kunskap, projektöverlämning, projektavslut, komplexa infrastrukturprojekt, konstruktion.

Contents

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First of all, I would like to thank my supervisor and examiner Petra Bosch-Sijtsema for all guidance and support throughout the master's thesis. Thanks to my supervisors Per Kärrdin and Emma Sturk at the Swedish Transport Administration for all reconciliation and feedback.

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Madeleine Johansson, Gothenburg, December 2022

List of abbreviations

GDPR	General Data Protection Regulation
ICT	Information and Communications Technology
SECI	Socialization, Externalization, Combination and Internalization
STA	The Swedish Transport Administration
TDOK	The Swedish Transport Administration's documents

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1 Introduction

This chapter presents a problem description of the master's thesis. Furthermore, the thesis purpose and aim, research questions and limitations will be described.

1.1 Problem description

A handover includes handing over responsibilities, facilities and management data from a project to the operation and maintenance (Trafikverket, 2021a; Trafikverket, 2021b). The handover process is a challenge in construction projects, but becomes even more challenging in complex infrastructure projects, since they are much larger and usually are built in several sub-projects, which results in a large amount of documentation.

Organizational knowledge is created through a continuous dialogue between explicit and tacit knowledge (Nonaka, 1994). However, construction knowledge is often tacit, which is retained by the individuals and organizations, and finally is lost once the project is completed (Nesan, 2012). There exist different models for learning and knowledge transfer, however, these models are quite general (Nonaka & Takeuchi, 1995; Prencipe and Tell, 2001; Szulanski, 1996).

Knowledge management is used to facilitate a structured approach to learn from construction projects and to find ways to share and reuse knowledge (Addis, 2016). Despite the interest and the effort many companies put into knowledge management, there are still limitations for the handover process (Nesan, 2012). Some of the reasons for why the limitations exist are that people responsible for collecting and archiving project data do not understand the specific needs of those who will use them (Koskinen & Ajmal, 2008; Nesan, 2012). Another reason is that the project-related data is captured and archived at the end of the construction stage, when the people who have knowledge about the project most likely have left for another project, which leads to that their experiences are not distributed (Koskinen & Ajmal, 2008; Nesan, 2012). Further, existing policies and procedures can limit how lessons learned are captured and transferred back to other projects (Fahri et al., 2007; Nesan, 2012). According to Nesan (2012) the above limitations hinder the sharing of tacit knowledge among individuals and organizations in the construction industry.

Not much has been published about the handover process in relation to knowledge transfer. In project management literature, there are publications about the close-out phase in construction projects, which is the last phase in the project lifecycle. However, there has rarely been anything published about how complex infrastructure projects should be handed over in relation to knowledge transfer. Therefore, this topic is relevant to be studied.

However, literature about megaprojects can be found, which handles the complexity in large projects, i.e., size, construction length, technical complexity, geographical area,

and a large number of different organizations. When projects become more complex, both technical and social, they may be classified as megaprojects (Flyvbjerg, 2014; Kardes et al., 2013). A road or a railway facility which contains a large number of technical installations and/or has a high traffic load is defined as a complex facility (Trafikverket, 2019a). Megaprojects are often infrastructure and are almost always perceived as complex projects. Therefore, this study examines literature related to megaprojects, which provides insight in the handover process.

1.2 Purpose and aim

The master's thesis focuses on Knowledge Transfer in Handovers of Complex Infrastructure Projects. The work will discuss knowledge transfer in the handover process, particularly in the context of maintaining operational and tunnel safety, as well as requirements for routines and working methods.

The purpose of the thesis is to investigate how knowledge is managed, stored and transferred from the project to the receiving organizations. This will be described in a current situation analysis with identified challenges from ongoing and previous completed complex infrastructure projects.

The aim of the thesis is to map challenges related to knowledge transfer for handovers, and to produce improvement proposals that the Swedish Transport Administration (STA) and other clients can benefit from. The thesis will create a foundation for further research of knowledge transfer for project handovers, and especially of complex infrastructure projects.

1.3 Research questions

Three research questions are investigated in order to accomplish the aim with the master's thesis:

- What challenges are there with handovers of complex infrastructure projects?
- How do projects manage knowledge related to handover?
- How can the handover process be improved?

1.4 Limitations

The master's thesis project represents 30 credits and will be carried out during one semester, thus some limitations on the scope of the project is necessary. Due to the great variety of complex infrastructure projects, the work will primarily concern railway projects and road tunnel projects with one single public client in Sweden. Moreover,

the work examines how complex infrastructure projects should be handed over to the receiving organizations in relation to knowledge transfer. Further, this study investigates possible improvements of the handover process, but does not delve into change management and the process for how these possible improvements should be carried out.

2 Literature study

The literature study consists of two main parts. The first one, discussing the literature on Knowledge Management, which includes a brief introduction to the large field of theoretical approaches of knowledge management, followed by knowledge-based view, explicit and tacit knowledge, and different applied and conceptual models for learning and knowledge transfer. These models are quite general, but there are adaptations (Nonaka & Takeuchi, 1995; Prencipe & Tell, 2001; Szulanski, 1996).

The second part discusses how the literature suggest that handovers should be performed in order to have a successful project handover. The literature study was conducted to map the current practices, opportunities, and challenges with knowledge transfer for handovers of complex infrastructure projects.

2.1 Knowledge Management

In the middle of the 1980s, individuals and organizations started to appreciate the crucial part of knowledge in the emerging competitive environment (Wiig, 1997). Grant (1996) states that developing a knowledge-based theory of the firm raises the question: *What is knowledge?* Grant (1996) believes there are many types of knowledge that are relevant for the firm, e.g., tacit and explicit knowledge. Additionally, Nonaka (1994) underlines the conversion of tacit knowledge to explicit knowledge and vice versa, which is further explained in Chapter 2.1.2 and Chapter 2.1.3.

Knowledge-based theory of the firm is based on the assumption that the main source of value is knowledge (Grant, 1996). According to Addis (2016), knowledge management is used to facilitate a structured approach to learn from construction projects and to find ways to share and reuse this knowledge. Therefore, an appropriate method needs to be used to be able to extract the greatest benefits from knowledge management (Addis, 2016).

2.1.1 Knowledge-based view

According to Grant (1996), knowledge-based view represents a confluence of long-established interests in uncertainty and information with several streams concerning the role of knowledge within the firm. Moreover, the knowledge-based view focuses on knowledge as being the most strategically and important thing of the firm's resources (Grant, 1996). Additionally, Barney (1986) identifies the transferability (not only between firms but more critically within the firm) of the firm's resources and capabilities, as a key factor in determining a firm's success.

According to Grant (1996), the resource-based view of the firm is an attempt to explain and predict why some firms are able to create a more competitive advantage than others. The resource-based view identifies the firm as a set of resources and capabilities, where

the primary task of management is to use resources and capabilities in order to maximize value and ensure and develop the firm's resource base for the future (Grant, 1996). However, the knowledge-based view addresses some crucial concerns of the theory of the firm, especially the organizational structure, the organization's capability, the role of management, and coordination within the firm (Grant, 1996).

According to Simon (1991) and Grant (1996), learning and knowledge takes place within the individual, as well as knowledge creation is an individual activity, while the organization mainly uses knowledge application rather than knowledge creation. Even Nonaka (1994) argues that new knowledge is developed by individuals, however, the organizations have a crucial part in articulating and developing that knowledge. Addis (2016) mention that it is possible to separate knowledge from individuals or groups which possess it, where the process of managing knowledge is considered as the extraction of knowledge from this group.

However, more importantly is the desire to understand the organizational process through which firms access and utilize the knowledge possessed by their members (Grant, 1996). According to Simon (1991), an organization learns in two ways, by either learning from its members or by acquiring new members who can provide knowledge which is new to the organization. Moreover, Håkanson (2010) mention that the possession and accumulation of knowledge, competences, and capabilities are fundamental characteristics of firms. Further, the knowledge-based approach to the theory of the firm is that the existence of firms is the result of their ability to manage knowledge, particularly in its tacit forms (Håkanson, 2010).

2.1.2 Explicit and tacit knowledge

According to Nonaka (1994) one aspect of the knowledge creation process can be drawn from a distinction between two types of knowledge: explicit knowledge and tacit knowledge. Further, organizational knowledge is created through a continuous dialogue between explicit and tacit knowledge (Nonaka, 1994). Nonaka (1994) mention that an organization that approaches a changing environment not only need to process information efficiently but also need to create information and knowledge.

According to Nonaka (1994), explicit knowledge is knowledge which is transmittable in formal, systematic language. Grant (1996) states that explicit knowledge is revealed by its communication, while tacit knowledge is revealed through its application. Tacit knowledge is complex since it has a personal quality that is deeply rooted in an individual's action, commitment, skills, intuition or involvement in a specific context, which makes it hard to formalize and communicate (Addis, 2016; Nonaka, 1994; Wang & Yang, 2015). Addis (2016) and Argote and Ingram (2000) state that tacit knowledge is hard to articulate, likewise Nesan (2012) claims tacit knowledge is bound to personal experiences, values, beliefs and body language which cannot be easily passed on to others.

Further, Wang and Yang (2015) believe that tacit knowledge is influenced by the individual's ideal, value, or emotion. According to Addis (2016), it is crucial to realize that tacit knowledge itself is not problematic, but rather that it is important to acknowledge that tacit knowledge exists by articulating the nature of it. However, Kogut and Zander (1992) mention that if tacit knowledge cannot be codified and only can be observed through its application and acquired through practice, its transfer between people is slow, costly and uncertain. On the other hand, if the knowledge can be codified and controlled, this can raise organizational performance (Addis, 2016).

2.1.2.1 How projects manage knowledge

Tacit knowledge can be acquired through education, training and experience (Addis, 2016). In construction projects, the employees can possess tacit knowledge when there is lack of documentation and motivations for decisions, but tacit knowledge can also be reused within the organization or when the employees start working in another project (Addis, 2016; Meloni & Villa, 2007). Nesan (2012) discusses how construction knowledge often is tacit knowledge, which is retained by the individuals and organizations, and finally is lost once the project is completed. According to Meloni and Villa (2007), both categories of knowledge are crucial to be able to create and foster knowledge within any organization.

According to Nonaka (1994) knowledge that can be expressed in words and numbers only represents the tip of the iceberg of the possible knowledge. If project managers would uncover the tacit knowledge which is hidden in their projects, they would be able to use the found knowledge to improve the performance of their project (Meloni & Villa, 2007). Furthermore, project managers will enhance their personal competences, expertise, become more open-minded and have the capability to "expect the unexpected" (Meloni & Villa, 2007).

Even though the importance of knowledge in management is discussed, relatively little attention has been paid to how knowledge is created and how the knowledge creation process can be managed (Nonaka, 1994). According to Nonaka (1994) an organization cannot create knowledge without individuals. Further, the organization supports creative individuals or provides a context for such individuals to create knowledge (Nonaka, 1994). Meloni and Villa (2007) state that explicit knowledge is dominating in Project Management, while tacit knowledge still has not been adequately recognized. Even though tacit knowledge remains unmanaged, it is still handled in diverse ways in order to achieve success in projects (Meloni & Villa, 2007).

