Integrated Product Service Offerings for Rail Infrastructure
– Potential Benefits and Challenges

Sofia Lingegård

Environmental Technology and Management
Department of Management and Engineering
Linköping University, SE-581 81 Linköping, Sweden
www.liu.se
Abstract

Large amounts of different materials are used when building and maintaining railway infrastructure, and the environmental impacts from the upstream production stages are significant. Industry’s motivation to innovate is low, new products or methods are rarely used, and the lowest price is the main driver for selecting a tender.

Integrated Product Service Offerings, or IPSO, has been put forward in the research literature as a potential concept to, from a life-cycle perspective, reduce the environmental impact of products and services, increase cost efficiency and quality, and act as a driver for change. Therefore, this thesis attempts to answer to the aim: “Can the concept of Integrated Product Service Offerings improve the management of rail infrastructure and if so, what would such an implementation induce in terms of risk factors?” The Swedish rail infrastructure is used as a case to discuss the considerations and feasibility of such an implementation. Theories such as product development, information asymmetry and innovation are used to complement the literature focusing on IPSO. The empirical part of the thesis has been collected using individual interviews, group interviews and a survey approach.

The contracts currently used in the railway industry have several advantages, such as being a familiar business model that is straightforward to calculate for the contractors. However, they are not optimal for innovation due to e.g. detailed specifications, standards and technological and market lock-in effects. Technological and market lock-in, in combination with a lack of information transfer between different contracts and actors, are major disadvantages with the current practice. Furthermore, the buyer’s conservative business culture makes it difficult to implement new types of contracts since it is difficult to break old habits. Even though the providers are part of the same mature market, the organizational changes needed for them to fulfill IPSO contracts are not seen as a barrier.

A benefit with IPSO is the holistic life-cycle perspective that provides incentives for dematerialization, resulting in a more resource-efficient and durable infrastructure. IPSO requires improved information transfer, something which stimulates innovation as well as processes for evaluation of the contracts. Further benefits are potential incentives to get contractors involved in the design phase, where the major decisions about the life-cycle are made, in order to reduce the infrastructure’s environmental impact and total life-cycle cost. The contractors hope that IPSO contracts will make the buyer focus less on e.g. the initial purchasing price and more on the total life-cycle cost in relation to quality in order to get the best solution.

The actors see themselves as parties with opposing interests. At the same time, IPSO will most likely imply more long-term cooperation, something that calls for common interests, shared risks and flexibility. The innovation possibilities with IPSO could benefit from loosening up the material handling monopoly that the buyer currently holds. Since the buyer
is a dominant actor within the industry, this organization has major possibilities to introduce changes that the other actors would have to conform to.

Several challenges with IPSO are discussed, and most of them are derived from the risk and uncertainty aspects that come with long-term contracts and inexperience with a new business model. On one hand, the contractors request more flexibility; on the other hand, they are reluctant to take on more responsibility that could lead to increased risk. However, risk does not have to be seen as something completely negative, as it depends on how the contractors choose to deal with it. They can either develop the necessary skills and competence needed to identify and handle the risk in a strategic manner, foster a competitive advantage, or take the problems as they come in a more ad hoc way. A way to reduce risk and uncertainty seems to be to focus on transparency and information sharing between the actors and the contracts. This would also open up IPSO contracts for reinvestments, where the current lack of information concerning the condition of the facilities results in reluctance for IPSO contracts.

This research has focused on IPSO for rail infrastructure management, using the Swedish rail infrastructure as a case to discuss the considerations and feasibility of such an implementation. The conclusions, therefore, are valid for rail infrastructure in other geographical locations as well.
Acknowledgements

The past two and a half years of research are now summarized, analyzed and concluded in this Licentiate thesis. It has been a challenging yet interesting process including many inspiring encounters with people from around the world.

First, I would like to thank my supervisor Mattias Lindahl for his commitment to the project and his flexible approach to providing guidance and feedback, regardless of it being a working day or a weekend. I would also like to thank my co-supervisor Niclas Svensson for sharing his knowledge about the rail infrastructure industry, wise from wisdom gained during his own work as a PhD candidate. Additionally I owe gratitude to Tomohiko Sakao for introducing me to the field of Integrated Product Service System and providing me with survival tips for conferences in Japan.

A collective thanks goes out to the Division of Environmental Technology and Management at Linköping University for their support during this fall. Additionally I would like to thank the Thursday cakes program, previously known as Monday cakes, which always contribute to the atmosphere. Another group thanks to my friends and fellow PhD student colleagues for welcome interruptions in the working process.

I would also like to thank the Swedish Transport Administration (Trafikverket) for financing this research as well as all the respondents for participating making the research possible.

Another thank you goes to Mica Comstock for contributing to the quality of the thesis by proof reading every sentence and making sure they are comprehensible.

I would like to thank my parents for providing long-distance support when I felt a bit down and to my sister to whom (I hope?) I am always welcome for a “fika.” Thank you Michael Martin for enduring me during this process and for supporting me all the way. Finally, thank you to Nivos our Vizsla for eating my floor boards, steeling my sandwhich spreads but still managing to lighten up my day with his constant happiness to see me.
List of Appended Papers


My contribution to articles

For [P1], [P2] and [P4] I have realized the data collection and the writing of the papers with guidance and support from Mattias Lindahl and Niclas Svensson. [P3] was written by Mattias Lindahl, Tomohiko Sakao and me as a joint effort where I contributed with one section.

Related Publications


# TABLE OF CONTENTS

1  INTRODUCTION ....................................................................................................................... 1  
   1.1 AIM AND RESEARCH QUESTIONS .................................................................................. 3  
   1.2 LIMITATIONS .................................................................................................................. 4  
   1.3 DEFINITIONS AND CONCEPTS ..................................................................................... 5  
   1.4 STRUCTURE OF THESIS ............................................................................................... 5  

2  FRAME OF REFERENCE ........................................................................................................... 7  
   2.1 A LIFE-CYCLE PERSPECTIVE FOR PRODUCT DEVELOPMENT ............................................. 7  
   2.2 INNOVATION .................................................................................................................... 8  
   2.3 TECHNOLOGY AND MARKET LOCK-IN ............................................................................. 9  
   2.4 INTRODUCTION TO INTEGRATED PRODUCT SERVICE OFFERINGS .................................... 10  
   2.5 DEVELOPING AN INTEGRATED PRODUCT SERVICE OFFERING ....................................... 13  
      2.5.1 The importance of the supply chain ........................................................................... 14  
   2.5.2 Life-cycle thinking and information asymmetry ........................................................ 14  
   2.6 ORGANIZATION AND CORPORATE CULTURE .............................................................. 15  
   2.7 FINANCIAL RISKS AND UNCERTAINTIES FOR LONG-TERM CONTRACTS ......................... 15  
   2.8 INDUSTRY EXAMPLES OF IPSO IMPLEMENTATION ....................................................... 16  
      2.8.1 BT Industries ................................................................................................................. 17  
      2.8.2 ITT Flygt ......................................................................................................................... 17  
      2.8.3 Danfoss .......................................................................................................................... 17  
      2.8.4 Rolls-Royce ..................................................................................................................... 18  

3  METHODOLOGY ..................................................................................................................... 19  
   3.1 RESEARCH STRATEGY ..................................................................................................... 19  
   3.2 RESEARCH PROCESS ...................................................................................................... 22  
      3.2.1 Literature reviews ........................................................................................................ 22  
      3.2.2 Interview study .......................................................................................................... 23  
      3.2.3 Survey ........................................................................................................................ 26  
      3.2.4 Group interview ........................................................................................................ 27  

4  SUMMARY OF CONTRIBUTIONS TO THE THESIS ............................................................. 29  
   4.1 APPENDED PAPERS ......................................................................................................... 29  
   4.2 [P1]: PSS FOR RAIL AND ROAD INFRASTRUCTURE .......................................................... 29  
   4.3 [P2]: PSS CONTRACTS FOR RAIL INFRASTRUCTURE .................................................... 30  
   4.4 [P3]: THEORETICAL ENVIRONMENTAL COMPARISON OF INTEGRATED  
       PRODUCT SERVICE OFFERINGS VS. TRADITIONAL SALES ........................................... 31  
   4.5 [P4]: IDENTIFICATION OF RISKS RELATED TO INTEGRATED PRODUCT  
       SERVICE OFFERINGS OF RAIL INFRASTRUCTURE ..................................................... 31
SWEDISH RAILWAY INFRASTRUCTURE IN RETROSPECT – A BRIEF SUMMARY .......................................................................................................................... 33

CONTRACTING FORMS CURRENTLY IN USE ................................................................................................................................. 35

6.1 CONSTRUCTION CONTRACTS ................................................................................................................................. 36
6.2 MAINTENANCE CONTRACTS ................................................................................................................................. 36
6.3 DESIGN-BUILD CONTRACTS ................................................................................................................................. 38
6.4 THE ACTOR’S PERSPECTIVE OF CURRENT PRACTICE ....................................................................................... 38

IPSO CONTRACTS FOR RAIL INFRASTRUCTURE ................................................................................................................. 41

7.1 MODELING AN IPSO CONTRACT ................................................................................................................................. 41
7.1.1 The Arlanda airport shuttle – an IPSO contract? ................................................................................................. 42
7.2 BENEFITS AND ADVANTAGES OF IPSO CONTRACTS ............................................................................................ 42
7.2.1 The view of the contractors ................................................................................................................................. 42
7.2.2 The view of the STA ............................................................................................................................................... 43
7.3 CHALLENGES FOR IPSO CONTRACTS ..................................................................................................................... 44
7.3.1 The view of the contractors ................................................................................................................................. 44
7.3.2 The view of the STA ............................................................................................................................................... 47

RISK FACTORS IDENTIFIED FOR USING PSS FOR RAIL INFRASTRUCTURE ................................................................................................................. 51

DISCUSSION ........................................................................................................................................................................... 53

9.1 THE CURRENT SITUATION RAIL INFRASTRUCTURE PROCUREMENT .................................................................................. 53
9.1.1 Technological lock-in and lack of information transfer .......................................................................................... 53
9.1.2 Conservative culture ............................................................................................................................................... 54
9.2 POTENTIAL BENEFITS AND CHALLENGES REGARDING IPSO FOR RAIL INFRASTRUCTURE ....................................................... 55
9.2.1 Increased value and cost reduction .......................................................................................................................... 55
9.2.2 Developing a more durable railway ....................................................................................................................... 55
9.2.3 Competition and supply chain ............................................................................................................................ 57
9.2.4 Organization and culture ....................................................................................................................................... 57
9.2.5 Contracting ............................................................................................................................................................ 58

CONCLUSIONS AND FUTURE RESEARCH ............................................................................................................................ 61

10.1 RQ1 – HOW IS RAIL INFRASTRUCTURE MANAGEMENT CURRENTLY PROCURED? .................................................................................. 61
10.2 RQ2 – WHAT ARE THE POTENTIAL BENEFITS AND CHALLENGES FROM THE PROVIDER AND BUYER PERSPECTIVES REGARDING IPSO FOR RAIL INFRASTRUCTURE? ........................................................................... 61
10.3 RQ3 – WHAT POTENTIAL RISK FACTORS CAN BE IDENTIFIED WHEN USING IPSO FOR RAIL INFRASTRUCTURE? ............................................................................................................................... 62
1 Introduction

Railway traffic in Sweden uses mainly electricity from hydro and nuclear power, resulting in a relatively small use of fossil fuels according to previous research (Svensson, 2006). The same dissertation states that when the railway is addressed in environmental terms, it rarely includes the pressures from the infrastructure that account for a substantial part of the greenhouse gas emissions from the railway transport. Large amounts of different materials are used when building and maintaining the infrastructure, and the environmental impacts from the upstream production stages are significant (Svensson & Eklund, 2007). Thus far, the Swedish Transport Administration, or STA, has not had a life-cycle approach to its work. There is a need for the STA to start working with the environmental management of products when designing new products, i.e. before introducing them in the material supply chain, to reduce their environmental impacts (Svensson, 2006).