According to Addis (2016), knowledge is generated throughout the whole construction project and can be captured, shared, and reused by first being codified and later used to, for instance, update documentation. Moreover, Addis (2016) believes that tacit knowledge plays an important role in construction practice since it by codification methods is used for converting tacit knowledge into explicit knowledge. However, the

experiences of construction professionals are based on a balance between explicit and tacit knowledge throughout the different phases of a construction project (Addis, 2016). Additionally, the main codification method that is used according to Addis (2016) is the SECI model by Nonaka and Takeuchi (1995). This is further explained in Chapter 2.1.3, and in particular Section 2.1.3.2.

2.1.2.2 Knowing how and knowing that

Tacit knowledge that is of great importance within the construction industry cannot be adequately addressed by the methods that are used for codifying tacit knowledge, so it can be converted into explicit knowledge (Addis, 2016). According to Addis (2016), the theoretical problems with a conversion method as the SECI model can be demonstrated by considering how tacit and explicit knowledge relate to the difference between Ryle's (1946, 1949) view of *knowing how* and *knowing that*. An example of this is:

"Knowledge of the chemical composition of plaster is knowledge that but the ability to plaster is knowledge how".

- Addis (2016), p. 442

Despite Ryle's (1946, 1949) view of knowing how and knowing that, Hartland-Swann (1956) finds that the distinction between knowing how and knowing that seems to be unstable when subjected to analysis, since every case of knowing that is a case of knowing how. Even Addis (2016) mention that there are difficulties with Ryle's (1946, 1949) view, since knowing how requires the possession of knowing that, where in the example about having the ability to plaster is partly dependent on knowing facts about plastering. However, Roland (1958) suggests that practice distinguishes the two kinds of capacities from each other.

Even if explicit knowledge is equivalent to knowing that, the relationship between knowing how and tacit knowledge is more difficult since the equivalence does not go both ways (Addis, 2016). According to Addis (2016) not all knowing how, is tacit knowledge because there is some knowing how which can be explained in for example manuals.

Further, there exist differences in the terminology of knowing how and knowing that, where Grant (1996) uses the term *knowing about*, instead of knowing that. Moreover, the differences between these types of knowledge are less apparent in English than German or French which both have specific verbs for these kinds of knowledge (Addis, 2016; Winch, 2009).

2.1.3 The SECI model

In 1995, Nonaka and Takeuchi (1995) designed a model, which is called the SECI model, where SECI stands for Socialization, Externalization, Combination and Internalization. The SECI model is based on an assumption that knowledge is created through interaction between tacit and explicit knowledge. Further, the model describes how knowledge can be generated and then spread within an organization.

Nonaka and Takeuchi (1995) state that tacit and explicit knowledge are fundamental for knowledge creation. Moreover, one type of knowledge, without the existence of the other, quickly loses its meaning. According to Nonaka and Takeuchi (1995) the knowledge process, which consists of four modes of knowledge conversion, is fundamental for organizations that want to create and develop organizational knowledge. Nonaka et. al., (2000) describe knowledge creation as being a journey "from being to becoming", where an individual or an organization possesses more knowledge and is in a higher intellectual state after the journey, than before the journey. The creation of knowledge occurs constantly, and the knowledge process is a dynamical process which consists of various conversion processes. Nonaka and Takeuchi (1995) describe these processes in the SECI model, also referred as the spiral of knowledge creation, see Figure 1.

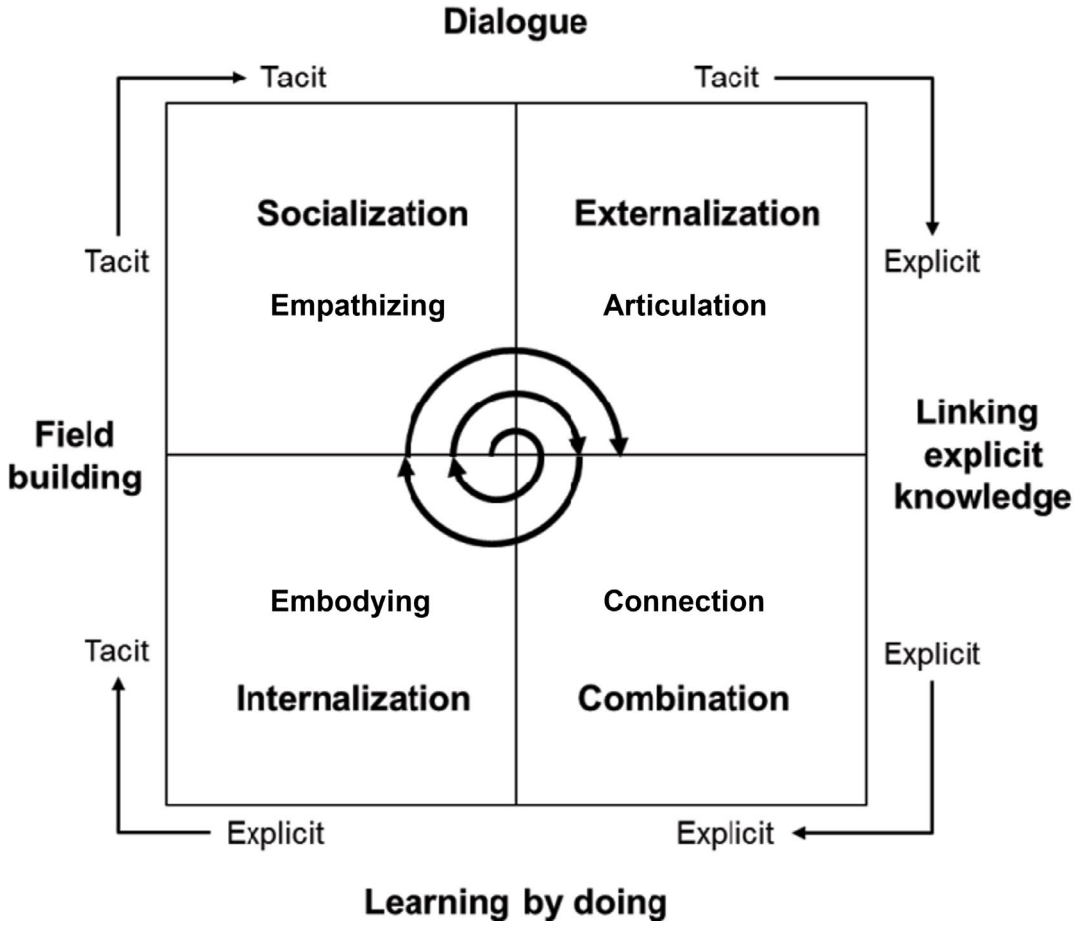

Figure 1 *The SECI Model, also referred as the spiral of knowledge creation (Nonaka et al., 2000:12).*

According to Nonaka and Takeuchi (1995) the spiral of knowledge creation describes the process where knowledge goes through the conversion processes: Socialization, Externalization, Combination and Internalization.

2.1.3.1 Socialization

In the socialization process, tacit knowledge distributes from an individual to another individual by sharing experiences from each other (Nonaka & Takeuchi, 1995). An example of this is when a newly employed begins in an organization and a senior employee guides the new employee through its tasks, have dialogues and is available to answer on potential questions. By following a senior employee for a longer period of time, there is the opportunity for the senior employee to share tacit knowledge to the newly employed. According to Nesan (2012), learning through apprenticeship improves skill levels of employees and is a strong source of tacit knowledge. In the socialization process, manuals, instructions, etc. are used to a very small extent (Nonaka & Takeuchi, 1995). In this example, the knowledge remains tacit since it is hard to convey to the whole organization. Lastly, a key word in the socialization process is "empathizing" (Nonaka, et al., 2000; Nonaka & Takeuchi, 1995).

2.1.3.2 Externalization

In the externalization process, tacit knowledge is determined in a way that makes it expressible in a formalized language (Nonaka & Takeuchi, 1995). This process occurs when an individual begins to explain and share their tacit knowledge, which thereby is made explicit. Then other people in the organization can take part of it, learn from it and lastly the knowledge becomes a part of the organization. The purpose of the conversion is to easier create a way to transfer knowledge between people. Moreover, people in an organization can have dialogues and reflect over their opinions of what they consider important and what knowledge they think should be taken advantage of. A keyword in this process is "articulation", which can be carried out by using different models to write down and highlight important aspects (Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

2.1.3.3 Combination

The combination process is when explicit knowledge develops into a higher form of complex explicit knowledge (Nonaka & Takeuchi, 1995). The processed knowledge is stored in databases and documents that are available to employees within the organization. An example is that explicit knowledge can be visualized by an employee who collects information from different parts of the organization and later compiles it in a report. Furthermore, the combination process involves standardization of the knowledge by compiling it in the form of manuals, instructions, documents, etc., to create a concrete product of the knowledge. As in the externalization process, it is of

utmost importance that the employees in the organization get involved and decide what form the new knowledge should have. A key word in this process is "connection", which can be discussed in different networking forums such as conferences, workshops, meetings etc. (Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

2.1.3.4 Internalization

Internalization happens through personal "learning by doing" (Nonaka & Takeuchi, 1995). It is the process when many individuals within the organization develop tacit knowledge, but at the same time with a codified knowledge which is stored in databases and documents. Moreover, an essential part in the process is to read and use documented knowledge. Through reflections and interpretations of the type of knowledge formulated during the combination process, it can be put into practice, which generates new knowledge on an individual level. Internalized knowledge means that a type of knowledge has become part of an individual's store of tacit knowledge. Moreover, a key word in this process is "embodying" (Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

2.1.4 Knowledge sharing and knowledge transfer

According to Argote and Ingram (2000), knowledge transfer in an organization is the process of when one unit (group, division or department) is affected by the experience of another. Nesan (2012) states that it has been argued that the construction industry is notorious for the way knowledge is transferred. Nesan (2012) believes that the organizations and individuals who are participating in a construction project bring their own unique skills, resources, experience and knowledge, however, these things are not shared to others.

According to Grant (1996), transferring knowledge is not an efficient approach to integrate knowledge. If the projects require integration of many people's specialist knowledge, the key to efficiency is to achieve effective integration while minimizing knowledge transfer through cross-learning by organizational members (Grant, 1996). According to Håkanson (2010), hindrances to knowledge transfer do not only arise from tacitness, but also from the fact that all knowledge is context dependent and that knowledge that is recognized as critical and useful in one social context, might be meaningless in another.

According to Wang and Noe (2010), research has shown that knowledge sharing may be facilitated by having a less centralized organizational structure, encouraging communication across departments and by informal meetings. Further, Wang and Noe (2010) mention that it is important to admit that employees may decide to share or not share knowledge for various reasons. For example, Wang and Noe (2010) mean that research has shown that individuals may share knowledge because they enjoy helping

others. Further, the strategy that benefits the development and implementation of new and existing knowledge is crucial for successful implementation of knowledge management (Nesan, 2012). According to Nesan (2012), the strategic goals reflect the priorities and values of organizations and may in result encourage or obstruct creativity and knowledge sharing.

2.1.5 Stages in the transfer process

Argote and Ingram (2000) mention that knowledge can be transferred by moving it from one unit to another, mainly through communication and education, as well as routines can be transferred from one unit to another. However, Szulanski (1996) states that transferring capabilities within an organization are far from easy. According to Szulanski (1996), the transfer of knowledge is a process consisting of four stages, namely: initiation, implementation, ramp-up and integration.

Initiation
Is the stage which includes all events that lead to the decision to transfer (Szulanski, 1996). Szulanski (1996) believes that a transfer begins when there is a need for the knowledge to exist within an organization. Further, the discovery of the need might trigger a search for potential solutions, which will result in a discovery of superior knowledge (Szulanski, 1996).