Certain contracting forms, such as performance contracting, can increase the drivers for change within the industry and thereby increase cost efficiency and quality from a life-cycle perspective (The Swedish Agency for Public Management, 2009). The fact that the provider has control over the whole life-cycle of the product provides incentives to realize more environmentally and economically sound development when considering the whole life-cycle (Lindahl, 2006). This type of contracting is also known as an Integrated Product Service Offering (IPSO), and implies that one actor has the responsibility to deliver a result and therefore has incentives to optimize the use of energy and material (Goedkoop et al., 1999; Tukker & Tischner, 2006b). IPSO is defined as “…from a lifecycle perspective, to offer and optimise a solution with a combination of products and services that satisfies an identified customer need, and at the same time increases the suppliers’ competitiveness” (Lindahl, 2006). Products and services that operate well together are developed in parallel into an integrated offering. This, however, implies that the provider needs to be in charge of the design phase for this to work. This is important, since it is in the design phase where materials are selected and most of the environmental impacts are locked into the product (Lewis & Gertsakis, 2001). In fact, the design phase in a product life-cycle corresponds to around 80% of the influence for the total environmental impact of the life-cycle of the offering (Sakao, 2009). There are a number of conditions that are well-suited to the IPSO business model (Tukker & Tischner, 2006a):

- products with high operations and/or maintenance costs;
- complex products that require special competencies to design, operate, manage and/or maintain;
- products with considerable consequences or costs if not used correctly or appropriately;
- products where operational failure or downtime is not tolerated;
- products with long life; or
- products with only a few major customers on the market.
All these conditions apply to the rail infrastructure industry, where a complex infrastructure system with high maintenance costs represents the product, and where this system causes major impact on the train traffic if it breaks down. The life-cycle of a railway lasts decades, and on the Swedish market there is only one customer, the STA.

The need for change and development is known within the industry; in 2003, the STA\(^1\) initialized the Renewal in the Civil Engineering Industry forum, with the purpose of creating a forum for renewal (FIA, 2011). Greater efficiency, improved interaction, better incentives for research investments and more effective mediation of knowledge are the established goals for this initiative, and terms like "life-cycle thinking" and "improve resource efficiency" are mentioned as ways to reach these goals (FIA, 2011). It is now the STA’s strategy to get as much railway as possible for the money spent. This includes increased productivity, level of innovation and competition and a will to think more from a life-cycle perspective and work more cost-efficiently. Changes in the business model is one of the strategies mentioned to reach these goals (Trafikverket, 2011).

Furthermore, productivity development in the construction industry in Sweden, such as road and rail infrastructure, has been weak for a long period of time, possibly due to the traditional form of contracting used (Nilsson, 2009a). The motivation to innovate is low in the industry, new products or methods are rarely used, and the lowest price is the main driver for selecting a tender (Olander et al., 2010). Construction contracts are currently used to a large extent in Sweden, but this type of contract has shortcomings concerning weak incentives for development of the procedures (Nilsson et al., 2006a). To create incentives for economic and environmental innovation, there is a need for strong public support (Cerin, 2006). The public part in the rail infrastructure industry in Sweden is the STA, and this organization is responsible for 80% of the total rail system in the country (Banverket, 2008). Before 2001, the STA procured all contracts within its own organization, but since 2001 the contracts have been procured in competition, which has resulted in a cost reduction; nevertheless, costs are still increasing (Banverket Produktion, 2009). The mismanagement of the rail infrastructure over the past decades has caused poorly maintained infrastructure and an inefficient organization (Alexandersson & Hultén, 2008; Thompson et al., 1998; Tullberg, 2000).

Implementing a new business model, however, is not without its challenges; when the business model changes, so do the risks (Nystén-Haarala et al., 2010). For an outcome-based contract such as an IPSO, the risk distribution changes and the supplier is responsible for risk concerning e.g. investments and maintenance (Nystén-Haarala et al., 2010). Risks are caused by uncertainties that, for a long-term performance-based contract, arise at the bidding stage

\(^1\) In 2010, the Swedish Rail Administration, the Swedish Road Administration and the Swedish Maritime Administration, as well as the Swedish Institute for Transport and Communications Analysis, all became a part of a new larger organization called the Swedish Transport Administration (The Swedish Transport Administration, 2010b)
(Erkoyuncu et al., 2011). Key uncertainties for an IPSO contract are performance, operation, training, engineering, affordability and commercial uncertainties (Erkoyuncu et al., 2011).

The research presented in this thesis is funded and supported by the STA showing that there is a will to improve the industry and increase productivity, the rate of innovation and competition. IPSO contracts could be one way to achieve this, by introducing the industry to life-cycle thinking and performance contracts. Previous research states that to create incentives for significant economic and environmental win-win innovation, strong public support is needed (Cerin, 2006). The author further suggests that this could be achieved by extended producer responsibilities and environmental public procurement, both of which IPSO contracts have the potential to include, either directly or indirectly.

This research has been realized at the Division of Environmental Technology and Management, Linköping University, a research group with the outspoken aim to work for proactive measures to solve environmental issues. As mentioned above, the rail infrastructure accounts for a large environmental impact; it is therefore of interest to investigate a business model like IPSO that could be used to provide a proactive approach to reduce this impact. This Licentiate thesis presents a starting point in the investigation of a complex issue, and will be followed by other research projects that more profoundly relate to this topic.

1.1 Aim and research questions

The concept of IPSO provides elements that could potentially improve some of the issues in the rail infrastructure industry. At the same time, this could generate risks: both now within other industries where the IPSE concept has been implemented, as well as later in during the course of long-term contracts. This reasoning provides the following aim for the thesis:

“Can the concept of Integrated Product Service Offerings improve the management of rail infrastructure and if so, what would such an implementation induce in terms of risk factors?”

It is important to emphasize that the research has been performed from the perspective of the buyer and the providers, which means that it is their perspective of this matter that is presented and analyzed. To answer the research aim, an initial research question was formulated to generate a foundation of knowledge. Furthermore, the aim itself has been broken down into two separate research questions. These questions are presented below.

RQ1: How is rail infrastructure management currently procured?

- a) What types of contracts are used today for procurement?
- b) How are the different actors involved in these contracts?
- c) What are the actors’ views on the current practice of procurement?
The research question will provide a description and analysis of the current situation for rail infrastructure management, investigating both advantages and disadvantages. This information is needed to understand the context for further investigation in RQ2 and RQ3. The actors in this context are, in most cases, the buyer and the providers.

**RQ2: What are the potential benefits and challenges from the provider and buyer perspectives regarding IPSO for rail infrastructure?**

This research question has a deliberately broad scope due to its explorative nature, and provides a mapping of benefits and challenges from the view of the buyer and the providers. This research question will provide a description and analysis of the scenario of using IPSO for rail infrastructure management in Sweden. Since IPSO has potential to make the infrastructure more resource-efficient, the main focus of these benefits and challenges will be environmental and economic. Additionally, to be able to answer RQ3 the knowledge of the benefits and challenges that would be created using IPSO is necessary. RQ2 provides an overview needed to generate a deeper understanding in RQ3.

**RQ3: What potential risk factors can be identified when using IPSO for rail infrastructure?**

After investigating the current situation in the industry and the potential benefits and challenges for IPSO for rail infrastructure, it is possible to take the investigation one step further. The focus for RQ3 is on an risk, which is essential for both long-term contracting and for implementation of IPSO. The concept of IPSO, where dematerialization and a life-cycle perspective in the design phase are essential, could potentially reduce environmental as well as economic risk. RQ3 will identify risk factors from the buyer and provider perspectives, as well as propose how the risks can be managed.

### 1.2 Limitations

This section presents the limitations placed on this thesis. The areas and topics below are not irrelevant to the aim and research questions, but are also not in the core of the research or considered for inclusion in further research.

- The first research question is, as described above, deliberately formulated to be open with an explorative approach. The area is later narrowed down to some focal areas, namely organizational changes, market and competition and risk.

- Excluded from the discussion concerning long-term contracts are contracting law and public procurement-related issues. It is assumed that the research is realized within the laws and regulations of public procurement.

- Performance measures that are normally used for IPSO contracts will not be discussed in more than a brief, qualitative way, since this focus will be included in future research.
• Pricing strategies for contracts will not be discussed as a focus area in this thesis. Pricing and cost are very much related to the risk management of the contracts, and will therefore be somewhat covered and explained when necessary for the reasoning as a whole. Cost will be one of the focus areas for future research.

• This thesis will not discuss different financing forms, such as Public Private Partnership, since the focus is on the content of the contracts and the organization around them.

1.3 Definitions and concepts
This section presents a shorter description of the definitions and concepts that are essential for this thesis. It is important to describe what they mean in the context of this research to avoid misinterpretations while reading.

Contractors: The companies that perform construction and maintenance work in the construction industry.

Innovation: Innovation is defined as “the introduction of something new, or an act or process for new ideas, methods, or devices” (Pakkala, 2002).

Integrated Product Service Offering, IPSO: IPSO be defined as “…from a lifecycle perspective, to offer and optimise a solution with a combination of products and services that satisfies an identified customer need, and at the same time increases the suppliers’ competitiveness” (Lindahl, 2006).

Life-cycle: A life cycle can be described as the concept of product life, and includes the life phases as well as the loops between them. The phases include design/development, resource extraction, production of materials, manufacturing, use and end-of-life activities. (Rebitzer et al., 2004). The life-cycle concept is an approach to products, processes and services where all life-cycle stages have environmental and economical impacts (Fava & Weston, 1997).

Product: A physical product/good is a tangible items that is available on the market and has a market value (Kotler, 2011).

Risk: The term risk in this thesis is defined as the threat of loss from an unwanted event, and the loss can concern financial, performance or timescale loss (Erkoyuncu et al., 2009).

Service: A service is a performance or a process that is intangible, perishable, and heterogeneous. Furthermore, the consumption and the production of a service are inseparable (Ng, 2008).

1.4 Structure of thesis
Chapter 1 includes the introduction where background, motivation, aim and research questions as well as limitations are presented.
In Chapter 2, the frame of reference for this thesis is described to provide a theoretical structure and scope.

The methodology of the research presented in this thesis is described in Chapter 3. This chapter includes both the research strategy, explaining which methodological choices were made during the course of the thesis project, as well as how they were realized and what measures that were taken to ensure the quality of the work.

In Chapter 4, a summary of the appended papers and a description of their contribution to the thesis are presented.

Chapter 5, which presents a brief summary of the management of the Swedish railway infrastructure, is needed to understand the background of the organization and the current condition of the rail infrastructure.

Chapters 6-8 present the results from the appended papers as well as new material needed to be included to answer to the aim of the thesis. Chapter 6 describes the contracting forms currently used in Sweden and the actors’ view of them, while Chapter 7 focuses on the potential use of IPSO contracts. In Chapter 8, potential risk factors related to the use of IPSO contracts are presented.

In Chapter 9, the results are discussed and the areas of the research questions are covered.

The conclusions of the thesis are presented in Chapter 10. This last chapter also includes planned and suggested future research.
2 Frame of reference
The theory used in this thesis spans several different areas of theory. The first section presents the concepts of the life-cycle perspective and resource efficiency for product development. This is essential to this thesis, since the management of rail infrastructure includes a large amount of material and is currently lacking a holistic perspective. Rail infrastructure represents a mature industry with long life-cycles and the concepts of innovation as well as technology and market lock-in area are of interest. These areas are presented in Section 2.2 and 2.3. Subsequently, the concept of IPSO is presented including key aspects, examples from the industry, benefits and challenges as well as an additional focus on uncertainties and risk for IPSO. Examples of IPSO offerings from four different companies are presented in the end of this chapter, in Section 2.8, to illustrate the business model.

2.1 A life-cycle perspective for product development
Given that railway infrastructure is responsible for large environmental impacts in Sweden, it would be interesting to look into proactive ways to improve future construction and maintenance work. It has been determined that a large degree of the environmental pressure of society can be attributed to flows of material and energy (Ayers, 1994). Previous research in the rail infrastructure area states that large amounts of different materials are used when building and maintaining the infrastructure, and that the environmental impacts from the upstream production stages are significant (Svensson & Eklund, 2007). For certain products, such as infrastructure, it is the initial stages of the life-cycle, i.e. the resource extraction as well as the processing and refining of raw material, that have the largest environmental impact (Clift & Wright, 2000). This is because the infrastructure requires large amounts of energy in the construction phase, but during the use phase the products are generally more passive in terms of energy use. Additionally, these products are typically non-complex since they do not include large amounts of different types of material, making the end-of-life treatment less complicated and thus less energy consuming (cf. (Svensson, 2006)). For the rail infrastructure, three products have been pointed out as the main contributors to material use and material-related energy: steel rail, concrete ties and ballast material such as crushed rocks (Svensson, 2006).

A strategy to reduce material and energy is dematerialization, where the focus is on lowering the inputs (Dobers & Wolff, 1999), and focusing on dematerialization can reduce the environmental impact (Mont, 2000; Öhlund, 2003). Dematerialization contributes to lowering environmental impacts as well as to reducing costs, and key factors are e.g. cooperation and a focus on functions, and not on products (Dobers & Wolff, 1999).

Previous research within the infrastructure industry states that the earlier in the planning process the provider is involved, the better the opportunities are to adapt the content and the realization of the project to its specific conditions and the requirements (Nilsson, 2009a). As
mentioned in the introduction, the design phase of an IPSO has the largest part in the influence on the environmental performance of an offer (cf. (Lewis & Gertsakis, 2001)). The importance of making decisions early in the product development process, when there is still freedom to make changes, is supported by the illustration in Figure 1. The further along in the process the more modifications cost, due to the difficulty in making the changes. This is more thoroughly described in Appendix 4.

![Diagram showing the relation between Freedom of action, Product knowledge, and Modification cost over time.](image)

Figure 1: The relation between “Freedom of action”, “Product knowledge” and “Modification cost” is shown (Lindahl, 2005).

The life-cycle of a product (goods and services) can be described as the concept of product life, including the life phases as well as the loops between them. The phases include design/development, resource extraction, production of materials, manufacturing, usage and end-of-life activities (Rebitzer et al., 2004). The life-cycle concept is an approach to products, processes and services and acknowledges that all life-cycle stages have environmental and economic impacts (Fava & Weston, 1997). This implies a holistic view of products, which emphasizes that the effects of a decision at one point in the life-cycle can cause environmental impacts at other stages. Previous research within the area of life-cycle thinking points at the integration of environmental considerations into design, manufacture, packaging and processes to achieve economic and environmental benefits as the ultimate goal (Fava & Weston, 1997).

2.2 **Innovation**

The management of the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new or improved process or product can be
described as innovation (Trott, 2012). Innovation could be improvements of a product or something new to the world or the firm (Ahmed & Shepard, 2010). This means that innovation can be both radical or incremental, and can be described as a life-cycle beginning with a radical change in technology (Trott, 2012). The performance of a technology is often displayed in a S-curve where the performance is plotted against time or engineering effort (Christensen, 1992), as illustrated in Figure 2.

A new and radical technology marks the beginning of the S-curve, whereas incremental innovations occur when moving along a given S-curve (Christensen, 2000). In the early stages of the curve the technology is poorly understood, but improvements in the technology begin to accelerate until a limit is reached (Schilling & Esmundo, 2009). Not all technologies reach their limit, but could instead be replaced by another technology somewhere along the S-curve (Christensen, 2000).

![Figure 2: The Technology S-curve (Christensen, 1992).](image)

In the beginning of the curve differentiation of design is in focus for the market, followed by a standardization phase where a dominant design is set (Trott, 2012). This is when the focus shifts to efficiency and lowering production costs (Schilling & Esmundo, 2009). It is here where the bargaining power for both supplier and customer will increase and the actors will secure positions on the market, providing entry barriers for new actors (Trott, 2012).

### 2.3 Technology and market lock-in

The dominant design is not always the best or optimal technology, but could instead be the design that has a faster learning curve; the result is that the more learning that occurs, the
less likely the actors will be to investigate other technologies, even if they are better (Ahmed & Shepard, 2010).

Technological lock-in is a result of mainly two elements; technological paradigms, i.e. technology S-Cures, and increasing returns to adoption, meaning incentive structures and reinforcement paths for a technology (cf. (Perkins, 2003)). Technologies are parts of broader networks with supporting infrastructures with physical evidence along with technical, economic and organizational structures enabling existing technologies (Perkins, 2003). Learning, culture and habit can lead to inefficiency due to employees’ unwillingness to explore new ways of doing things, since this could cause them to lose their positions of control and power (Ahmed & Shepard, 2010). The costs for switching a technology becomes significant, since not only physical elements need to be changed but also existing skills, behavior patterns and work practices (Perkins, 2003). This is also in line with the design paradox, seen in Figure 1, where the modification costs increase over time. It is also true for customers that become attached to products even though there are better or cheaper options (Ahmed & Shepard, 2010). These network factors raise the barriers for new technologies that are not part of the dominant technological design to enter the market (Perkins, 2003). The result is a type of market lock-in. For the rail infrastructure market and technology, lock-ins are e.g. the width of the tracks and the signal system that need to be compatible with the trains. Another market lock-in is the situation where there is only one dominant buyer on the market, as is the case for rail infrastructure in Sweden.

### 2.4 Introduction to Integrated Product Service Offerings

Many different definitions and names exist for contracts or business models based on performance or function (Ng & Yip, 2009a; Ng et al., 2009; Nilsson et al., 2006a; Zietlow, 2004). A further development of these models are the ones including a systems approach, where the life-cycle of the product and service are included (Alonso- Rasgado et al., 2004; Brady et al., 2005a; Goedkoop et al., 1999). Additionally, some business models take the life-cycle approach one step further and emphasize the integrated development of the product and the service for the offering (Lindahl, 2006; Meier et al., 2010; Meier et al., 2005) Names and definitions of these concepts are presented in Table 1.

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition/description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome-based contracting</td>
<td>“…a contracting mechanism that allows the customer to pay only when the firm has delivered outcomes, rather than merely activities and tasks.”</td>
<td>Ng et al., 2009, p. 1 (Ng et al., 2009)</td>
</tr>
<tr>
<td>Performance-contracting</td>
<td>“The contract terms are based on that future users are given access to some specific services, not on the contractor fulfilling technical specifications: it is the performance of the asset over the contracting period that matters.”</td>
<td>Nilsson et al., 2006, p. 7 (Nilsson et al., 2006a)</td>
</tr>
<tr>
<td>Performance based contracts</td>
<td>“…are about contracting on performance, rather than tasks or outputs by the service provider.”</td>
<td>Ng and Yip, 2009, p. 207 (Ng &amp; Yip, 2009b)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Performance contracts</td>
<td>“Performance Contracts are defining a product and it is up to the contractor how to achieve this. Therefore, work selection, design and delivery are all his responsibility.”</td>
<td>Zietlow, 2005, p. 3 (Zietlow, 2004)</td>
</tr>
<tr>
<td>Solutions projects</td>
<td>“…solutions projects usually include the responsibility for the provider to manage, resource, support and improve the delivery of the solution through the life of the product or system in use.”</td>
<td>Brady et al., 2005, p. 364 (Brady et al., 2005a)</td>
</tr>
<tr>
<td>Functional sales</td>
<td>“The customer purchases a function and the hardware plus service includes the totality of activities that enable the customer to benefit from a total functional provision.”</td>
<td>Alonso-Rasgado et al., 2004, p. 515 (Alonso- Rasgado et al., 2004)</td>
</tr>
<tr>
<td>Product service system, PSS</td>
<td>“a marketable set of products and services capable of jointly fulfilling a user’s need”</td>
<td>Goedkoop et al., 1999, p. 18 (Goedkoop et al., 1999)</td>
</tr>
<tr>
<td>Integrated Product Service Systems, IPS²</td>
<td>“…is characterized by the integrated and mutually determined planning, development, provision and use of product and service shares including its immanent software components in Business-to-Business applications and represents a knowledge-intensive socio-technical system.”</td>
<td>Meier et al., 2010, p. 608 (Meier et al., 2010), originally in (Meier et al., 2005)</td>
</tr>
<tr>
<td>Integrated Product Service Offerings, IPSO</td>
<td>“…from a lifecycle perspective, to offer and optimise a solution with a combination of products and services that satisfies an identified customer need, and at the same time increases the suppliers’ competitiveness.”</td>
<td>Lindahl et al., 2006, p. 1-2 (Lindahl, 2006)</td>
</tr>
</tbody>
</table>

The two models using the integrated approach, Integrated Product Service Systems, IPS² and IPSO are largely interchangeable, but in this thesis the IPSO will be the concept used.

IPSO has a life-cycle perspective and includes large parts of the value chain in an integrated offering that instead of selling physical products provides functions, service and performance (Sundin, 2006). With integrated development, it is no longer possible to separate the product and the service in the different phases of the life-cycle (Meier et al., 2010). Figure 3 illustrates how an IPSO includes the activities of the product life-cycle for a product with a high environmental impact from the use phase, which is true for many cases (Sakao, 2009). The bars show a rough estimation of the environmental impact of the activities (left vertical axes), while the dotted line shows the accumulated environmental impact (right vertical axis).
In this thesis, an IPSO is a result-oriented service, meaning that the buyer and provider agree upon a functional result but the provider is free to decide how to achieve this result (Tukker, 2004). Figure 4 presents a framework, based on a review of the research area, that illustrates the concept of IPSO in the figure referred to as IPS², and the elements involved in the life-cycle to provide success for the offering (Roy & Cheruvu, 2009). The left side of Figure 4 presents drivers for IPSO, such as customer affordability, technology development and environmental sustainability. Three main aspects of the commercial environment of the IPSO are presented: risk and uncertainties, contractual platform and cost and revenues. Design, delivery and adaptation are presented as the three main stages of the IPSO life-cycle, and listed beneath them are the required capabilities for the different actors involved in the offering. These include among other things service network, organization structure and co-creation of value. The main outcome from an IPSO is sustainable customer value, where customer value is defined as the difference between what the customer receives and what the customer has paid, as well as the time and energy spent to buy the product and learn how to use it.
Developing an Integrated Product Service Offering

IPSO provides the supplier with a possibility to increase the value of the solution for the customer, as seen in Figure 4, by integrating components in new ways (Brady et al., 2005a), and is thereby a driver for the development of technical solutions (Lindahl, 2006). There are incentives for the supplier to realize improved economic and environmental development when considering the whole life-cycle (Lindahl, 2006), as illustrated in Figure 3. Infrastructure projects procured using integrated contracting including design, construction and maintenance have better life-cycle costs (Pakkala, 2002). Additionally, using a product-service mix with more durable materials and other designs may prolong the lifetime of the product and potentially optimize maintenance and operations (White et al., 1999). Previous research has also shown that projects with an integrated process, such as IPSO projects for infrastructure, are completed faster (Pakkala, 2002).

IPSO could be initiated by the provider to generate growth or a continuous revenue stream throughout the whole life cycle of the product (Brady et al., 2005a; Mont, 2002). In a mature industry, IPSO could be part of a growth strategy (Mont, 2002). Other internal drivers for the provider are resource management and environmental improvements (Mont, 2004). The external drivers vary depending on the industry sector. In a mature market like the rail infrastructure industry it can be difficult for providers to differentiate due to standardized technology, which makes the competition focused on price and subsequently low profit margins (Mont, 2004). There are innovation possibilities since the offerings follow the customer’s needs, but this requires a focus on the whole system with suppliers and buyers.
The knowledge that actors gain through experience provides leverage in the process of incremental innovation (Trott, 2012). A benefit mentioned in the literature for IPSO is the possibility to gain knowledge during the use of the offering to reconfigure or redesign it (Meier et al., 2010). The knowledge base of a company is larger than the sum of the individual knowledge of the employees (Trott, 2012). This knowledge is not easily accessible for other actors, since it is distinctive to the firm and includes the individual way in which the technology is applied (Trott, 2012).