Implementation
The stage of implementation begins when the decision to proceed has been taken (Szulanski, 1996). In this stage, the resources flow between the recipient and the source. Moreover, implementation-related activities diminish or end after the recipient begins to use the transferred knowledge (Szulanski, 1996).

Ramp-up
According to Szulanski (1996), the ramp-up stage begins when the recipient starts using the transferred knowledge. During, this stage, the recipient will identify and try to solve unexpected problems that hinders the performance of the knowledge transfer. At first, the recipients are most likely to use the new knowledge ineffectively. However, the performance will progress by gradually be improved and ramp-up towards a satisfying level (Szulanski, 1996).

Integration
The stage of integration begins after the recipient achieves satisfying results with the transferred knowledge (Szulanski, 1996). Moreover, the usage of transferred knowledge increasingly becomes routinized. As time goes by, the transferred knowledge is built up in the recipient. Szulanski (1996) believes, that it is in this way new practices become a part of the organization.

2.1.6 Learning and knowledge transfer in project-based organizations

In Prencipe and Tell's (2001) article, the learning abilities of project-based organizations are discussed. Prencipe and Tell (2001) investigated the ability of project-based organizations to transfer knowledge to other projects or other parts of the organization. According to Koskinen and Ajmal (2008) project-based organizations are characterized by uncertainty, uniqueness and complexity. Further, Koskinen and Ajmal (2008) describe that the benefits of knowledge transfer have been recognized in project-based organizations for a long time. However, the effectiveness of knowledge transfer varies among organizations due to their capabilities to create, value and share knowledge (Koskinen & Ajmal, 2008).

Organizations do not only process information, but also elaborate and interpret it according to beliefs developed and accumulated by them over time (Prencipe & Tell, 2001). According to Prencipe and Tell (2001), project-based organizations are organized solely around projects. Further, three learning processes are explained which are based on the framework proposed by Zollo and Winter (2002), namely: experience accumulation, knowledge articulation and knowledge codification. Prencipe and Tell (2001) believe that the effectiveness of these processes depends on the characteristics of the tasks that the organization pursuit to learn. According to Prencipe and Tell (2001) the processes of experience accumulation, knowledge articulation and knowledge codification are not unidirectional. Moreover, there are overlaps between these types of learning and a distinction between them may sometimes be unclear (Prencipe & Tell, 2001).

Experience accumulation

Experience-based learning tends to be local and especially close related to existing routines. According to Levitt and March (1988), organizational learning is target-oriented, based on historical experience and is stored in routines. Further, learning by doing, as discussed by Nonaka and Takeuchi (1995) in Chapter 2.1.3, and in particular Section 2.1.3.4, is based on experience from previous actions. Additionally, Nelson and Winter (1982) believe organizations tend to carry out existing operational routines in response to problems that are encountered.

Moreover, Zollo and Winter (2002) discuss how experience accumulation and organizational routines are elementary for organizations' capability to develop. Firstly, functioning routines create the possibility for automatic behaviour among the employees, which requires less attention and effort on behalf of the skilled employee (Penrose, 1959). Secondly, organizational routines create the possibility for efficient coordination and specialization (Nelson & Winter, 1982).

"While each organisation member must know his job, there is no need for anyone to know anyone else's job. Neither is there any need for anyone to articulate or conceptualise the procedures employed by the organisation as a whole".

- Nelson & Winter (1982), p. 105

Knowledge articulation

According to Nonaka and Takeuchi (1995), the behavioural focus on learning as routine-based, results in that some of the processes that are involved in organizational learning becomes forgotten. Schön (1983) discusses how an employee by experimenting can obtain reflection-in-action, which is an ability to attend to a situation where the employee is performing routine-based knowledge. Moreover, articulation of knowledge might arise in the context of experiential learning (Prencipe & Tell, 2001).

Knowledge codification

An organization might produce higher cognitive achievements in the process of codification, since codification in a way is an extension of articulation (Prencipe & Tell, 2001; Zollo & Winter, 2002). Furthermore, the ability to codify knowledge allows creation of externalized knowledge. Moreover, codified rules which are contained in manuals and procedures can also provide guidelines for repetitive actions (Prencipe & Tell, 2001).

2.2 Handover of complex projects

Not much has been published about how complex infrastructure projects should be handed over. However, literature about megaprojects can be found, which handles the complexity in large projects, i.e., size, construction length, technical complexity, geographical area, and a large number of different organizations. Megaprojects are often infrastructure and are almost always perceived as complex projects. Therefore, literature related to megaprojects is considered, which provides insight in the handover process.

When projects become more complex, both technical and social, they may be classified as megaprojects (Flyvbjerg, 2014; Kardes et al., 2013). According to Fahri et al., (2007) megaprojects often attract a high level of public attention, political interest and have both direct and indirect impacts on the community, environment, and national budgets, where the project's success usually has been measured when the project outputs are handed over, after the project close-out phase.

Project close-out is one of the most important project phases according to Othman and Zaid (2007). The project-close out marks the stage when project outputs such as the product and documentation are delivered (Fahri et al., 2007; Othman & Zaid, 2007). The types of documentation generally delivered are described in Chapter 2.2.2. Common issues that arise for large infrastructure projects are the large investments of

time and money and an uncertain scope, which raise the complexity of the project (Fahri et al., 2007). According to Haidar and Ellis (2010) megaprojects cause project management difficulties that lead to underperformance. In addition, megaprojects are often carried out in unique and challenging environments, where several stakeholders who often have conflicting expectations need to be satisfied (Fahri et al., 2007). Moreover, the various stakeholders who are involved in megaprojects tend to cause uncertainty and stakeholders also change throughout the project lifecycle, due to the long lifetime of the project (Fahri et al., 2007).

Megaprojects delivery lifecycle ends at a definite point at which deliverables as documentation reach final completion and acceptance from the client (Fahri et al., 2007; Lessard & Lessard, 2007; Othman & Zaid, 2007). According to Fahri et al., (2007) the impact of a project depends on how deliverables are used after the project is completed. Further, it might take time before benefits or impacts of the outcomes are realized when the project is handed over (Fahri et al., 2007).

Lessard and Lessard (2007) mention that it is important for organizations to plan for a steady transition of the project toward the operation and/or maintenance. Further, the organizations need to develop a plan on how to redistribute resources among project team members (Lessard & Lessard, 2007). Some critical factors for a successful project close-out are acceptance by the end-users, good collaboration with the end customer, achievement of the project's goal or objectives and knowledge transfer (Fahri et al., 2007; Kardes et al., 2013; Lessard & Lessard, 2007).

2.2.1 Post-project evaluation

For decades, post-project evaluation has been the subject of project management research (Toor & Ogunlana, 2010). However, there are challenges with carrying out post-project evaluation in practice. According to Cleland (1985), post-project evaluations are not an assessment of the sustainability of the project deliveries, but rather the targets of evaluation the time directly after the project phase-out. Furthermore, Ahsan and Gunawan (2010) believe it can be difficult to carry out a profound evaluation of the project, since the employees usually moves on once the project is finished. Additionally, existing policies and procedures can limit the ways that information is returned to the decision makers, since there is usually no obligation to conduct post-project evaluations (Ahsan & Gunawan, 2010; Fahri et al., 2007).

Despite the challenges with post-project evaluation, it is an important part of how organizations learn and improve (Fahri et al., 2007). Moreover, Fahri et al., (2007) believe that a management that supports the evaluation process and values transparency in the process, is crucial to capability development.

2.2.2 Handover of documentation

According to Tan et al., (2018), project data in the handover package vary from project to project, but will generally include construction drawings, schedules, product data sheet, instructions for operation and maintenance, manuals and product warranty information. Moreover, Tan et al., (2018) believe that all the information that is required to be handed over to the operation and maintenance, should clearly be stated in the contracts to avoid any confusion or inconveniences. According to Lessard and Lessard (2007) it is the project manager who is responsible for all documentation being handed over to the operation and maintenance.

3 Methodology

In this chapter, the selected methodology of the thesis will be presented and explained to provide an insight to why the given research methodology was chosen to achieve the aim of the thesis. Further, the conduction of the thesis will be described.

3.1 Research approach

Since the thesis aims to map challenges related to knowledge transfer in handovers, an open and exploratory approach is required, whereby a qualitative research strategy is appropriate (Davidson & Patel, 2019). According to Bell et al., (2022) a qualitative research approach is suitable when the research will make use of detailed and rich answers.

To be able to answer on the research questions, the report is based on a current situation analysis with experiences from ongoing and previous completed complex infrastructure projects, where the intention is to seek concrete and informative answers to get an insight of how and to what extent STA manages knowledge in handovers of complex infrastructure projects.

The overall process of the thesis included a literature study, an interview study, analysis, and a presentation. The interview study was carried out to gain an empirical perspective on the literature study. The findings from the interview study were summarized and thereafter the data was analysed and compared with the literature study. Later, the relationship between the literature study and the interview study was discussed. Lastly, conclusions and suggestions for further research were presented.

3.2 Data collection methods

This section presents the data collection methods. At first, the interview study is described, which includes conduction of the interviews and a brief introduction about the interviewees, followed by a description of which documentation have been used in this thesis.

3.2.1 Interview study

The interview study is based on semi-structured interviews, aimed to present how STA manages knowledge transfer in handovers of complex infrastructure projects. The interview study has three main topics, namely: challenges with handovers of complex infrastructure projects, how projects manage knowledge during handover and possible improvements for the handover process.

A semi-structured technique was used, which gave the possibility to add or remove interview questions, depending on how the interviewees answer (Davidson & Patel,

2019). Further, Bell et al., (2022) mean that a semi-structured interview contributes to a deeper understanding of what the interviewees experience as important. Moreover, the order of the pre-determined questions in the interview guide is not fixed, which means that the order can be adapted depending on the situation.

The interview study was carried out in order to gather qualitative research data. Moreover, Bell et al., (2022) recommend the usage of an interview guide. Therefore, an interview guide was created and sent to the interviewees via e-mail in advance to give them the opportunity to be prepared on the questions that would be asked, see Appendix.

3.2.1.1 Conduction of the interviews

The interviews were held over Skype since the selected interviewees were situated in different parts of Sweden. Since STA is a government agency, the interviewees anonymity is of utmost importance. How ethical issues have been taken into consideration during the study is described in Chapter 3.4.

The interviewees were informed about the context of the thesis and how their participation could contribute to the thesis, when first getting an e-mail about participating in an interview for the thesis. If the interviewee accepted to participate, an additional e-mail was sent to once again inform about that the interview data would be anonymously handled, see Chapter 3.4. Further, the interviewees had the possibility to ask questions to the author if something was unclear about the interview or the thesis.

The interviews started with a brief description of the author and the aim of the thesis, followed by causal small talk to create a good mood among the interviewees before the interview could start. Notes were taken during the interviews and permission was given to record the interviews, which would ease transcription and correction of the notes afterwards to ensure reliability and readability. Additionally, the interviews were carried out in Swedish, since Swedish is the mother tongue of all the interviewees.

3.2.1.2 Interviewees

Interviews were conducted with representatives with experience of Project A-F, see in Chapter 4.3. Project A-F were selected since they are complex infrastructure projects in urban cities in Sweden, where there is much to learn about challenges with the handover process and how knowledge is managed. The interviewees have been involved in the construction phase and/or the management phase. The management phase includes operation and maintenance of existing facilities.