It can be difficult, however, to convert abstract demands into concrete quality performance indicators, resulting in difficulties for buyers to know if they got what they asked for, and for providers to determine what to supply (Tukker, 2004). To reduce the gap between required and delivered results for performance-based contracts such as IPSO the actors need to agree on performance measures (Datta & Roy, 2011).

2.5.1 The importance of the supply chain

One of the great challenges with IPSO is to manage the supply chain, which plays an important role for the business model (Meier et al., 2010; Mont, 2004). Uncertainties related to the supply chain include capacity, resource availability and capability in the supply chain network (Erkoyuncu et al., 2011). Conflicts of interest between the different actors in the supply chain can also be a challenge for IPSO (Mont, 2002). Other uncertainties affecting the performance are those from the supply chain: scale of chain, skill requirements, degree of customization and changes in the requirements (Meier et al., 2010). Another external barrier for IPSO could be the lack of demand from public procurement, which otherwise could serve as a driver (Mont, 2002)

2.5.2 Life-cycle thinking and information asymmetry

The environmental impact of a product is caused by the different stages of the life-cycle, such as the raw materials or the use phase (Lewis & Gertsakis, 2001). Hence, by changing e.g. the characteristics or the process of usage or end-of-life, the environmental impact could potentially change as well. The provider needs to be competitive, something which requires a minimum use of resources for a maximum utilization of the element in the offering (Meier et al., 2010).

However, information is needed to do so, and it might not always be easily accessible. Between the provider and the user, information asymmetry is found in many cases; this is thoroughly described in [P3], (Lingegård et al., 2011). Briefly explained, the provider often holds more information about the product than the user. This could be information concerning toxicity of a product, or perhaps how to achieve the best energy performance. The reasons for this asymmetry could be diverse, such as a lack of user education or a deliberate strategy from the provider’s side. Nevertheless, the information asymmetry could be a key factor in making IPSO a meaningful business model and the provider has the possibility to provide more efficient maintenance or upgrades during the use phase.
2.6 Organization and corporate culture

To become a service provider, considerable changes have to be made within the organization, capabilities and management of the firm (Oliva & Kallenberg, 2003). For a company to shift to IPSO instead of selling products and services separately requires an organizational change. In fact, this change is considered one of the major barriers for the business model, as it leads to changes both within the organization as well as changes in the relationship with other actors in the product-service chain (Mont, 2002). Profitability during an IPSO contract depends on how skilled the organization is in assessing failure risks for the equipment (Oliva & Kallenberg, 2003).

Earlier research has pointed out the difficulties associated with a traditional mindset among customers (Alonso-Rasgado et al., 2004). Instead of focusing on the product price, the customers need to focus on the price for the whole life-cycle, and these two cannot be directly compared. The customer needs to learn about the cost structure of the offerings; otherwise, this lack of knowledge could serve as a barrier (Mont, 2002). There is, therefore, a need for models and tools that can illustrate in a simple way the financial benefits of the offerings (Berggren & Björkman, 2002). Additionally, customer acceptance of the offering as well as trust between the actors is of importance (Mont, 2002).

The transition to an IPSO business model imposes organizational challenges for both provider and buyer. Buyers might lack life-cycle cost knowledge needed to evaluate the offering and understand the concept due to a traditional business mindset (Mont, 2004). The new conditions require that operational and organizational structures for the provider need to be adapted (Meier et al., 2010). For instance, a cross-functional way of working to design an IPSO is a necessity, meaning that representatives from different areas and departments in the provider organization need to be involved (Brady et al., 2005a). Since more information is needed, more trust is required between the buyer and supplier to achieve this transparency (Lingegård et al., 2010). IPSO also implies a longer business relationship that needs to be strong for long-term performance (Meier et al., 2010).

2.7 Financial risks and uncertainties for long-term contracts

Implementing IPSO as a business model is not without challenges; as for any change in the business model, the risks change as well (Nystén-Haarala et al., 2010). IPSO implies taking over some of the customer’s processes, which is a major risk for the provider (Meier et al., 2010). On the other hand, IPSO also reduces unpredictability and variability of demand during the contract time, which makes risk reduction a driver for the business model (Mont, 2004; Oliva & Kallenberg, 2003).

Long-term contracts increase risks and uncertainty, and the risks are caused by uncertainties that for a long-term performance-based contract arise at the bidding stage (Erkoyuncu et al., 2011; Meier et al., 2010). The term “risk” in this thesis is defined as “the threat of loss from an unwanted event,” and the loss can concern financial, performance or timescale loss
Managing the uncertainties for the whole life cycle at the bidding stage is challenging, and the major inputs to calculate the cost are e.g. historical data, supplier inputs and user requirements (Meier et al., 2010). Assumptions concerning equipment failure have to be made as well as a prediction of maintenance activities (Datta & Roy, 2010). Another problem with long-term contracts is the risk of obsolescence with a technology or component no longer in use and unable to be purchased (Romero Rojo & Roy, 2009).

Figure 5 illustrates the uncertainties that arise during the life-cycle of long-term performance-based contracts, such as long-term IPSO contracts. The reliability of the information from the customer is important for cost estimations (Datta & Roy, 2010).

Risk assessments including forecasting and economic development are very important for these long-term contracts and also to consider both sides of the risk, namely the supplier and the buyer sides (Alonso-Rasgado & Thompson, 2006). For outcome-based contracts such as IPSO contracts the risk distribution changes, and the supplier is responsible for risk related to e.g. investments and maintenance (Nystén-Haarala et al., 2010). The uncertainties and risks need to be identified, planned, assessed, handle and monitored, and the provider and customer should cooperate in doing so (Meier et al., 2010).

### 2.8 Industry examples of IPSO implementation

In this section, examples of implemented IPSOs are presented. The examples, representing different industry sectors, were collected from different research groups in Europe.
2.8.1 BT Industries

BT Industries is a global forklift manufacturer owned by the Toyota Material Handling Group. The company provides forklifts on a long-term rental basis with the aim to provide customers with a forklift function at the lowest price (Sundin E. & Bras B., 2005). The rental solution includes forklifts, maintenance, spare parts and driver training and can be complemented with back-up trucks during peak seasons (Kowalkowski, 2008). Information is gathered, by maintenance personnel or software solutions, from products in use at the customer site to better control the fleet of rental forklifts (Östlin et al., 2008). After use, the product returns to the seller and a remanufacturing operation is realized (Östlin et al., 2008).

The idea behind the solutions is that the customers should focus on their core business and let BT Industries take responsibility for the material handling (Sundin E. & Bras B., 2005). By doing so, customers know the cost of their material handling in advance and avoid having capital tied up in forklifts (Kowalkowski, 2008). For the customer, this implies less risk as well as more flexibility (Sundin E. & Bras B., 2005).

2.8.2 ITT Flygt

Submersible pumps are the most common products provided by ITT Flygt, a leading supplier in this area. The description in this section has been collected from earlier research in the industrial service area (Kowalkowski, 2008). The company has an ambition to offer the customers trouble-free operations and the lowest possible maintenance and energy cost by using advanced monitoring and control systems. The company has related an after-market ladder for the development of service offerings. The ladder starts with part distribution and traditional maintenance and repair, and ends with long-term service contracts such as condition monitoring and operation agreements where the customer pays a fixed price per volume of liquid. In 2008, all the different types of offerings were in place except the last mentioned above. The aim of the service contracts is to create value for the customers in the form of reliability, extended product life, cost control etc. A fixed predictable income and a better position in the replacement business are benefits for the provider, ITT Flygt.

2.8.3 Danfoss

The description of the IPSO provided by Danfoss has been collected from a case description in a PhD thesis (Matzen, 2009). The company is a Danish manufacturer of refrigeration, heating, and motion control products for a global market, and has traditionally sold controls and refrigeration components to refrigeration equipment manufacturers and contractors. A new service offering called RETAIL-CARE was developed targeting food retail companies with hundreds of stores. The remote monitoring and control functionality of electronic refrigeration control systems for their offerings range from remote monitoring to project management contracts. Customer training and technical support are examples of services that existed before the IPSO contracts, but they are now a revenue-generating activity instead of a sales support function.
2.8.4 Rolls-Royce

Rolls-Royce, a global manufacturer of gas turbines, provides integrated power systems and services for several different markets for use on land, at sea and in the air (Rolls-Royce, 2011). Instead of selling the engine to the customer, Rolls-Royce leases out “power-by-the-hour” in a Total-Care Package (Baines et al., 2007). The company gets paid based on availability, meaning the number of hours the engine is in use (Erkoyuncu et al., 2011). The company has direct access to the products and can collect data to enable improvements such as increased efficiency and maintenance schedules. This reduces cost and environmental impact (Baines et al., 2007). To achieve this, Rolls-Royce works with a supply chain with 20 worldwide storage locations to be able to optimize support and avoid disruption within its customers’ operations (Rolls-Royce, 2011).
3 Methodology

This chapter presents the overall research design, followed by the research process, where an overview of the methods used is presented. The chapter continues with a more detailed description of the use of the methods, followed by a short summary of the appended papers and their contribution to the thesis.

3.1 Research strategy

The overall aim of this thesis “Can the concept of Integrated Product Service Offerings improve management of rail infrastructure and if so, what would such an implementation induce in terms of risk factors?” is of an exploratory nature. An exploratory orientation is used to give fundamental knowledge and understanding about an area of interest, and to provide input to better narrow down the research for further investigation (Lekvall & Wahlbin, 2001; Yin, 2009). The research presented in this licentiate thesis is of an exploratory nature, as not much has been done before in the area of IPSO for rail infrastructure. Furthermore, the result and conclusions from this licentiate thesis will be used as a stepping stone for further research. However, the research also has descriptive and explanatory features which depend on the characteristics of the research questions that were derived from the overall aim.

The aim was too complex to investigate without specifying more detailed research questions, which follow a linear structure where the output from one research question provides the input for the subsequent question. This was true except for the first research question, where an initial clarification interview provided the input needed. The interview was exploratory and unstructured, which is useful when there is a need to find out the important topics to investigate, as well as what to exclude from the study (cf. (Merriam, 1994)). Research can be realized using both primary data collection, where the researcher collects data from the original source, and secondary data collection, where for example existing statistics and reports are included (Lekvall & Wahlbin, 2001). The research in this thesis is based on both primary data including interviews, a focus group and a survey, and secondary data including literature reviews.

RQ1: How is rail infrastructure management currently procured?

RQ1 provides a description and an explanation of the current situation in the rail infrastructure industry, as well as investigates what research has been realized within the topic of interest. This research question has clearly-formulated, specific questions with a focus on how industry currently works, which makes the nature of the research question descriptive (cf. (Lekvall & Wahlbin, 2001)). This information is fundamental to the realization of the following research questions. Furthermore, this question asks “how” the infrastructure is procured, with “how” being an explanatory question used for explaining operational links (cf. (Yin, 2009)). However, this research question also includes elements of an explorative investigation, since it is used to frame the following research questions and provide input for
them (cf. (Lekvall & Wahlbin, 2001; Yin, 2009)). Two of the sub questions of RQ1 are of an exploratory nature, asking “what types of contracts?” and “what are the actors’ views?” Typically questions using “what?” as an interrogative are exploratory (Yin, 2009).

For RQ1, a literature study was conducted to aid in an initial framing of the problem and provide direction for the research question. This is a common procedure for qualitative research (Creswell, 2009). Furthermore, more limited literature reviews have been used throughout the research process to investigate certain topics for the appended papers, for example. Additionally, an interview with a respondent from top management at Arlandabanan Infrastructure AB was conducted to learn more about the Arlandabanan project, since it is the project in Sweden that is the closest to becoming an IPSO contract for rail infrastructure. The interview followed the same procedures as for the main interview study described below but using a less structured approach. Furthermore, the interview study described for RQ2 focused primarily on IPSO contracts, but it also included questions concerning the current situation. Information from the interview study was used to provide answers to RQ1 as well. This was the explanatory part of RQ1, where the information from the literature was not enough to answer the question.

RQ2: What are the potential benefits and challenges from the provider and buyer perspectives regarding IPSO for rail infrastructure?

RQ2 has a more consistent exploratory nature, since IPSO contracts are not commonly used in Sweden for rail infrastructure and little has been published in this area. The question asks for “what the potential benefits and challenges are?” and as described above “what” questions are generally explorative (cf. (Yin, 2009)). For this phase, a qualitative interview study was used to collect the information needed. This type of interview is used to obtain a description of a phenomenon from the perspective of the respondent (Kvale, 1997). To choose an interview study as the main data collection method is appropriate when it is believed to provide more and better information at a lower cost than other methods (Merriam, 1994). In this case, no other method could provide the type of information needed since it is based on the experience and opinions of the respondents, and therefore could not be found for example in archives. Additionally, other methods basing data collection on primary sources such as surveys would not be adequate, since a survey only provides quantitative or numeric descriptions (Creswell, 2009). The interviews give descriptions of the context within the respondents’ work environment and their interpretation of it. This is an example of descriptions that can only be provided by asking the respondents, and then interviews are the only way (cf. (Merriam, 1994)).

The structure for interviews can vary from open, where only the themes are chosen in advance, to very structured, where the interview consists of standard questions (Kvale, 1997). The more structured an interview is, the easier it is to analyze; on the other hand, the spontaneous and unexpected answers that come with a less-structured interview might be lost as a result (Kvale, 1997). Open interviews are used when little is known about the
research topic and the researcher does not have enough knowledge to ask specific and relevant questions (Merriam, 1994). In this case, there was sufficient background knowledge available to conduct semi-structured interviews. Semi-structured interviews are used to retrieve certain information from all respondents, and are guided by some preset main questions, but the order or exact formulation are not decided before the interview (Merriam, 1994). This made the interviews focused, but there was still room for additional questions or shorter discussions about related areas (cf. (Kvale, 1997)). For this thesis, the main theme for the interviews was IPSO contracts for rail infrastructure. To frame an interview and state the topics and the main questions to be included, the use of an interview guide is helpful (Kvale, 1997). Semi-structured interview guides, one for the buyer and one for the providers, were constructed using the input from the literature study and the initial clarification interview. The interview guides can be found in Appendix 1.

The results from the interviews were validated using a survey that was sent out to all the respondents. A survey is normally used to detect patterns and to enable comparisons; in this case, it was a cross-section, where data is collected at one point in time (cf. (Creswell, 2009; Merriam, 1994)). Here, the results were used mainly to confirm that the key elements derived from the interviews were in fact key elements, but also to let the respondents rank the importance of each element. The respondents from the STA and the contractors received slightly different surveys, depending on the results from the interviews. While the questions were the same, the factors they were asked to rank differed. There were two reasons for not sending the survey to others as well. First, it required some explanation in the beginning of the interviews to make sure than the respondents understood what types of offerings were to be discussed. Sending the survey to those that were uninformed could decrease the validity of the study. Second, the underlying causes for why they would answer in a certain way cannot be detected in a survey.

**RQ3: What potential risk factors can be identified when using IPSO for rail infrastructure?**

From both the initial literature review and the performed interviews it was evident that risk was a key parameter for the discussions. Risk is therefore the focus of RQ3; even though the topic is narrowed down to risk factors, the nature of RQ3 is still explorative since the factors are unknown. The interview study provided information for this research question, but to gain more knowledge on the topic a group interview was initiated. A group interview is a type of interview that is appropriate for exploratory investigations, where deeper understanding for the respondent’s perspective in a defined area is desired (Lekvall & Wahlbin, 2001). In group interviews the interviewer has less control over the situation, and the interaction between the respondents can easily result in spontaneous statements (Kvale, 1997). The purpose of the realized focus group was to trigger a discussion between the respondents, since they represented different perspectives of the studied topic.
The empirical parts of research questions two and three have been collected simultaneously and thus overlap, but their analysis can be described as a linear process where the results and analysis from one part were used as input in the subsequent part. The research has primarily a qualitative approach, but some elements of quantitative methods were introduced as well to further establish the quality of the results. The concept of triangulation has been used throughout the research, using several different sources of information for each research question (cf. (Merriam, 1994)).

3.2 Research process

The research process consisted of several steps and different data collection methods. The following sections describe in more detail how the research methods were used. Table 2 shows what methods were used to answer each research question, or RQ. Additional information about the methods used can be found in the appended papers.

Table 2: Research methods used to answer each research question. X denotes that data from this method was used extensively to answer the RQ. (X) indicates that only a small part of the data was used for a particular RQ.

<table>
<thead>
<tr>
<th>RQ</th>
<th>Initial literature review</th>
<th>Semi-structured interview study</th>
<th>Focus group</th>
<th>Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>X</td>
<td>X</td>
<td></td>
<td>(X)</td>
</tr>
<tr>
<td>RQ2</td>
<td>(X)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RQ2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2.1 Literature reviews

Different literature reviews were performed during the course of this thesis project. The main and initial literature review was performed in the first phase of the project to gain knowledge about PSS contracts or similar ones already realized, as well as to collect information about research performed in this area. This literature review has a broader scope than the scope of this licentiate thesis, since the focus included not only rail infrastructure but also road infrastructure, as well as other industry areas where long-term contracts are used such as the aircraft industry. Since very little has been done in the area of IPSO for rail infrastructure, it is of great interest to investigate what other areas have learned in terms of benefits and challenges when implementing IPSO. To keep the focus, the most relevant material for this particular research was prioritized while the rest was merely skimmed through (cf. (Yin, 2009)). The search was done in databases and gradually, as relevant literature was found, the corresponding reference lists were investigated as well. Literature reviewed included several different kinds of sources: scientific articles, reports, homepages, masters theses as well as doctoral and licentiate theses. Throughout the process, the information has been read in a critical way to understand what audience it was written for and with what purpose in mind (cf. (Yin, 2009)).
Initially, keywords were used to narrow down the search to relevant literature. Examples of keywords used are infrastructure, long-term contracts, IPSO contracts, performance contracts, Design-Build contracts etc. The aim was to find research focusing on the long-term aspect, performance aspects and also on larger and complex contracts. No geographical limits were used when searching for literature; instead, the search included literature from several continents. To be able to properly use information, it is important to identify its source and date of the information (Holme & Solvang, 1996). The difficulty in judging the quality is why some information is not included in this thesis or in the appended articles. Furthermore, the conditions for some of the contracts were far from the ones found in Sweden, and therefore not relevant in this study.

The information has, when it was possible, been triangulated using different sources. However, the information concerning the use of IPSO contracts for rail and road infrastructure was limited to just a few sources. This could imply that the information was biased, but most of the information was retrieved from the Swedish National Road and Transport Research Institute. When the same references started to show up in the search the literature review was stopped (cf. (Merriam, 1994)). Furthermore, less extensive literature reviews were performed within the process of writing the appended papers, and thus focused on the specific scope of the paper.

3.2.1.1 Analyzing the literature

The information was structured by dividing it into examples of IPSO or similar contracting already realized for rail and road infrastructure, and to benefits and challenges identified for IPSO in other industry areas. The focus for both the examples and for experiences from other industry areas was on long-term complex contracts such as for roads, the railway and the defense industry. Different concepts of contracts have been compared, as well as similarities and differences between the examples of contracting, using IPSO or parts of the concept. The differences in the level of detail between the presented examples of projects resulted in them not being entirely comparable. On the other hand, the comparison is still feasible for most of the issues and provided an overview of issues for further research. The result and analysis of the literature provided an outline and a starting point for the interview guide.

3.2.2 Interview study

The interview study was performed from the spring to the fall of 2010 to provide different perspectives and ideas concerning the research problem.

In this case, the interview guide was based on the results from the literature study and the initial clarification study. The guide was also validated by the same respondent as in the clarification study before it was used on other respondents. The interview guide was developed into two different interview guides, one for the STA and one for the contractors. The overall questions were the same, but they were angled to better fit the situation of the respondents. The guides included around 40 overall questions as well as keywords and
additional questions to ask if the respondent did not cover all the areas of interest. The interview guide was not constructed to be followed in a strict manner, but rather as a guide to keep the interview on the right track and make sure nothing was forgotten. The semi-structured interview guides, both translated to English, can be found in Appendix 1.

3.2.2.1 Selection of respondents

The choice of respondents was made to get the overall picture of the industry and to gain knowledge of both the buyer and the providers’ perspectives and their interaction. In total, the results from 14 interviews are included in this thesis. The criteria for the respondent selection at the STA were to include both representatives from the Investment Division and the Traffic Division of the organization, as well as to focus on people holding positions at a managerial level. This was a conscious choice, since an overview of the organization and an understanding of the strategy and market was preferred to contribute to the research. The respondents at the STA are presented in Figure 6. Apart from providing information concerning the research topic, the initial clarification interview also provided potential respondents within the STA that could be of interest for the interview study. Subsequently, the respondents themselves suggested others as potential respondents during the course of the interview study.

<table>
<thead>
<tr>
<th>Division at the STA</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Purchasing and Tendering (former Supply and material handling)</td>
<td>Supply Chain Advisor</td>
</tr>
<tr>
<td>Traffic</td>
<td>Operative maintenance control</td>
</tr>
<tr>
<td>Traffic</td>
<td>Procurement manager for maintenance contracts</td>
</tr>
<tr>
<td>Traffic</td>
<td>Business developer for maintenance contracts / Procurement maintenance contracts</td>
</tr>
<tr>
<td>Investments</td>
<td>Operating procurement</td>
</tr>
<tr>
<td>Major Projects</td>
<td>Operating control and coordination for larger projects</td>
</tr>
<tr>
<td>Investments</td>
<td>Top Management</td>
</tr>
</tbody>
</table>

Figure 6: a) The respondents from the STA participating in the interview study. b) Illustrates the organization of the STA with the divisions of the respondents circled. Modified picture, (Trafikverket/The Swedish Transport Administration, 2010).

A similar approach was used for the respondents at the contracting companies. The respondents at the STA provided contact information to their contacts within the contractors’ organization. Almost all of the respondents from the contractors’ organizations worked in the marketing or business divisions of the companies. These respondents provided knowledge concerning the operations and strategies within their own companies, as well as information regarding the relationship and interaction with the buyer, the STA. A few respondents worked in the maintenance area, while others had an overall responsibility,
which contributed to the total picture of the contractors' perspective. The respondents within the organization of the contractors are presented in Table 3.

Table 3: Respondents from the providing side.

<table>
<thead>
<tr>
<th>Contractors</th>
<th>Position of the respondent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor A</td>
<td>Regional Business Manager</td>
</tr>
<tr>
<td>Contractor B</td>
<td>Marketing Manager</td>
</tr>
<tr>
<td>Contractor C</td>
<td>Marketing Division, Tender and Calculations Coordinator</td>
</tr>
<tr>
<td>Contractor D</td>
<td>Business Area Manager, Maintenance</td>
</tr>
<tr>
<td>Contractor E</td>
<td>Business Area Manager, Maintenance</td>
</tr>
<tr>
<td>Contractor F</td>
<td>Design Consultant, Project Manager</td>
</tr>
<tr>
<td>Contractor G</td>
<td>Marketing Manager</td>
</tr>
</tbody>
</table>

Within the STA, seven different respondents were interviewed, providing different perspectives since they work in different divisions as well as hold different positions within the divisions. Interviews were also performed for the contractors, where most of the contacts were provided by respondents at the STA. Others were contacted spontaneously to complete the perspective. All in all, seven contractors were included in the study, two of these so-called construction companies and the rest specific railway contractors. Most of the respondents worked in managerial positions within the organizations. More detailed information concerning the respondents is presented in the results. Both phone interviews and face-to-face interviews were performed, and all were recorded. This is helpful to be able to focus on the respondent and the dynamic of the interview (Kvale, 1997). The principle of convergence was used to determine when enough interviews had been performed, namely when the results indicated that further interviews would not contribute with new information (cf. (Lekvall & Wahlbin, 2001)). Each interview lasted approximately one hour and was recorded. To improve the reliability, most of the respondents have been sent the data from the interview to be able to validate the content and thereby improve the quality of the data. The interview study was geographically limited to Sweden.