The interviewees are anonymized in this thesis and are instead referred as I and a serial number afterwards, where I stands for interviewee, see Table 1. The interview study was comprehensive, since 18 interviewees accepted to participate in this thesis. The

average duration of the interviews was 50 min. Further, I14 and I15 were interviewed together due to their similar background and professional roles at STA.

The choice of interviewees is made based on recommendations from the supervisors at STA, by using a goal-oriented selection (Davidson & Patel, 2019). The interviewees are chosen regarding their professional roles and experiences of handovers of complex infrastructure projects. The goal of the interviews is to understand the interviewees' own perception, insights, and opinions.

Most of the interviewees have a background either in business area Maintenance, Investments or Major Projects, the different business areas are described in Chapter 4.2. The diversity of the participating interviewees is considered since multiple perspectives give a comprehensive study, as their point of view may be different since they work in different business areas at STA. It also enables comparisons and connections between them. However, it is not possible to generalize the results for all the six business areas at STA since the study mainly consists of interviewees from business area Maintenance, Investments, Major Projects and only one interviewee from business area Traffic Management (Davidson & Patel, 2019).

Table 1 Information about the interviews.

Interviewee	Professional role	Interview duration
I1	Station Manager at business area Maintenance	86 min
I2	Technical Project Manager at business area Maintenance	57 min
I3	Project Manager at a receiving organization at business area Maintenance	45 min
I4	Installation Planner at business area Major Projects	39 min
I5	Project Manager at business area Maintenance	45 min
I6	Installation Coordination Manager at business area Investments	57 min
I7	Project Manager for maintenance of Installation systems at business area Maintenance	39 min
I8	Tunnel Safety Specialist at business area Investments	27 min
I9	National Coordinator for complex road facilities at business area Maintenance	58 min
I10	Senior Tunnel Safety Specialist at business area Investments	66 min
I11	Commissioning Coordinator at business area Major Projects	56 min
I12	Project Manager at a receiving organization at business area Maintenance	38 min

I13	Operation and Safety Coordinator at business area Maintenance	46 min
I14 & I15	Responsible for operational documentation and education within a function in business area Major Projects	50 min
I16	National Coordinator for tunnel safety in railway systems at business area Maintenance	48 min
I17	Business Developer for railways at business area Traffic Management	34 min
I18	Unit Manager for railway systems at business area Maintenance	50 min

3.2.2 Documentation

Several documents were collected in order to get a full picture of STA as an organization, but also to get an understanding of how the handover process is carried out at STA. By having access to STA's intranet, it was possible to read and retrieve internal documents that are relevant for this study. Furthermore, the Swedish Transport Administration's documents (TDOK) were used to understand the handover routine for new and changed infrastructure, and to get an insight of some professional roles that are relevant for a handover at STA, see Chapter 4.4.

3.3 Data analysis

According to Thorne (2000), textual data from interviews in qualitative research tend to be unstructured, which makes the data hard to analyse. Further, Thorne (2000) means that analysing qualitative data is challenging, where it is important that the author does not get too caught up in the large amount of the collected interview data.

Bell et. al (2022), recommends using a thematic analysis as a data analysis approach for empirical findings. Therefore, a thematic analysis approach has been chosen in the master's thesis. All the interviews were transcribed within a few days after the interviews were carried out. At first, superfluous information in the interview data was sorted out. Thereafter, the interview data was identified and sorted into different topics that were relevant for the thesis. The main topics that were found are: challenges with handovers of complex infrastructure projects, how projects manage knowledge during handovers and possible improvements for the handover process. Great caution was taken to first separate the different interviewees opinions and experiences, and thereafter merge together the shared views among the interviewees. Further, views and opinions that only were uttered by a single interviewee were excluded, in order to focus on the most commonly identified issues. Finally, when the interview data was summarized, the analysis phase started.

3.3.1 Trustworthiness of data

According to Bryman (2012), trustworthiness is a criterion of how good a qualitative study is. Trustworthiness consists of four different criteria: credibility, transferability, dependability and confirmability.

Credibility

Credibility is the validity of the findings, i.e., how believable the findings are. According to Bryman (2012) the establishment of the credibility of the findings involves both ensuring that the research is carried out according to the practice, but also by providing the research findings to the participants in the study, to validate that the author correctly has understood the information. This can be carried out by a technique called respondent validation. Another technique which is useful within this field is triangulation (Bryman, 2012).

Transferability

Transferability is the external validity, i.e., the applicability of the findings in other contexts (Bryman, 2012). Since qualitative research usually involves an intensive study of a small group or individuals who share certain characteristics, qualitative findings tend to be oriented to the uniqueness of the aspects of the participants being studied. According to Bryman (2012), generalizability of the findings is not expected in qualitative research, therefore transferability of qualitative data ensures that the findings are applicable to similar settings or individuals.

Dependability

Dependability is the reliability of the findings, i.e., how applicable the findings are at another time (Bryman, 2012). In order to address the dependability, Shenton (2004) believes the processes within the study should be reported in detail, by enabling a future researcher to repeat the work, if not necessarily to gain the same results.

Confirmability

Confirmability is the objectivity of the author, i.e., if the author has allowed his or hers values to intrude to a high degree while carrying out the research (Bryman, 2012). To achieve confirmability, the researchers must demonstrate that the findings emerge from the data and not their own perceptions (Shenton, 2004).

In this thesis, all four criteria of trustworthiness have been taken into consideration. Credibility has been considered by letting the supervisors at STA read through the report before publication, in order to ensure that the information in the interview study is correct. Further, transferability has been taken into account since the methods, research questions and findings of this study also are relevant for other public clients in similar areas in Sweden or in other countries. Moreover, dependability is addressed by clearly describing the methods used to achieve the results of this study. Lastly,

confirmability has been assured by having the data checked throughout the data collection and analysis to ensure the findings from the interview study.

3.4 Ethical considerations

Davidson and Patel (2019) emphasize the importance of clarifying in which way interviewees' contributions will be used. Therefore, all information is handled confidentially regarding how the interviewees approve that the information is reproduced. The interviewees are also informed that the interview is a voluntary participation and has thus been able to cancel it whenever desired.

According to Birkmann and Kvale (2018), there are seven ethical issues that can arise throughout an interview inquiry, namely: thematizing, designing, interview situation, transcription, analysis, verification and reporting. These ethical issues have been taken into consideration when writing the thesis. According to Bell and Bryman (2007) ethical considerations are crucial for the research process. Bell and Bryman (2007) have identified 11 categories of ethical principles, where several are similar to the ethical issues that are investigated by Birkmann and Kvale (2018).

A couple of ethical principles that have been taken into account in this thesis are avoidance of harm of the interviewees and informed consent, where the interviewees can make decisions regarding their participation in the thesis. Before the interviews were carried out, the interviewees were asked if they would give their consent for the interview to be recorded. The interviewees were informed that the recording only would be used to ease transcription of the interviews.

Before the interviews, the interviewees also were sent an e-mail asking for their consent to use the interview data. The interviewees had the following two options to choose between:

1. **Everything that is said by me during the interview can be used in the thesis and can be quoted with my consent.** I am aware of that my real name or specific role will not be used, mentioned or stated in the thesis, but people who are involved in the same project as I may still recognize me in the text.
2. **Everything that is said by me during the interview can be used in the thesis, but may not be quoted.** I am aware of that my real name or specific role will not be used, mentioned or stated in the thesis, but people who are involved in the same project as I may still recognize me in the text.

As stated above the interviewees were informed about the protection of their anonymity. Further, a total of six projects were investigated in this study, which have been anonymized and given the names Project A-F, see in Chapter 4.3.

Moreover, General Data Protection Regulation (GDPR) was followed throughout the process of handling the interviewees data, such as names, contact information, transcriptions and recordings of the interviews. Moreover, the interviewees have been kept anonymized to comply with GDPR.

4 Context of this study

This chapter presents the context of this study by introducing the infrastructure public client the Swedish Transport Administration (STA). Further, STA's overall organization structure is described together with the business areas, the handover routine for new or changed infrastructure, and some professional roles that are relevant for a handover at STA. Moreover, a project description will be given of the projects that are investigated in this study.

4.1 The Swedish Transport Administration

STA is the Swedish government agency which is responsible for long-term planning of the transport system for road, railway, sea and air transport. Further, STA is responsible for construction, maintenance and operation of state roads and railways (Trafikverket, 2022a).

STA's mission is to secure that the transport system is functioning by creating conditions for safe transportation, as well as taking health and the environment into consideration while planning the transport systems. According to STA, a good accessibility is necessary to maintain a functioning society (Trafikverket, 2022b).

STA's vision is to create long-term sustainability in a socially, ecologically, and economically way. STA have created a vision statement that expresses the long-term direction for STA, which is: "Everyone arrives smoothly, the green and safe way" (Trafikverket, 2022b).

4.2 Overall organizational structure

STA consists of six business areas, six central functions, four profit centres and one program (Trafikverket, 2019b). In Figure 2, STA's overall organizational structure is shown, where the business areas which are relevant for this study are circled in bright red. The relevant business areas are mainly Maintenance, Investments and Major Projects. However, the business areas of Traffic Management and Information & Communications Technology (ICT) will be mentioned, but not be delved into in this thesis. Therefore, only business area Maintenance, Investments and Major Projects are described in this chapter.

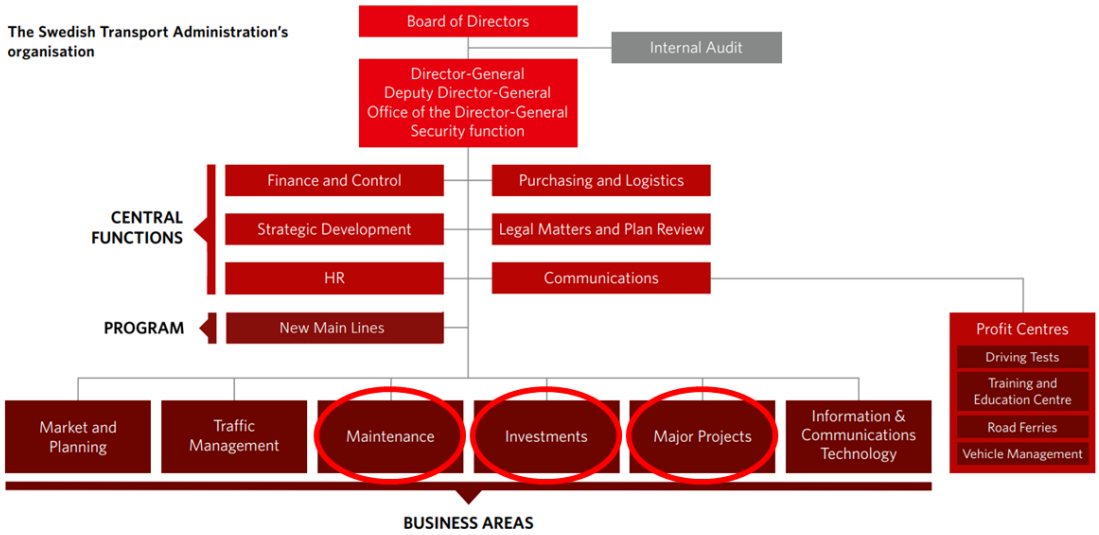

Figure 2 *The Swedish Transport Administration's overall organizational structure. The relevant business areas for this study are circled in bright red (Trafikverket, 2019b:9).*

4.2.1 Maintenance

Business area Maintenance is responsible for managing, maintaining and developing the existing and future road and railway networks via preventive and planned maintenance. This responsibility also extends to developing and managing the technical systems that are part of these networks (Trafikverket, 2019b).