Interviews with additional respondents from different divisions of the STA could have provided more information, but not necessarily new information. Interviewing those in more operative positions would have provided more detailed information about operations and implementation, but at this stage this was not the type of information preferred. After seven interviews the results were converging, with the respondents highlighting the same areas of interest, which is why the interviews study was ended. What was really needed was more in-depth information; this is why the decision to gather a focus group was made.

3.2.2.2 Analysis of the interviews

The interviews were recorded, which made it possible to transcribe them afterwards. This was not done literally; rather, the content of the interviews was condensed into summaries focusing on the essence of the information. Some quotes, however, were written down word
by word to be used later in the results. A transcription of an interview is a sort of interpretation done by the person transcribing, and the quality of the information can be improved by having clear purpose and process for the transcription, as well as by checking its reliability (Kvale, 1997). The interview guide was used to frame the transcription process and to ensure the answers for the main questions were retrieved. Furthermore, the transcription was sent to the respondents to validate the information.

The transcribed information was compiled for each interview and structured in the different topics of interest. This was done using the concentration approach, were the information is formulated into shorter, more concise sentences (Kvale, 1997). Advantages and challenges for the current contracts, and well as for IPSO contracts, were derived and compared. The comparison was made both within the group of contractors and within the respondents from the STA, as well between the contractors and the STA. Both the actual factors as well as the motivation behind them have been studied. The factors were listed, and depending on how many of the respondents mentioned a specific factor, the factors were seen as more or less essential. The factors that were indicated by at least two of the respondents were then used in a survey study to further validate the results.

3.2.3 Survey

The aim of the survey was not so much to retrieve new information, but more to validate the results from the interview study and to try and make the respondents narrow down the most important factors in the questionnaire that was sent out to them. This type of sample selection for a survey can be seen as a "judgment" or "assessment" selection. Such a selection is common in exploratory studies, and is based on respondents being chosen using certain criteria (cf. (Lekvall & Wahlbin, 2001)). In this case, the criteria were that the respondents had participated in the interviews and were well-informed in the area.

The survey was constructed using the Survey Monkey web tool and sent out to the respondents in May 2011. Using a web tool provides several advantages; the survey can be easily sent out to the respondents, and the respondents cannot be influenced by upcoming questions since they are not accessible (Lekvall & Wahlbin, 2001). On the other hand, this also implies that the respondents do not get an overview of the survey (cf. (Lekvall & Wahlbin, 2001)). This, however, was solved by stating the number of questions and the estimated time for completion, which in this case was seven questions and approximately five minutes, both in the email and in the beginning of the survey. The survey was sent to the respondents’ email, making it a fast method of distribution. On the other hand, the survey easily disappeared in the numerous email received by the respondents each day, which is why a reminder was sent out a week after the first email.

There are several different types of questions to use in a survey; in this case, closed questions, open-ended questions and scale questions were used (cf. (Bell, 1993)). The survey began with closed questions, where the respondents were asked to state their name, organization and position. This means that the respondents were not anonymous and that it
was possible to connect the survey results with the interview results. The majority of the questions, however, were scale questions, where the respondents were asked to grade the answer on a scale from 1-5, where 1 = strongly disagree and 5 = strongly agree. The respondents were asked to rank statements derived from the interviews on this scale. The statements represented challenges for the current practice, benefits and challenges for PSS contracts. Benefits for the current practice were asked using an open question, since not enough information concerning this had been retrieved from the interview results.

3.2.3.1 Analysis of the survey

Most of the respondents completed the survey, and the results could therefore be analyzed and used to validate the information from the interviews. This was realized by determining that the information was correctly understood and that the actors identified were in fact important factors. Furthermore, the ranking of the factors is used as an indication of their in-group relationship. The results are displayed in graphs in this thesis to provide a clear picture of the ranking.

3.2.4 Group interview

The group interview was conducted in May 2011 at a conference hotel in Stockholm to which the respondents were invited. The recorded discussion lasted five hours, but the topic was continuously discussed during coffee breaks and the lunch break. Three of the respondents from the interview study were invited to participate. Those chosen represented important areas within the STA: the Business developer for maintenance contracts and the Procurement Manager for maintenance contracts from the Traffic Division, and a manager from the Investment Division. The fact that these three respondents participated was a conscious decision; apart from having knowledge on the topic, they also showed interest in the topic during the interviews, as well as being outspoken and generous with their ideas and beliefs.

For a group interview, it is important to think through the group constellation as well as to not include too many respondents (Lekvall & Wahlbin, 2001). Besides the respondents, three from the research team also participated, mainly as moderators. As stated in the Research Strategy, the purpose was to trigger a discussion between experts in the area. The value of this method is that, as a result of the group dynamic, discussions and aspects are generated that would not appear during individual interviews (Lekvall & Wahlbin, 2001). Even though this interview was unstructured in nature, there were still set focus areas to frame it.

3.2.4.1 Analysis of the group interview

During the interview, notes were taken at times where important information was discussed. This facilitated the transcription process and narrowed it down to only those particular parts of the interview. Having the three respondents present at the same time made this interview different from the other interviews, since the respondents’ intergroup discussion brought the topic to a deeper level where arguments that had not previously been raised were presented. The respondents’ intergroup dynamic contributed to enriching the information already
collected, adding another dimension to the discussion. Additionally, the group interview was a great way to validate the information and address remaining questions from previous interviews.
4 Summary of contributions to the thesis

The data for this thesis was collected using a literature review, an interview study, a focus group and a survey, as described in Chapter 3. Some of the data has been presented and analyzed in the appended papers that are presented in Section 4.1. Other parts of the information from the data collection have not previously been presented in the papers but are needed to complement the presentation of the results in Chapter 5-8. Table 2 in Section 3.2 illustrates what data collection methods that have been used to provide results for each of the research questions.

4.1 Appended papers

This section briefly summarizes the contribution from each of the appended papers as well as the method employed. Table 4 shows which papers that contributed which one of the three research questions.

Table 4: Contribution of the appended papers to the research questions. [P1], [P2] and [P4] directly contribute to answer the research questions, while [P3] indirectly contributes by providing to the theoretical framework, illustrated with (X).

<table>
<thead>
<tr>
<th></th>
<th>[P1]</th>
<th>[P2]</th>
<th>[P3]</th>
<th>[P4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>RQ2</td>
<td></td>
<td>X</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>RQ3</td>
<td></td>
<td></td>
<td>(X)</td>
<td>X</td>
</tr>
</tbody>
</table>

4.2 [P1]: PSS for Rail and Road Infrastructure

Aim

To aim of this paper was to investigate what has been published in the area of Product Service Systems\(^2\), PSS, and contracts for rail and road infrastructure, as well as to look into the current state of rail infrastructure procurement. More specifically, the paper answered the following three research questions:

- RQ1: What types of contracts are currently used when procuring rail and road infrastructure?
- RQ2: To what extent are PSS contracts used for rail and road infrastructure?
- RQ3: In what way are PSS contracts for rail and road infrastructure documented?

Method

This paper was entirely based on the initial literature study, where several different types of printed sources were used.

\(^2\) Product Service Systems in this paper is equivalent to Integrated Product Service Offerings.
Contribution

This paper provided several examples of realized projects for rail and road infrastructure where contracts with similarities to PSS contracts had been used. Additionally, it was concluded that the lack of publications, in combination with interest from the industry in the field, implies that there is a gap in the area where research is needed - both to facilitate the use of the contracts and to move the research forward.

4.3 [P2]: PSS Contracts for Rail Infrastructure

Aim

To aim of this paper was to investigate what has been realized thus far for rail infrastructure in the Product Service Systems area and to highlight potential benefits and challenges when using PSS contracts for rail infrastructure. Furthermore, the aim was to present a model illustrating traditional contracts and PSS contracts. This resulted in the following research questions:

- RQ1: To what extent are PSS contracts used for rail infrastructure?
- RQ2: What phases are included in a model for traditional contracts and PSS contracts, when procuring rail infrastructure?
- RQ3: What possibilities and challenges do actors identify for PSS contracts for rail infrastructure?

Method

This paper was partly based on the initial literature review, and partly on the interview study. The literature review served as a framework for the development of the interview guide.

Contribution

Both benefits and challenges when using PSS contracts for rail infrastructure are discussed. The potential for optimizing the process and lowering the total cost are highlighted benefits, while a major concern is the increased risk-taking by the contractors, potentially increasing the prices and thereby neutralizing the potential cost reduction from the optimization. Other issues are the type of project suitable for PSS contracts, the length of the contracts and the conservative culture within the STA.

Furthermore, the paper presents models constructed to illustrate the contracts used today for procuring rail infrastructure. Models illustrating the composition of PSS contracts for rail infrastructure are also included. The models clearly show the different phases of the contracts, and state which actors are responsible for each phase. The models have been modified partly after input from the focus group where they were presented and discussed. The updated versions of the models are presented in [P4].

3 Product Service Systems in this paper is equivalent to Integrated Product Service Offerings.
It was concluded that further investigation of the reasoning of the respondents was needed, including the use of a focus group.

4.4 [P3]: Theoretical Environmental Comparison of Integrated Product Service Offerings vs. Traditional Sales

Aim
The aim of this book chapter was to lead a theoretical discussion regarding which IPSE factors are expected to increase environmental performance of the product and service life-cycle compared to a traditional product sales business.

Method
The method used was a literature review covering the main relevant factors.

Contribution
This paper compares IPSO and traditional sales from an environmental point of view. The theoretical discussion points out four aspects that are of importance for the environmental impact: product development, asymmetry of information, economies of scale and risk. The four aspects are interlinked with each other, and this connection needs to be further investigated. Risk was identified as a crucial parameter to consider, and economies of scale were shown to be an enabler to more effectively control of risk. The paper contributes to the theoretical framework of the thesis as well as serves as a framework for what needs to be further investigated in the case of using PSS contracts in the rail infrastructure. This chapter will be further developed into a journal paper.

4.5 [P4]: Identification of Risks related to Integrated Product Service Offerings of Rail Infrastructure.

Aim
The aim of this paper is to identify potential risk components when using IPSO for rail infrastructure, from both the perspective of the provider and buyer. Furthermore, the aim is to investigate how these risks can be potentially reduced or avoided.

Method
Risk was identified as a key parameter for IPSO and was highlighted as a challenge in [P2], making risk the first factor to be more deeply investigated. The interview study as well as the group interview served as empirical input for this paper.

Contribution
This paper identifies potential risk components when using IPSO for rail infrastructure, from both the perspective of the provider and buyer. The risk factors can be categorized into three different groups: market risks, contractual risks and organizational risks.
5 Swedish railway infrastructure in retrospect – a brief summary

A brief summary of the management of the Swedish railway infrastructure is needed to understand the background of the organization and the current condition of the rail infrastructure. In this section, the history of railroad technology, from its start in the middle of the 19th century until the present time, is described.

The history of the Swedish State Railways (Statens Järnvägar), SJ, starts in the middle of the 19th century, when the railroad came to Sweden and was from the start a topic for discussion concerning financing (Tullberg, 2000). In 1939, the Swedish Government decided that the entire rail infrastructure should be state-owned and the tracks should be privatized. The history continues into the 1950s, when the market for the railroad totally changed with the use of private cars, and when SJ began to prioritize important tracks while cancelling others (Tullberg, 2000). When a line started to show losses, the investments in the infrastructure were normally halted (Alexandersson & Hultén, 2008).

During the 1980s, rail traffic increased again due to environmental thinking related to the oil crisis. However, SJ could not handle this increase, and the result was higher costs for the organization. This led to a questions about the organization’s finances and efficiency, and it was considered unwieldy, reluctant and incapable of change (Tullberg, 2000). In 1988, SJ was divided into two parts: the Swedish Rail Administration, responsible for infrastructure, and a reorganized SJ, in charge of train traffic (Riksrevisionen, 2005). The driving force behind this was SJ’s recurring problems (Alexandersson & Hultén, 2008). The organization now had stand-alone business units within the Divisions that had their own profit centers, and internal service markets were created (Kopicki & Thompson, 1995).

Since 1995, train traffic in Sweden has been open to competition (Tullberg, 2000). Prior to 2001, the construction and maintenance of the infrastructure were only realized by a single internal organization, Banverket Produktion at the Swedish Rail Administration, but since then are now procured in competition. Infranord (formerly Banverket Produktion) is still the dominate actor in the market (Banverket, 2008). In 2008, the Swedish Rail Administration was responsible for 80% of the total rail system in Sweden (Banverket, 2008). Since 2010, the organization has been part of a larger administration called the Swedish Transport Administration, which includes the Swedish Road Administration, the Swedish Maritime Administration as well as the Swedish Institute for Transport and Communications Analysis (The Swedish Transport Administration, 2010b).

The split between the rail infrastructure and train traffic functions as well as increased competition, may have resulted in sub-optimization of the system and loss of economies of scale (Alexandersson & Hultén, 2008). On the other hand, the reorganization was needed for several reasons, e.g. to change the managerial focus from production to customer service (Kopicki & Thompson, 1995). The reorganization of the railways and of the tender system also put focus on operational cost efficiency (Alexandersson & Hultén, 2008).
6 Contracting forms currently in use

This section describes the different types of contracts used in Sweden today for construction and maintenance of rail infrastructure. In addition, the views of the STA and the contractors are presented. The results presented in this section are from the interview study, the focus group and the survey unless another reference is stated.

Between 2006 and 2010, the cost for operation and maintenance has increased due to the deteriorating condition of the infrastructure and simultaneous increase in total traffic volume. Furthermore, the total maintenance and reinvestment costs corresponded to around 38% of the total investment cost during 2010 (The Swedish Transport Administration, 2010a). The STA has three types of contracting currently in practice: construction contracts, design-build contracts and performance contracts, where the last two are recent developments in the contracting forms to improve the situation. The current procurement process is illustrated in Figure 7.

![Figure 7: The current procurement process. (The Swedish Transport Administration, 2010b)](image)

The STA is divided into two divisions, where the Investment Division participates in the Design and Construction phase, while the Traffic Division is involved in the Operations and Maintenance contracts. The contractors formulate tenders based on detailed specifications provided by the STA, and the procurement of the construction and the subsequent operations and maintenance are done independently. When a maintenance contract ends, a new procurement process is initiated for a new maintenance contract until a reinvestment is needed to improve the standard of the facility.

In traditional contracting, the life-cycle of the rail infrastructure is divided into several different contracts, with different actors involved in each phase. There is no continuation between building and maintaining, since these are separate contracts and there could also be separate contractors who win the contracts. However, the contractor that is in charge of maintaining a section is likely to keep maintaining it, since this organization already is established in the area and therefore can offer a lower price than its competitors.

35
6.1 Construction contracts

Construction contracts, or Design-Bid-Build contracts, where the procurer specifies what, how and how much, are the most common contracts within the infrastructure construction industry in Sweden (Nilsson & Pyddoke, 2007; Nilsson et al., 2006b). In fact, 87% of all projects with new rail infrastructure were realized as construction contracts during 2010 (Olander et al., 2010). Typically, the scope of the projects and the detailed design specifications are realized by consultants on behalf of the STA, and the contractor is obliged to realize the project within the set time, price and standard level (Pakkala, 2002). The choice of tender is mainly based on the lowest price (Hedström et al., 2005). Construction contracts imply that the procurer carries all the risk, and a maximum roof for the price is set which does not create any incentives for the contractors to make the processes more efficient; instead, they benefit from reaching the maximum sum (Nilsson et al., 2005). Figure 8 presents a schematic diagram of the construction contract. The shaded part of the figure shows the maintenance contracts and is described in Section 6.2. The Design phase is estimated to take around three months and the Construction phase between half a year and three years, depending on the project.

![Diagram of construction contract](image)

Figure 8: A schematic diagram illustrating the construction contracts. The shaded part of the figure shows the maintenance contracts that are described in Section 6.2. Modified figure from [P2], (Lingeård, 2011).

6.2 Maintenance contracts

Since 2005, performance contracts have been used for maintenance in Sweden, meaning that the STA procures a set functionality of the track and the contractor decides appropriate measures to take while still considering maintenance regulations (Banverket Produktion, 2009; Riksrevisonen, 2010). Performance contracts are similar to Design-Build contracts in that the contractor is responsible for parts of the detailed design. The function, however, is set on a detailed level, and is far from an overall function. Examples of functional requirements (Banverket, 2009):
“The snow depth at the railway yards (...) is not to exceed 200 mm over the top edge of the sleepers.”

“Clearing of snow around gears (...) on the railway yards is to be executed regardless of snow depth so that full function can be achieved.”

Table 5 presents the content of a performance contract in greater detail.

Table 5: The content of the performance contract. (Banverket, 2009).

<table>
<thead>
<tr>
<th>Performance contracts</th>
<th>Operations</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter-related services</td>
<td>Corrective</td>
<td>Preventive</td>
</tr>
<tr>
<td>Slipperiness caused by leaves</td>
<td>Execution of inspection comments</td>
<td>Inspections</td>
</tr>
<tr>
<td>Property maintenance</td>
<td>Error recovery</td>
<td>Work with signal system, railways yards, tracks etc.</td>
</tr>
<tr>
<td></td>
<td>Damages, accidents and crimes</td>
<td></td>
</tr>
</tbody>
</table>

The length of a performance contracts is five years, with an additional two-year option that usually falls out, and with bonuses and penalties used as a control mechanism. Several maintenance contracts are procured after each other during the life-cycle of the facility. Figure 9 illustrates a schematic model of maintenance contracts where the repetition of contracts is shown. Additionally, during the lifetime of the infrastructure reinvestments are needed, but they are not shown in this figure. The difference between maintenance and reinvestment is different cost levels.

Figure 9: A schematic diagram illustrating the maintenance contracts. The shaded part to the left in the figure illustrates the construction contract for the facility that was described in Section 6.1. Another type of building contract, described in Section 6.3 below, is also a possibility. Modified figure from [P2], (Lingegård, 2011).
6.3 Design-Build contracts

A newer type of contracting for building rail infrastructure is the Design-Build contract, where the contractor is responsible for both the more detailed design phase as well as the construction phase (Nilsson, 2009b). This provides an opportunity for the contractor to influence the construction. In Sweden, Design-Build contracts have not been used for more than a few years, and during 2010 only 13% of the building contracts for railway were Design-Build contracts (Olander et al., 2010). Figure 10 presents a model of the Design-Build contract. The STA has the overall responsibility until the construction phase, where it is shared with the contractor that is in charge of the detailed design. The overall design has already been determined by the STA with the help of design consultants, and performance requirements are set for the technical standards, but the way in which these requirements are met is the contractor’s choice.

![Diagram of Design-Build contract]

Figure 10: Schematic diagram illustrating the Design-Build contract. Figure based on data from the interviews.

6.4 The actor’s perspective of current practice

Traditional contracting, and specifically construction contracting, has several advantages such as being a familiar business model which all actors can relate to and calculate. The STA also emphasizes the fact that they know what they get, since the contract has been specified all the way to its end. Furthermore, the contractors are also restricted to buy all the material from the STA. A quote from one of the respondents at the STA explains the current situation:

“Not only do we write the recipes; we give them the ingredients too!”

Top manager, STA

When the contractors and the STA were asked to state benefits with the current contracting forms, the majority were positive to the newer type of contracts, Design-Build and performance, where the responsibility of the contractor is greater. On the other hand, the disadvantages and challenges with the traditional form of contracting, especially
construction contracts, are several, with the most essential presented in Figure 11. The STA and the contractors were asked to rank how well the statements, derived from the interviews, reflect their view of the industry. For the STA, 7/7 respondents answered this question, while the number for the contractors was 6/7. This survey serves as a validation for the interviews as well as an indication of the importance of each factor. The values represent the average of the respondents’ rankings.

Figure 11: The upper graph illustrates the contractors’ view of the challenges and problems with the current contracting situation and the lower graph illustrates the STA’s view. On the scale 1=strongly disagree, 5 =strongly agree.

The current procurement practice is seen as resource-demanding from both sides. As one of the contractors expressed it, “every step has to be controlled by the STA which is resource-demanding, especially for an industry that has a shortage of resources in labor”. The STA agrees that the system as it works today is inefficient. An example is the design results that are delivered by consultants that are not optimal for actual building; the phrase “paper solution” was mentioned during the interview. These quality issues are noticed by the contractor during the building phase, and result in lost time and money when the design has to be taken back to the drawing table.

Most of the critique is aimed at the construction contracts, where the actors feel that the contractors are not involved early enough in the process to make a difference. On the other
hand, the contractors are participating in the newer Design-Build contracts as early as in the
design phase. However, during the interviews it was revealed that sometimes these contracts
end up looking a lot like construction contracts due to the STA, which interferes in the
contractor's work. It is similar for the maintenance contracts based on performance where the
function is in construction technicalities, since the stretch, design and appearance are already
set. It is said that old habits are hard to break, and that the STA is a very technically-oriented
organization and always has controlled the technical details. The respondents of the STA are
well aware of the fact that there is little room for creativity for the contractors; in fact, one of
them expressed it as follows:

“What creative dishes come out of only following recipes in detail?”

Top Manger, STA

Furthermore, the incentive structure was discussed and the contractors feel that the bonuses
are just for show, while the penalties are disproportionally larger. Another disproportionate
area is the market distribution, with one larger actor dominating. This actor is Infranord, the
former in-house contractor at the STA before the deregulation in 1999.
7 IPSO contracts for rail infrastructure

This section will focus on IPSO contracts for rail infrastructure, starting with the presentation of a schematic model for the contracts. Then, the perspectives of the STA and the contractors concerning IPSO are described and categorized according to benefits and challenges. The results presented in this section are from the interview study, the focus group and the survey unless another reference is stated.

7.1 Modeling an IPSO contract

An IPSO contract can be described as a Design-Build contract with a long-term maintenance commitment, where both the design concerning the construction and the maintenance are taken into account and integrated in the initial design phase. In this case, the functional requirements are on a higher level than for the Design-Build and performance contracts currently used for maintenance. An IPSO contract includes design and construction as well as operations and maintenance, as illustrated in Figure 12. The STA procures a function and does not specify in detail how the contractor should realize it, e.g. "build a railway from A to B with C capacity and maintain it for X years. After the contract period the railway should have Y required capacity." According to the respondents, the initial planning of the stretch and the environmental evaluations would still be performed by the STA. This is because the phase includes e.g. redemption of house and environmental impact assessments that can make or break the approval and realization of the project, which is not a risk the contractors are willing to take. The design of the construction and the maintenance, however, is the responsibility of the contractor. The design and construction phases in the IPSO contract depend on the scale of the project, while the operations and maintenance phase is estimated by the actors to run between 10-45 years.

![Figure 12: Schematic figure illustrating an IPSO contract for rail infrastructure. Modified figure from [P2], (Lingegård, 2011)](image-url)
7.1.1 The Arlanda airport shuttle – an IPSO contract?

The information concerning the Arlanda airport shuttle contract has been retrieved from the interview with Arlandabanan Infrastructure AB. There is currently only one contract in Sweden using the concept of a long-term performance contract, and that is the one for the airport shuttle between Stockholm and Arlanda airport. The contract was formulated as a functional contract where the buyer asked for a specific result, namely “an airport shuttle to Arlanda with connection to the north”. The design was not specified, but the travel time was set at 20 minutes and the speed at 200 km/h. In this case, the train traffic was part of the contract. The project was also partly financed by a private party. The consortium that won the bidding consisted of several larger construction companies, including a train producer. The result to this constellation was that the construction companies sold their shares in the project when the building phase was completed. This means that they only had a 5-year perspective, and that the new owners are now more focused on the maintenance. There were no companies with a maintenance focus in the consortium, and no actor with the overall responsibility. The construction and the maintenance of the infrastructure are two separate contracts lacking continuity and incentives to lower the cost and increase the efficiency of material use over the life-cycle of the infrastructure. Therefore, while this is not an example of an IPSO contract, it can be seen as a step in that direction.