4.2.2 Investments

Business area Investments procures and monitors the majority of STA's refurbishments and new investments. Business area Investments work with over 1,500 projects across a broad spectrum of assignments, with everything from new construction or adjustments of roads and railways, to building pedestrian and cycle paths, train platforms and bus stops. Additionally, business area Investments is responsible for road and railway projects with the cost of 5 million SEK to 1 billion SEK (Trafikverket, 2019b).

4.2.3 Major Projects

Business area Major Projects is responsible for procuring, implementing and monitoring Sweden's biggest and most complex infrastructure projects, such as Förbifart Stockholm and Västlänken. This includes investment projects for road, railway and water, with a cost of over 1 billion SEK, excluding New Main Lines (Trafikverket, 2019b).

4.3 Project description

A total of six projects were investigated in this study, where all of the projects have been carried out by STA. The projects have been anonymized in this thesis and instead given the names Project A-F. The following section gives a description of the different projects.

4.3.1 Project A

Project A is a major transport infrastructure project in an urban city in Sweden. The project is an 8 km long double track railway, which includes a 6 km long railway tunnel. The railway will facilitate traveling by increasing the train frequency, shortening travel times and enable travellers to reach more destinations without transfers. Moreover, the project will increase accessibility with three underground stations. The construction of the project is estimated to go on between 2018-2026.

4.3.2 Project B

Project B is a 6 km long commuter railway tunnel which is located beneath an urban city in Sweden. The construction of Project B started in 2009 and the railway tunnel opened for traffic in 2017. Further, two underground stations are located in the city centre.

4.3.3 Project C

Project C is a 17 km railway link in an urban city in Sweden. Further, 6 km of the railway link consists of a tunnel below the urban city. Project C enables transportation from Sweden to a neighbouring country. The construction of the project started at 2005 and the facility was opened in 2010. Moreover, Project C has two underground stations.

4.3.4 Project D

Project D is a new route for the European highway (E4). The link will connect the southern and northern parts of an urban city in Sweden, which will lead to reduced traffic in the city area. Further, the link is 21 km long, where of 18 km are in tunnels. The construction of the project started at 2015 and is estimated to be completed by 2030. STA estimates that the link by 2035 will be used by approximately 140 000 vehicles per day.

4.3.5 Project E

Project E is one of the largest road tunnel projects in northern Europe. The construction of Project E started in 2007 and the facility opened for traffic 2014. The purpose of Project E, among other things, was to solve the given region's traffic problems, by moving the traffic below surface. The total length of Project E is 5 km, where the longest tunnel section is 4 km.

4.3.6 Project F

Project F is a railway tunnel which is located between the southern and northern sides of a ridge in Sweden. Construction of the project started in 1992 and the facility opened for traffic in 2015. Project F consists of two single track tunnels that are 8,7 km each, which makes it the longest railway tunnel in Sweden.

4.4 Handover routine for new or changed infrastructure

There are governing and supporting documents for STA's processes, so-called the Swedish Transport Administration's documents (TDOK). STA's handover routine that applies new or changed infrastructure is called TDOK 2012:139. The purpose of the handover routine is to clarify the workflow when handing over responsibility, facility, and management of operation data from a project to receiving organizations (Trafikverket, 2021c).

Moreover, the handover routine gives the conditions for all actors to know how the handover should take place, regardless of scope and complexity of the project. Further, it ensures that operational preparation and measures are carried out by those who hand over and receive the facility. Lastly, the handover routine clarifies the division of responsibilities between the project and the operation and maintenance after the facility has opened for traffic or until the final handover and end of the warranty period (Trafikverket, 2021c).

In the handover routine, STA applies a handover workflow that varies depending on the scope and complexity of the project, which determines the degree to which each activity is carried out. Some activities can be carried out simultaneously and in a different order than what the workflow describes, provided that the handover and receiving coordinators agree (Trafikverket, 2021c).

The handover routine does not say which documents that need to be handed over from the project to the receiving organizations. However, the handover routine mention that the receiving organizations shall have access to documents that are needed for operational operation (Trafikverket, 2021c). On the other hand, there are set requirements for which documentation about the railway and road facilities that STA needs to store in its operation systems (Trafikverket, 2022c). The set requirements for

the railway facilities are found in TDOK 2016:0407, while the set requirements for road facilities are located in TDOK 2019:0210 (Trafikverket, 2022c; Trafikverket, 2022d).

4.4.1 Handover coordinator

According to TDOK 2012:1170, the handover coordinator's purpose is to enable a handover of responsibilities, facilities and management data from a project to the operation and maintenance, by coordinating the handover within the project together with the receiving coordinator. The handover coordinator is responsible for following the handover routine for new or changed infrastructure, TDOK 2012:139. Moreover, the handover coordinator is responsible for coordinating designated resources that are responsible for delivering data, so that this takes place in accordance with STA's requirements regarding time and content. Lastly, the handover coordinator shall ensure that the delivery of management data takes place in accordance with the delivery plan and relevant TDOK in terms of content, quality and time (Trafikverket, 2021a).

4.4.2 Receiving coordinator

According to TDOK 2012:1198, the receiving coordinator's purpose is to enable the receipt of responsibilities, facilities and management data from a project to the operation and maintenance, by coordinating the receipt together with the handover coordinator. The receiving coordinator is responsible for following the handover routine for new or changed infrastructure, TDOK 2012:139. Furthermore, the receiving coordinator is responsible for ensuring that the project managers which are concerned are given the opportunity to receive a new or changed facility. Moreover, the receiving coordinator shall ensure that respective recipient have received and approved submitted management data (Trafikverket, 2021b).

5 Result of the study

This chapter presents the findings from the interviews that were carried out with representatives from the Swedish Transport Administration (STA).

5.1 Challenges with handovers of complex infrastructure projects

There are many challenges with handovers of complex infrastructure projects. The following chapter discusses the main issues identified from ongoing and previous completed complex infrastructure projects. Among these are: organizational challenges of the handover process, and challenges with communication in the handover process.

5.1.1 Organizational challenges of the handover process

According to the interviewees, STA is a very large and complex organization, and it is therefore easy to miss something during the handover process due to the organizational structure. There are several organizational challenges of the handover process, where this section will discuss: lack of preparation with complex facilities, lack of resources and knowledge for new types of facilities, lack of early involvement from the maintenance organization, organizational differences in handling of the process, and handover of an unfinished facility.

5.1.1.1 Lack of preparation with complex facilities

According to the interviewees, there are working methods, governing documents, guidelines, and routines for how information should be transferred from a project into an operation and maintenance organization. STA has processes and rules for facilities that are normally recurring and common to receive, but when it comes to complex facilities, there is potential for development. For a handover, there must be both handover and receiving coordinators involved, according to STA's governance system. However, the handover routine does not handle all aspects, as it is based on a normal road or railway project. According to the interviewees, there is therefore a risk that the routine will not be applicable to complex infrastructure projects. The interviewees believe the handover process is a challenge in ordinary cases, but that it becomes more challenging with complex facilities, since the requirements for how the handover shall be carried out is not identical.

5.1.1.2 Lack of resources and knowledge for new types of facilities

According to the interviewees new knowledge will be lost when a new kind of facility has been built which the receiving organizations have limited or no experience of. STA

is experienced with facilities that include railway-specific equipment, where there already exist systems, descriptions and routines. However, the quantity of equipment in complex facilities and the size of the facilities are extremely much larger than what the handing and receiving organization are used to handle and therefore misunderstandings can occur. Consequently, at the de facto handover, the interviewees mention that it is realized that the complexity of the facility was something completely different than expected. Therefore, STA has a need of resources and knowledge for how to hand over knowledge concerning new types of facilities.

5.1.1.3 Lack of early involvement from the maintenance organization

The interviewees state, that when complex infrastructure projects are to be handed over, it is necessary to cooperate with each other on a fairly close level in order to become integrated with what is happening in the project. Several interviewees from business area Investments believe that business area Maintenance often does not have an early involvement. The interviewees state that it is good if the maintenance organization is involved through a continuous dialogue already in the planning stage, but no later than 3–4 years before the handover. According to the interviewees, it should be identified early on which roles the information should be handed over to. It should not be person-based and dependent on a single person or a few individuals, but instead several from business area Maintenance need to be involved. The interviewees believe, that when the receiving organization has not staffed up at a sufficiently early stage, certain competence from the handing organization will be lost.

5.1.1.4 Organizational differences in handling of the process

Interviewees from business area Major Projects, believe that the organization who work with railway has organized itself well in the handover process to business area Maintenance, while the handover to business area Traffic Management has been a problem throughout the ages, because business area Maintenance and business area Traffic Management do not have the same issues. Since projects usually are planned to be carried out during a long period of time, there is a risk that issues will be moved between different business areas.

5.1.1.5 Handover of an uncompleted facility

According to the interviewees, a common problem is that the handing organization does not have time to complete the project and thus does not have time to do a proper handover. The interviewees mention, that the project is rarely 100 percent completed when the facility is handed over. Further, the interviewees mean that if there are remaining deficiencies, it is difficult to address and obtain knowledge if the project is finished.

5.1.2 Challenges with communication in the handover process

There are many challenges with communication in the handover process. However, the areas that will be discussed are: challenges with contacting operation and maintenance in previous completed projects, information exchange issues, and lack of circulating knowledge back to the project organizations.

5.1.2.1 Contacting operation and maintenance in previous completed projects

The receiving organization at Project A has chosen to contact those who operate and manage complex facilities in several urban cities in Sweden, in order to learn from their experiences of errors and shortcomings. In fact, the interviewees believe that the same people are used to a fairly high extent in complex infrastructure projects. However, the interviewees mention that there is no guideline on which people to contact, so it remains as tacit knowledge. According to the interviewees, it is important to highlight which information carriers there are and that they possess knowledge. Moreover, the interviewees mean that the knowledge is accumulated by time and experience by these people who have been involved in complex infrastructure projects in the past.

"There is no routine for how to look back at previously completed projects and this means that it is a lot of searching before you find the right person who carries knowledge. Then once you have found the right person, they carry an incredible amount of knowledge. It is far too unclear and difficult to find the right skills to gain the right experiences".

- I6, business area Investments

5.1.2.2 Information exchange issues

The interviewees mean that information exchange is limited through a few contact surfaces. This creates a filter where the information does not get through or is reinterpreted and changed along the way. Hence, the interviewees believe, the information exchange must take place between the actual users of the information, i.e., the organization that has the knowledge needed to decide what is right or wrong, as well as what information needs to go from the smaller midsize projects to business area Traffic Management, ICT or Maintenance.

5.1.2.3 Lack of circulating knowledge back to the project organizations

According to the interviewees, experiences are put to good use through experience exchanges, study visits and workshops. However, the interviewees believe that there is no functioning structure for how the dissemination of knowledge or experiences from business area Maintenance should be returned to the project organizations. According to the interviewees, there is currently a lack of circulating knowledge, because STA is not a self-learning organization that gives feedback on how to do certain things.

However, making use of knowledge is very person-driven, and because of this, the interviewees think that problems are not caught quickly enough and usually remain as problems.

Table 2 describes challenges with handovers of complex infrastructure projects. The challenges exist within different areas considering the organization and communication in the handover process.

Table 2 Challenges with handovers of complex infrastructure projects.

Challenge	Description
Organizational challenges of the handover process	
Lack of preparation with complex facilities	The handover routine does not handle all aspects, as it is based on a normal road or railway project.
Lack of recourses and knowledge for new types of facilities	New knowledge will be lost when a new kind of facility has been built which the receiving organizations have limited or no experience of.
Lack of early involvement from the maintenance organization	The maintenance organization often does not have an early involvement.
Organizational differences in handling of the process	The handover process is handled differently in different business areas.
Handover of an unfinished facility	The project is rarely 100 percent finished when the facility is handed over.
Challenges with communication in the handover process	
Contacting operation and maintenance in previous completed projects	By contacting those who operate and manage complex facilities, learnings can be made from their experiences, but knowing who to contact is a challenge.
Information exchange issues	The information exchange does not get through or is reinterpreted and changed along the way.
Lack of circulating knowledge back to the project organizations	There is no functioning structure for how the dissemination of knowledge or experiences from different business areas should be returned.

5.2 How projects manage knowledge during handover

In the following chapter, the knowledge which is transferred from the project to the receiving organizations will be discussed. This knowledge includes explicit knowledge as in documentation, and tacit knowledge.

5.2.1 Explicit knowledge: Documentation

Explicit knowledge is knowledge which can be articulated, described, and written down in words, for instance through documentation. Management of knowledge at STA takes place during educations, as well as when using manuals, routines and instructions. However, the interviewees mention that there is a limitation in how much knowledge that can be transferred in the handover.

"If I tell someone about how something works or if I write a manual on how something should work, you understand the facility right there and then. But then the knowledge is lost, especially if you do not usually use this information. Then this information is handed over to the receiving organizations which may not be on site or not have the opportunity to be involved".

- I2, business area Maintenance

Documentation is transferred from the project to the receiving organizations. According to the interviewees, it takes a lot of energy to try to understand the existing documentation systems. The interviewees believe that it is much up to how the individual experience the documentation system, as well as how good the individual is at finding the files.

"Even today, some documentation is missing from the facilities in several urban cities in Sweden, due to a lack of structure to receive the documentation. The format has been different. We also do not have a receiving structure in our systems, and this means that we lose a huge amount of information. For example, in Project C they are still looking for the original documentation for the facility".

- I3, business area Maintenance

5.2.1.1 No standardization in terms of documentation

For Project A, there is no dedicated system today for where the documentation should be stored, and which organization should be responsible for it. According to the interviewees, a dedicated system for documentation will be created, but one of the problems is that there are no clear requirements on how the documentation should be named and what it should contain. At Project A, there are employees who know from experience what should be included in the documentation, but the interviewees mean that there is always a risk when there are no clear requirements for what is to be

produced. Hence, the interviewees believe this can lead to overworking or doing something that business area Maintenance does not expect. According to the interviewees, there must therefore be a detailed and agreed set of requirements about what both parties expect the documentation to contain.

"We have so many rules on how to make a drawing frame for a construction document, but we still cannot agree on which documents should be transferred from the smaller midsize projects to the operation and maintenance".

- I11, business area Major Projects

5.2.1.2 Unclear prioritization of critical documentation

According to interviewees from business area Investments, it is not unusual for the receiving organization, several years after the documentation has been delivered, to contact the handing organization and ask them to send certain documents again. The interviewees believe this is because the receiving organization has received a large number of documents and then there will be a much greater risk of missing knowledge. According to the interviewees from business area Maintenance, it is easy to miss doing a sufficient review of the large number of documents that shall be delivered. However, the interviewees agree that the amount of information must be cut down, so it is only the documentation that is critical which is transferred.

5.2.1.3 Problems with updating documentation

According to the interviewees, documentation can be missed to be updated both when changes are made to a facility and when new things are learned about a facility after the handover. The interviewees from business area Major Projects assesses that a necessary follow-up of documentation is not done after a handover. According to the interviewees from business area Investments, it must be defined who has the task after commissioning to manage the documents that have been produced. The interviewees state that, the documentation for operational and tunnel safety is current on the day of commissioning, but if it is not clear who is responsible for the documentation, it will not be updated either.

"When there is documentation that you do not even know if it is business area Maintenance or business area Traffic Management who is responsible to update it, then you have a problem. That issue is being addressed right now, and there is currently no effective way of handling this type of documents".

- I11, business area Major Projects

On the other hand, interviewees from business area Maintenance state that the documentation is usually updated if an incident has occurred or if a deficiency has been

discovered. Furthermore, the interviewees from business area Major Projects believe that business area Maintenance can be better at working with continuous improvements of documentation, but what causes this deficiency is that there still is an unclear management responsibility.

5.2.2 Tacit knowledge

Tacit knowledge is knowledge which is hard to express or extract. This includes among other things, experience and intuition. Thus, it becomes more difficult to transfer tacit knowledge to others verbally or through writing. This section describes issues with transfer of tacit knowledge at STA, in terms of: valuing experience and circulating knowledge, knowledge on an individual level, how knowledge is handled in projects, loss of knowledge after project handover, knowledge gaps between business areas, lack of routines for knowledge sharing, and difficulty in maintaining knowledge about critical events.

5.2.2.1 Valuing experience and circulating knowledge

According to the interviewees, it is time and experience that create tacit knowledge. Furthermore, the interviewees believe that it is only possible to secure tacit knowledge by valuing it, giving it a name and allowing it to exist. The interviewees mention, that in today's project-based organizational structure, the projects must have a start and an end, where it is hard to see that it is a recurring loop of time and experience that accumulates tacit knowledge.

"I can quickly get a picture of a situation, and this is based on my previous experience with these things. I have heard this before, I have done this before, this reminds me of things I have been through before. I feel that I have knowledge which means that I can make a rational decision".

- I1, business area Maintenance

5.2.2.2 Knowledge on an individual level

According to the interviewees, tacit knowledge becomes very individual and there are problems accessing it. Transferring knowledge verbally can help for the time being, but not in a few years due to the staff turnover that exists at STA. Often, the people who possesses a lot of knowledge are not the best at writing it down, which is a challenge according to the interviewees. The interviewees believe there are some shortcomings regarding how knowledge is handled and stored, as well as where it can be obtained without it being tied to a person.

"If you highlight it as a concretization that tacit knowledge exists, then it enables recognition that it exists and then you can look at how to organize to secure tacit

knowledge. But if you do not talk about it, then you do not miss it either. If it does not exist, it is not something you need".

- I1, business area Maintenance

5.2.2.3 How knowledge is handled in projects

The interviewees believe that the knowledge has been handled differently in different projects and often is connected to the people who are involved. There are specialists who are responsible for being the link between business area Investments and business area Maintenance and knowledge can thus be transferred between them. According to the interviewees, it is difficult to know how to manage knowledge within STA.

"Most of the time, you are given what to do, but perhaps you do not know how to carry it out. So, it is usually a challenge that we face. It says that this should be done, but how do you actually do it? There is no practical example of how to proceed".

- I5, business area Maintenance

5.2.2.4 Loss of knowledge after project handover

Towards the end of a project, it is common for construction managers and project managers to want to move on to the next project. The interviewees believe, that even if the construction of the facility is finished, part of the construction is also all operating documentation, models, measurements, and things that were not completed in the construction phase, but still must be fixed in some residual contract. In addition, the interviewees mention that it is a problem to get this done because it is easy for people to let go of the knowledge and move on. As long as people start a new project within STA, they can usually be found, but they are more difficult to be found after they have left STA.

5.2.2.5 Knowledge gaps between business areas

According to the interviewees, there is a knowledge gap when competent people leave the project, and a maintenance organization takes over. The interviewees mention, that it takes a long time to develop the knowledge level of the people who will operate the facility. Although complex railway facilities are a type of facility that is not normally built, a traditional railway contractor is still brought in. The interviewees believe that a railway contractor usually does not have the expertise that is needed for these systems, as there are more property-related systems in a complex railway facility such as tunnels, fire alarms, lighting, fans, pumps, etc. There are basically no such systems within railway. Moreover, the interviewees mention that there is an unfamiliarity with dealing with these systems, because it is very rare to have this complexity in an ordinary railway facility.

5.2.2.6 Lack of routines for knowledge sharing

The interviewees believe that in previous projects it has been chance and dedication that have created tacit knowledge. Namely, there are no descriptions of how to go about making use of tacit knowledge. Moreover, there is no routine that says that those who work in Gothenburg must share their knowledge with their colleagues in, for example, Stockholm. According to the interviewees, the tacit knowledge is deeply rooted, and it is difficult to make use of it, because it depends a lot on the individual.

"The knowledge is there, but it remains silent because no one knows that they should spread it. There must be a recipient if you are going to spread such experience. If you do not actively seek it out, it will just be deeply rooted. The tacit knowledge must be included in a suitable communication platform so that you can spread it to each other".

- I10, business area Investments

5.2.2.7 Difficulty in maintaining knowledge about critical events

The interviewees from business area Major Projects, believe that the things that are written between the lines in the educational material are difficult to convey in writing, i.e., anecdotes and the accumulated experience. For the operating staff, an image of what they should be able to do is conveyed, but then everyday life comes in and everyday life is not the same as what they are trained for. According to the interviewees everyday life is: restarting escalators, letting maintenance staff in and administer maintenance work. The interviewees believe that this leads to the operating staff becoming very good at certain tasks, but can easily lose the knowledge of how critical events are to be handled, which is an important part of why the operating staff exist.

"The critical events that the facilities are dimensioned for will hopefully never occur. But on the day in x number of years when it does occur, it is important to do as right as possible".

- I6, business area Investments

Table 3 describes how projects at STA manage knowledge, in terms of explicit knowledge such as documentation, and tacit knowledge.

Table 3 How knowledge is managed in handovers of complex infrastructure projects.

Handling of knowledge	Description
Explicit knowledge: Documentation	
No standardization in terms of documentation	There are no clear requirements on how the documentation should be named and what it should contain.
Unclear prioritization of critical documentation	The amount of information must be cut down, so it is only the documentation that is critical which is transferred.
Problems with updating documentation	Documentation can be missed to be updated when changes are made to a facility.
Tacit knowledge	
Valuing experience and circulating knowledge	Tacit knowledge should be ensured by valuing it and letting a recurring loop of time and experience accumulate it.
Knowledge on an individual level	There are shortcomings regarding how knowledge can be obtained without it being tied to a person.
How knowledge is handled in projects	Knowledge is handled differently in different projects and is often connected to the people who are involved.
Loss of knowledge after project handover	It is easy for people to let go of the knowledge and move on to the next project.
Knowledge gaps between business areas	Knowledge gaps can occur when competent people leave the project and a maintenance organization takes over, but also when dealing with technical systems in complex facilities.
Lack of routines for knowledge sharing	There are no descriptions of how to go about making use of tacit knowledge.
Difficulty in maintaining knowledge about critical events	Operating staff becomes very good at certain tasks but can easily lose the knowledge about how critical events are to be handled.

5.3 Possible improvements for the handover process

This chapter discusses possible improvements for the handover process, where a long-term perspective must be taken into consideration. This includes organizational structure suggestions, education, standardization of documentation handling, maintaining competence, and a need of an offboarding process.

5.3.1 Organizational structure suggestions

The following section presents suggestions for how the organizational structure can be improved. This includes new organization structure based on experience feedback meetings and change of tasks to include maintenance.

5.3.1.1 New organization structure based on experience feedback meetings

Currently in Project A, the interviewees from business area Maintenance mention that a new structure for how the receiving organization should think, how the facility should be distributed, as well as how the various parties should cooperate in the facility are underway. According to the interviewees from business area Maintenance, this is based on experience feedback meetings with Project B, Project C and Project F, where there has been a discussion about what they have experienced in their facilities several years after the facility has been put into operation. However, the interviewees believe STA might have been organized in a way that causes loss of experience. Therefore, the interviewees believe that a new organization structure which is based on experience feedback meetings should be considered.

"No one talks about explicit and tacit knowledge, since there are standardized projects. There is a handing over and receiving process, but it would be necessary to talk about the fact that there is also specific knowledge".

- I1, business area Maintenance

5.3.1.2 Change of tasks to include maintenance

According to the interviewees from business area Investments, one possible improvement for not handing over unfinished facilities could be if business area Investments was responsible for maintenance on everything they build during the entire warranty period. The interviewees mention that business area Investments would in principle have to run a small maintenance organization during the warranty period. Then they would be forced to take on maintenance experience and, moreover, business area Investments would not be able to build an unfinished facility with lots of problems in it, because then they would have to handle the problems themselves. Thus, the interviewees believe that the incentive to build robust facilities would increase.

5.3.2 Education

According to the interviewees, a large education effort is required for, among others, receiving coordinators and handover coordinators. This section discusses suggestions for how the education can be improved by ensuring the possibility to conduct education. This includes: having education that is adapted to complex facilities, setting aside time for conducting education, having separate education for different roles, and making sure that the information in the education is actively up to date.

Ensure the possibility to conduct education

According to the interviewees, one way to ensure competence is through education. Once the facility is in operation, it may happen that the contractor is replaced from time to time. The interviewees mention that when a new contractor is hired, there must be an assurance that there is education that is adapted for complex facilities, so it is possible for the new staff to gain knowledge through education. However, the education that exists today for complex facilities usually takes place during one day, and there is a lot of information on that education day. The interviewees believe the arrangement of the education can be improved, by setting aside time for conducting education during several days.

Considering the maintenance required of a complex facility, the interviewees also believe that efforts must be put in having separate education for different roles, because everyone have different responsibilities for creating a reliable facility. Furthermore, the interviewees from business area Major Projects mention that organization changes often occur, and all organizational changes are a big loss of knowledge. The interviewees believe that one way to take this into consideration when conducting education, is to actively update the information in the education.

5.3.3 Maintain competence

The interviewees believe that there must be a long-term view of how competence can be maintained. This section will discuss the possibility of changing contract types to maintain knowledge, keeping a link between the project and operation and maintenance, and implementation of a specialist organization.

5.3.3.1 Change of contract types to maintain knowledge

According to the interviewees from business area Maintenance, one way to ensure access to a certain type of knowledge is by using key people as construction managers from the project to the operation and maintenance phase. According to the interviewees from business area Maintenance, Project C has been maintained by the same contractor who built the facility. This means that the contractor has knowledge of what must be maintained in the facility. According to the interviewees from business area

Maintenance, when Project E was handed over to business area Maintenance, they managed to sign a contract with the same construction managers who were involved in the project. By making a change of contract types, it will lead to a gained facility knowledge and possibility to transfer a great amount of that knowledge to business area Maintenance. According to the interviewees, this might be the best possible solution for transferring knowledge from business area Investments to business area Maintenance.

However, the interviewees from business area Investments believe that this improvement can be difficult to achieve without changing the contract types, since there is nothing that says that these construction managers will continue in the operation and maintenance organization. The interviewees state that these construction managers might quit or start working on some other project.

5.3.3.2 Keeping a link between the project and operation and maintenance

When the project is handed over, the interviewees mean that there should be a resource in the project who has been the link to what has been going on in the project and later brings the knowledge to the operation and maintenance. Then this person has been involved during a transition period, which the interviewees mean leads to a smoother handover in the end. According to the interviewees from business area Maintenance, this resource would discourage letting go of all knowledge and moving on. However, I6 from business area Investments states that this is not the whole solution to the challenge:

"There will be errors and shortcomings when the facility is in operation and therefore the whole solution is not that those who have been involved in building the facility should continue to be responsible for it. They have a tendency for being ashamed of flaws and mistakes and not wanting it to be exposed or come to the surface about how badly something works. Instead of using their technical skills to improve things, they almost try to hide the flaws, which is much more dangerous to do."

- I6, business area Investments

5.3.3.3 Implementation of a specialist organization

According to the interviewees from business area Major Projects, there should be a specialist organization that works with important issues on a national level, which can have several projects running at the same time and benefit from the experiences between the projects when they are ongoing. The interviewees from business area Major Projects believe that implementation of such an organization would help the handling of knowledge in the operational phase, as well as catch the issues much earlier in the project.

5.3.4 Standardization of documentation handling

According to the interviewees from business area Maintenance, there is a structure for documentation for railway facilities, but there is no structure for handling of documentation in a complex infrastructure project like Project A. This section discusses implementation of reference ID.

Implementation of reference ID

The interviewees from business area Maintenance mention that in Project A, work has begun to implement reference ID, where all documentation that is transferred must be coded. The purpose of the work is to create a prerequisite for the transfer to the receiving organizations, so that the information can be read into a system, but also is structured and searchable. The interviewees from business area Maintenance mention that reference ID is completely new for STA but is on the other hand quite common on the industrial side or the real estate side, for example in hospitals and nuclear power stations. Nevertheless, the interviewees from business area Maintenance state that reference ID has existed since the 90s, but it is something that has not been considered to be used at STA until now.

5.3.5 Offboarding process needed

This section discusses the need of an offboarding routine and process set up. Interviewees from business area Investments believe that there should be time to write down experiences before key people disappear from the project. However, it can be difficult for someone else to take time to read what the previous person who has had the same role as someone has written down. Moreover, the interviewees believe that some things people must experience by themselves to be able to absorb.

"There must be time for handover if someone were to quit, that you bring in a replacement who overlaps. So that you can pass on as much knowledge as possible. Because I think that even if we create lists and write down information, it can become too much administration, so then we do not do it anyway and the person who is going to read it might not think it is the most exciting thing to read either. There must be time for handover when new people are brought in".

- I8, business area Investments

Offboarding routine and process set up

The interviewees from business area Maintenance mention that there usually is a clear limit, that the project works until a certain date and then hand over the facility to business area Maintenance. Instead, the interviewees believe that there should be a floating limit or time before the facility is handed over. However, several of the interviewees believe that it can be hard to implement this improvement because it is a

challenge with resources, since project managers from the maintenance organization already have day-to-day tasks that they are responsible for and in addition they must put in additional time to receive a facility.

The interviewees believe that there should be a working method where there is room to be involved for a certain amount of time before the project is handed over. According to the interviewees from business area Maintenance, by having this set up of the process it would make it easier for the project managers to be able to participate in the handover, since having the possibility to set aside time is one of the most important things for achieving a good handover.

Table 4 describes possible improvements for the handover process.

Table 4 Possible improvements for the handover process.

Possible improvement	Description
Organizational structure suggestions	
New organization structure based on experience feedback meetings	A new organization structure which is based on experience feedback meetings should be considered.
Change of tasks to include maintenance	Business area Investments could be responsible for maintenance on everything they build during the entire warranty period.
Education	
Ensure the possibility to conduct education	The education need to be adapted for complex facilities, better arranged, separate for different roles and continuously updated.
Maintain competence	
Change of contract types to maintain knowledge	By making a change of contract types, it will lead to a gained facility knowledge and possibility to transfer a great amount of that knowledge to business area Maintenance.
Keeping a link between the project and operation and maintenance	There should be a resource in the project who has been the link to what has been going on in the project and later brings the knowledge to the operation and maintenance.
Implementation of a specialist organization	There should be a specialist organization that works with important issues on a national level.

Standardization of documentation handling	
Implementation of reference ID	Work has begun to implement reference ID where all documentation that is transferred must be coded.
Offboarding process needed	
Offboarding routine and process set up	A new working method could be investigated in which there is room for project managers of the operation and maintenance to be involved for a certain amount of time before the project is handed over.

6 Discussion

In this chapter, the findings from the empirical study are discussed in relation to the literature study. The discussion is divided into three sections where each research question is discussed separately.

6.1 Challenges with handovers of complex infrastructure projects

The main challenges that were identified in the interview study are organizational and communication challenges in the handover process. Organizational challenges in the handover process include: lack of preparation with complex facilities, lack of resources and knowledge for new types of facilities, lack of early involvement from the maintenance organization, organizational differences in handling of the process, and handover of an unfinished facility. Moreover, the communication challenges in the handover process include: challenges with contacting operation and maintenance in previous completed projects, information exchange issues, and lack of circulating knowledge back to the project organizations.

The findings from the interview study show that one organizational challenge is to have the maintenance organization involved in an early stage in order to receive knowledge from the project. The interview study highlights that it is good if the maintenance organization is involved through a continuous dialogue already in the planning stage, but no later than 3–4 years before the handover. However, it is challenging for project managers from the maintenance organization to have an early engagement since they already have day-to-day tasks that they are responsible for.

Even though the case organization has handover processes and rules for facilities that are normally recurring and has developed a common practice to receive documentation, an organizational challenge is that there is a lack of preparation for complex facilities. For complex facilities, the quantity of equipment, technical complexity, and the size of the facilities are much larger than what the handing and receiving organizations are used to handle. This suggests that the case organization has a need of resources and knowledge for how to handover knowledge concerning new types of facilities. From the knowledge-based view literature, the awareness and discovery of this need for knowledge might trigger a search for potential solutions (Szulanski, 1996).

A communication challenge which the interviewees agreed on is that there is a lack of circulating knowledge back to the project organizations, which can be connected to the literature where it is mentioned that existing procedures can limit the ways that information is returned to the decision makers, since there is usually no obligation to conduct post-project evaluations (Ahsan & Gunawan, 2010; Fahri et al., 2007). Today, the author believes that this is a quite common problem for many clients in the construction industry. However, it becomes even harder in complex projects where the

interviewees state that there is no functioning structure for dissemination of knowledge or experiences at the case organization.

A finding from the literature study, is that knowledge management is used to facilitate a structured approach to learn from construction projects and to find ways to share and reuse this knowledge (Addis, 2016). Regarding the interview study, contacting those who operate and manage complex facilities can result in that learnings can be made from their experiences. However, the interview study highlights this as a communication challenge since there is no guideline at the case organization on which people to contact, so this knowledge remains tacit. Grant (1996) emphasizes that knowledge is the most strategically and important resource of the firm's resources in the knowledge-based view. Moreover, the transferability of the firm's resources and capabilities are identified as a key factor in determining a firm's success (Barney, 1986). The author believes that this can be connected to the case organization and other clients, where a communication challenge is that the information exchange is limited through a few contact surfaces, which creates a filter where the information does not get through or is reinterpreted and changed along the way.

6.2 How projects manage knowledge during handover

This study contributes to the lack in literature concerning handover project processes in relation to knowledge transfer. Therefore, it becomes important to study tacit knowledge transfer in this process in more detail.

The findings from the interview study demonstrate how explicit and tacit knowledge is managed and transferred from the project to the receiving organizations. The interview findings on how complex projects manage knowledge during handover can be related to the SECI model (Nonaka, et al., 2000; Nonaka & Takeuchi, 1995).

In the socialization process, tacit knowledge is distributed from an individual to another individual by sharing experiences with each other (Nonaka & Takeuchi, 1995). However, from the interview study it became clear that there is a problem with accessing knowledge on an individual level in the handover process. The interview study shows that there are shortcomings regarding how knowledge is managed during handover, as well as where it can be obtained without it being tied to a person.

Further, the externalization process occurs when an individual begins to explain and share their tacit knowledge, which thereby is made explicit (Nonaka et al., 2000; Nonaka & Takeuchi, 1995). The author believes that this process is not clear at the case organization, since there seem to be a lack of routines and no clear descriptions of how to go about making use of tacit knowledge. If the process was clearer, other people in the organization could take part of it and learn from it, and lastly the knowledge would become a part of the organization (Nonaka et al., 2000; Nonaka & Takeuchi, 1995). Furthermore, the literature study highlights that the use of organizational routines create

the possibility for efficient coordination and specialization (Nelson & Winter, 1982). There are specialists at the case firm who are linking the projects with the receiving organizations, but they all work with their own processes which are not standardized. Thereby, the author believes that much of the knowledge they take with them stays tacit for these particular individuals.

Additionally, the findings show that the case organization works with the combination process where explicit knowledge is stored in documents and databases that are available to employees within the organization (Nonaka et al., 2000; Nonaka & Takeuchi, 1995). At the case organization, it is the handover and receiving coordinators who are responsible for ensuring that the delivery of management data is delivered, received, and approved. The author believes these roles are clearly described and appointed per project, but that these roles are more an administrative function. However, it is the project manager who is the main responsible at the end for all documentation to be handed over to the operation and maintenance (Lessard & Lessard, 2007). Furthermore, the author believes that it is not clear how it is ensured that all the knowledge, including tacit knowledge, has been transferred, and not only ticked off at the handover and receiving coordinator's list.

Moreover, an issue that is identified in the findings which also can be related to the combination process is that there are problems with updating documentation, which results in that documentation can be missed to be updated when changes are made to a facility. This can be caused due to a loss of knowledge since competent people move on to the next project. This corresponds to the literature where Nesan (2012) discusses how construction knowledge often is tacit knowledge, which is retained by the individuals and organizations and finally is lost once the project is completed. One way for the public client and other organizations to hinder this knowledge loss is by developing a plan for a steady transition of the project into the operation and maintenance and how to redistribute resources among project team members (Lessard & Lessard, 2007).

Moreover, the internalization process, "learning by doing" occurs at the case organization since there are many individuals within the organization who have developed tacit knowledge, but at the same time supported by codified knowledge which is stored in databases and documents, where the knowledge can be read and used (Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

Lastly, the interview study shows that knowledge is handled differently in different projects and is often connected to the people who are involved, where the literature study confirms that the effectiveness of knowledge transfer varies among organizations due to their capabilities to create, value and share knowledge (Koskinen & Ajmal, 2008). Even if the findings of how projects manage and transfer knowledge can be applied in the SECI model, Addis (2016) state that there are theoretical problems with a conversion method as the SECI model which can be demonstrated by considering how tacit and explicit knowledge relate to the difference between Ryle's (1946, 1949)

view of *knowing how* and *knowing that*. In comparison, the interviewees highlighted that often there exists documentation on what to do, but not how to do it, which makes many of the existing documentation (e.g., TDOK:s) open to one's own interpretation. Even if the case organization has a solid foundation for explicit knowledge and *knowing that*, the author believes that the process for integrating tacit knowledge and *knowing how* during handover can be improved.

6.3 Possible improvements for the handover process

The findings from the interview study highlight possible improvements for the handover process. Since this section is future oriented and about possible improvements, it becomes difficult to connect to the literature which is more problematizing.

The main possible improvements that were identified are maintaining competence by changing the organizational structure and conducting education. These improvements are in line with the earlier mentioned challenges on organizational and communication challenges, in which the organization's processes and structure were sometimes hindering knowledge transfer. The communication challenges showed a difficulty in transferring information and also a lack of knowledge.

The findings show that there is a need of organizational improvements, where the author believes that the organization could be restructured in order to accommodate a better knowledge transfer between the different groups. Firstly, a specialist organization could be implemented that works with important issues on a national level, where experiences between ongoing projects can be taken into consideration. This would enhance the transfer of knowledge, especially tacit knowledge since there rarely exists a functioning structure for making use of this knowledge in many client organizations, as discussed in Chapter 6.1. Secondly, the organization could investigate in a new working method in which there is room for the project managers of the operation and maintenance organization to be involved for a certain amount of time before the project is handed over. The findings show that one reason for why this improvement has not been implemented yet could be that it is a challenge with resources.

Another possible improvement from the findings is that the clients can reorganize their organization by adding maintenance to the project organization. However, this would require a big change of the organizational structure. On the other hand, this solution can solve several of the challenges with handovers, such as knowledge circulation and other challenges that are discussed in Chapter 6.1. However, the author believes that such a major organizational change would need to be investigated internally in relation to the consequences and risks involved with such a change.

Lastly, tacit knowledge can be transferred and acquired through education, thereby an improvement to ensure the possibility to conduct education is needed (Addis, 2016;

Argote & Ingram, 2000). The findings from the interviews show that the education need to be adapted for complex facilities, better arranged, separate for different roles and continuously updated.

7 Conclusions

In this chapter, the conclusions from the thesis are presented. Furthermore, the answers to the research questions are followed by suggestions on further research. The thesis has highlighted that the handover process is a challenge in construction projects, but becomes even more challenging in complex infrastructure projects, since they are much larger. Therefore, the aim with the thesis was to map challenges related to knowledge transfer for handovers and to produce improvement proposals that the case organization and other public clients can benefit from.

7.1 Answers to the research questions

What challenges are there with handovers of complex infrastructure projects?

Organizational and communication challenges in the handover process are the main challenges that were identified in this study. Since the handover routine at the case organization is based on a regular and more or less standardized road or railway projects, the knowledge of new types of facilities is less clearly defined and more easily lost. This organizational challenge suggests that the case organization has a need of resources and knowledge for how to handover knowledge concerning new types of facilities. Another organizational challenge is for the maintenance organization to be involved in an early stage in order to receive knowledge from the project.

There are communication challenges in the way that knowledge can be circulated back to the project organizations. However, it becomes even harder in complex projects where there is no functioning structure for dissemination of knowledge or experiences for complex projects. Furthermore, a guideline or structure on who to contact in order to make use of learnings from those who operate and manage complex facilities is lacking at the case firm, i.e., a contact list of who has competence within a certain technical area.

How do projects manage knowledge related to handover?

The findings on how knowledge is managed during handover for complex public projects are related to the SECI model (Nonaka, et al., 2000; Nonaka & Takeuchi, 1995). The study demonstrates how explicit and tacit knowledge is managed and transferred from the project to the receiving organizations, where it is highlighted that the case firm has challenges with accessing knowledge on an individual level in the socialization process. Moreover, there are issues with the externalization process at the case firm. On the other hand, the combination and internalization process work well at the case firm, which mean that explicit knowledge is handled relatively well in the process, meanwhile tacit knowledge is more difficult and has challenges.

How can the handover process be improved?

The handover process can be improved in many ways, but the main possible improvements that were identified in this study are maintaining competence by changing the organizational structure and conducting education.

There is a need of organizational improvements, where the organization could be restructured in order to accommodate a better knowledge transfer between the different groups. To begin with, a specialist organization could be implemented that works with important issues on a national level. Furthermore, the organization could investigate in a new working method in which there is room for the project managers of the operation and maintenance organization to be involved for a certain amount of time before the project is handed over.

Another possible improvement is that the clients can reorganize their organization by adding maintenance to the project organization. Lastly, tacit knowledge can be transferred and acquired through education, thereby an improvement to ensure the possibility to conduct education is needed.

7.2 Limitations

The master's thesis has been carried out during a short period of time, which have set some limitations on the scope of the project. Due to the comprehensive interview study which resulted in a large amount of data, only the most relevant data has been taken into consideration in this study.

Since there is a great variety of complex infrastructure projects, the work primarily concerned railway projects and road tunnel projects in Sweden, with one single client in the public sector.

Moreover, the study was limited to a qualitative research approach, by conducting semi-structured interviews. However, a quantitative research method by for example conducting a survey in addition to the interview study would have provided more facts on this topic and given an additional perspective to the study.

7.3 Suggestions for further research

Several of the findings in this master's thesis have created a foundation for further research of knowledge transfer for project handovers, and especially of complex infrastructure projects. Further research can be done by continuing the mapping of challenges related to knowledge transfer in handovers by conducting a more quantitative research approach. Moreover, further research can be done by studying the different approaches on how explicit and tacit knowledge transfer can be improved at public client organizations.

In addition, changes in the organizational structure to enhance knowledge transfer would be relevant to study in more detail. While organizational structure can impact knowledge transfer, this has not been studied for larger public client organizations in relation to the handover process of infrastructure projects.

The perspective on this topic can also be broadened by looking into how different clients or organizations in other countries handle knowledge transfer for handovers of complex infrastructure projects.

Finally, the thesis has produced improvement proposals that the case firm and other clients can benefit from, but also investigate further into.

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Appendix – Interview guide

Background

- What is your current professional role?
- Can you describe your professional background?
    - Name some projects that you have been involved in.
    - What was your role?
    - Were you involved in the construction phase or the management phase?

Knowledge

- How is knowledge managed, stored and transferred within complex infrastructure projects?
- How is it ensured that knowledge about operational and tunnel safety is maintained?
- How is knowledge about operational and tunnel safety implemented in the receiving organizations?
- How can explicit knowledge be used in complex infrastructure projects?
    - *Explicit knowledge is knowledge that easily can be articulated or stored. It can be expressed in formal and systematic language, as well as shared in the form of data, scientific formulas, specifications, manuals, etc.*
- How can tacit knowledge be used in complex infrastructure projects?
    - *Tacit knowledge is knowledge that is difficult to express or extract. This includes experience or intuition. Thus, it becomes difficult to transfer the knowledge to others verbally or in writing.*
- How is knowledge handled in the handover of complex infrastructure projects?

Handover

- What is important to consider in order to achieve a good handover?
- What problems can arise in the handover of complex infrastructure projects?
- How can delimitation problems be handled?
    - Within the contract with several sub-projects/suppliers?
    - Receiving business areas/operation and maintenance?

- Have you experienced a lack of communication in the handover process?
    - Is there something that is easy to miss during the handover process?
- What requirements are there for the development of routines and working methods for operational and tunnel safety?
- How should operational and tunnel safety be documented?
- How has the collaboration worked between the handing organization/handover coordinator and the receiving organization/receiving coordinator?
    - What is important to consider in order to achieve a good collaboration?

Operation and maintenance

- Do you possess knowledge about which requirements and governing documents you work with in order to maintain operational and tunnel safety?
- What routines and manuals/checklists do you work with operationally that support you and the business area you work at, with fulfilling requirements and governing documents?
    - How well are these implemented in the business area where you work at, on a scale from 1-10?
- How do you work with continuous improvement of operational and tunnel safety?
    - Do you update and improve documentation for operational and tunnel safety?
- How does the coordination of operational and tunnel safety function for a complex facility with both railway/road, traffic tunnels and underground stations/operating stations?

Experiences

- How are experiences from previously completed projects used?
- What experiences regarding knowledge management and handover of complex infrastructure projects do you bring with you from previous projects which you have been involved in?
    - What has gone well and less well?
- What have been the biggest challenges in the projects you have been involved in?

Miscellaneous

- Do you have anything else to add?

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

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