7.2 Benefits and advantages of IPSO contracts

The factors that were emphasized the most during the interviews, and that were mentioned by more than one respondent among the contractors and the STA respondents, were transferred to a survey study. Figures 13 and 14 present the results. Among the contractors, 4/7 answered this question, while 5/7 of the respondents at the STA answered it. The values represent the average of the respondents’ estimates and serve as an indication for the importance of the statements. This section presents an overview of the general perspectives of the STA and the contractors, and does not go into detail concerning the opinions of the specific contractors and employees of the STA.

7.2.1 The view of the contractors

According to the contractors, extended responsibility compared to today is required for development, but the positive outcomes of the IPSO contract would not come overnight but can be viewed as a long-term drive for development. The increased responsibility would start a thinking process, one that does not exist if you only follow a specification, and making use of the knowledge within the organization. It was pointed out that the contractor would have to start thinking about where in the life-cycle you could make money and how. One suggestion was that the contractors could buy the material themselves, and this could then be used as a factor for competition. One of the contractors claimed that everything lasts for five years, but with longer contracts they would be more thorough. It would be more interesting for a contractor to use solutions that lower the operations and maintenance costs.
This could be done with solutions that are more durable and do not require many measures. It was stated that this would probably increase the lifetime of products. This was the opinion of most of the contractors, but one of the respondents did not see the incentives of building better if the maintenance also was included in the contract, and stated that IPSO contract would not make a difference in quality.

From an organizational perspective, the benefits would be a smoother transition between the construction and the maintenance phase of the projects, as the knowledge is already within the organization of the contractor. Furthermore, this knowledge could be used to discuss solutions in the organization, and ensure that no one takes shortcuts, since the contractor is responsible for the entire project. Additionally, a long-term contract would provide long-term planning, making it easier to make investments due to the longer payback time. Finally, it was said that this could lead to it no longer being the lowest price that wins the bidding, but the proposal with the best solution.

Figure 13: The contractors' perspective concerning benefits and advantages for PSS contracts for rail infrastructure. On the scale 1=strongly disagree, 5 =strongly agree.

7.2.2 The view of the STA

The STA respondents think that the IPSO contract would provide more thought through construction in terms of maintenance. The holistic view would make the contractors adopt a life-cycle perspective and consider the life-cycle costs of the infrastructure. The contracts would spur innovation development in the industry, since sufficiently skilled contractors would realize solutions providing a lower cost, which would result in a competitive advantage. This would be a driver for the whole industry to be innovative, but the development would start with small steps.

In general, the STA believes that the contractor would build more durably if they knew they were to maintain the infrastructure for a longer period as well. Some of the respondents also believe that the contractors would probably control the design consultants in a better way...
than the STA, which would save both time and energy compared with the current situation. Even though the opinion was that these types of contracts would narrow down the possible number of national contractors due to the size of the projects, the international contractor would probably be interested in these types of projects due to their size.

![Figure 14: The STA’s perspective concerning benefits and advantages of PSS contracts for rail infrastructure. On the scale 1=strongly disagree, 5 =strongly agree.]

7.3 Challenges for IPSO contracts

Similar to the previous section concerning benefits and advantages, the factors that were mentioned by more than one of the respondents, among the contractors and the STA, were transferred to the survey study. The results from this study are presented in Figures 15 and 16. Among the contractors, 6/7 answered this question while 5/7 of the respondents at the STA answered. The values represent the average of the respondents’ estimates and serve as an indication of the importance of the statements. The more detailed explanation of the challenges in this section presents an overview of the general perspectives of the STA and the contractors, and does not go into detail concerning the opinions of the specific contractors and employees of the STA.

7.3.1 The view of the contractors

The contractors identified several challenges that can be narrowed down into challenges related to the contract, the market and the organization. The different challenges are presented in Figure 15.
STA’s competence to evaluate the tenders
Requires a new way of thinking for the STA
Risk-sharing between the STA and the contractors
Requires large enough projects for financial turnover
Transparency between the contractors and the STA
Continuity of the contracts is required
Difficult to measure quality
The contractors will take greater risks
Risk for locking the market long-term
Design competence within the contractors’ organizations
Risk for higher total cost due to larger risk-taking for the contractors
Problematic for reinvestments
Which company will be the PSS provider, general och technical
A supporting corporate group is required for the contractor

Figure 15: The contractors’ perspective of challenges using IPSO contracts for rail infrastructure. On the scale 1=strongly disagree and 5=strongly agree.

7.3.1.1 Contractual challenges

The way in which the risk would be shared with the IPSO contracts was one of the main concerns the contractors had, even though there were different opinions concerning how big of a challenge the increased risk taking was. They all agreed that the risks have to be calculable, and that not all the risk could be transferred to the contractors. The IPSO contract would give the contractors more risk, but some of them also identified more opportunity, and as long as these two factors were in balance it would not be a problem. One contractor said that there are regulations that handle risk, but the more risk the contractor takes, the more it will cost for the buyer, and several contractors did not think the STA realized this. On the other hand, it was believed by others that the total cost would be lower, since the price would be kept down by the competition. Furthermore, risk was pointed out as something that is difficult to price since it had not been done before. The pricing would be done depending on the method that was chosen, but it was also indicated by one of the contractors that a very risky method would not be chosen for a long-term contract. Re-negotiations during the course of the contract period were mentioned as a way to reduce the uncertainties.

The length of the contracts was another major issue. The longer the contracts are, the more durable the construction must be. If the contracts are too long, however, it will be difficult to calculate and there will be a charge for the risk, making it more expensive for the community, and that is not the point with this type of contract. Another challenge is the
content of the contract in terms of limits. Since the rail infrastructure is a system, it would be difficult to measure the function or capacity of a single contract, since it depends on the conditions of the contracts surrounding it. Another question raised was the starting point of the contractor’s involvement. The contractors believed that more transparency would be necessary as well as common goals for this type of contract to work. Another limit is the volume of the projects, which need to be large enough to be profitable for the contractor that needs to make investments to maintain the railway. If the project is not large enough, there is a risk that the contractor will outsource the maintenance to a contractor that is in charge of the surrounding maintenance contracts.

The functional requirements result in difficulties in measuring and evaluating the contract. The contractors emphasized the need for factors that are measurable and factors that the contractor can influence. This also included a set residual value that is measureable. Additionally, how would the benefits for society be measured? The functional requirements for an IPSO would make it difficult to set a price on the contract. The clearer and more straightforward a contract is, the more bids will be received. The reason that the performance contracts for maintenance receive few bids today is because the contractors will not start calculating an offer unless they are, according to one contractor, 80-90% sure of winning the contract. The fact that it will require more time and effort for calculating the IPSO offerings will make them more expensive.

7.3.1.2 Market-related challenges

The contracts have to be large enough as described above, but on the other hand the contractors also are concerned that too many larger contracts would result in a locking of the market, leaving some contractors outside for years. This would then decrease the competition. Some contractors point out that the market is not working today anyway, due to a monopoly situation for enjoyed by one contractor.

The contractors believe that IPSO contracts would only work for new investments, since there is a need for information concerning reinvestments that does not exist today. Documentation of rail facilities in Sweden is described as inadequate by some contractors. This could potentially be solved by having some parts of the facility, such as changes of switches, outside the contracts due to their high cost.

7.3.1.3 Organizational challenges

The IPSO contract is complex, and none of the contractors think they can handle all the parts within their own organization. They believe that companies will join forces, but the interface between them was identified as a difficulty. One contractor has to take the overall responsibility for the IPSO contract. Most of the contractors agreed that the technical contractors specified on railway projects could affect the capacity of the infrastructure the most, and it would be the most natural for those types of companies to have the main responsibility. On the other hand, it was said that they lack the required financial strength
and project management experience. Therefore, it would be more logical if the general contractors had the IPSO responsibility. The long-term survival of the contractors was also mentioned, and the technical contractor did not believe that long-term resources would be a problem if they had the responsibility, but it would be a different story for the general contractors that would be dependent on the technical resources from outside their organizations. Another issue related to the long-term perspective was that the interest within the contractors’ organization might disappear during the course of the contract, since the same people are not working in the organization during the entire period. This also relates to the continuity of IPSO projects that is needed on the market to maintain the competence within the organizations. One of the contractors mentioned that the offering would probably not be immediately cheaper, since it takes time to learn.

Currently, the contractors do not have design competence within their organizations. One problem that was mentioned was that the same consultants would be used by the contractors as the STA uses today, and therefore it would not generate a new way of thinking. The contractor would, on the other hand, control the consultants more than the STA. Some contractors stated that they would have a competence base in-house; another contractor took it further and said they needed their own development division to achieve real innovative solutions. Others argued that all the competence does not have to be in-house, but that enough is needed to master the technology and understand the process and production. It is important to know what is bought from subcontractors. A few contractors stated that they have been prepared for this type of contract through their international corporate group.

There are different opinions among the contractors concerning the competence and readiness of the STA. The IPSO contract is another business model and requires a new way of thinking; this part was seen as the most difficult for the STA. Most of the contractors do not believe that the STA is prepared for the life-cycle price of the contracts, and doubt the organization can evaluate the bids. Some contractors were milder in their judgment, saying that the STA has the competence but the different divisions need to communicate and interact more, which would be a huge adjustment. The STA is described as conservative, which could result in the STA trying to control the contracts, in turn causing problems with responsibility and risk-taking.

7.3.2 The view of the STA

Similar to the contractors, the respondents at the STA also indicated a number of challenges that can be categorized into challenges related to the contract, the market and the organization. The challenges for IPSO contracts are illustrated in Figure 16.
7.3.2.1 Contractual challenges

The respondents agree that the partner with the best ability to affect the risk should be the one with the responsibility for it. For the IPSO contracts, the contractors would take all the responsibility and thereby more risk, which they might compensate for with a higher price. According to the STA, this increased risk-taking will have to be compensated for by intelligent solutions. On the other hand, most of the respondents believe that there is a risk for a higher total cost when the contractors take the overall responsibility. In general, incentives are seen as better to use than penalties to achieve quality, but some believe that penalties give the contractor a reason to maintain a high standard of work. A payment plan where the contractor receives a sum for maintenance, but where a reduction is made every time maintenance work is performed, was mentioned as a way to regulate the payment to the contractors.

The length of an IPSO contract was an issue that all the respondents indicated as important, but at the same time difficult to decide. It has to be long enough so that the contractor is forced to take the consequences in the maintenance phase for choices made during the design and construction phases. In addition, it has to be long enough for the contractor to be able to make investments and build an organization around the project. Some respondents think that the contracts should last the entire economic lifetime of the infrastructure, but also add that this might not be possible since it would be too long. Concerns of excessively long contracts were mentioned, since the respondents feel that there is a risk that the parties will become tired of each other or that the contractor will stall in the work procedures.
The procurement process was thought to be longer, since it would take more time for the contractors to calculate, and because the time for the STA to evaluate the tenders would increase. Furthermore, they believed that the procurement process would be more expensive, but that this would be somewhat compensated for by less frequent procurements. The evaluation of both tenders and the actual projects themselves were seen as a major problem. Also mentioned was the difficulty in evaluating a long-term contract, because it takes many years to get the overall picture. In addition, the complexity of defining functional requirements for the contracts, setting appropriate measures as well as measuring the residual value of the infrastructure will be challenging.

A related topic was the interface between two IPSO contracts, since some parts such as the contact line cables have a considerably longer stretch than the tracks. If the power needs to be closed down at one part that belongs to Contract A, this could affect the performance of Contract B. This issue would have to be considered for reinvestment contracts where the infrastructure already exists.

Currently, the STA is responsible for all the material handling and purchasing, and concerns were raised concerning the fact that the contractors could choose to use non-standard material in their investments. This would then cause problems with the spare part handling if the STA was still to be responsible for this part. Some of the STA respondents foresaw problems if the contractors themselves would be in charge of the material handling. Non-standard material would be expensive to store, and when the long-term contract ends the responsibility for the maintenance and the spare parts once again would be the responsibility of the STA. If the contracts were as long as the lifetime of the material this would not be a problem, but different materials have different lifetimes, and it would be difficult to find the point in time where it would be most efficient to end the contract.

7.3.2.2 Market-related challenges

According to the respondents, IPSO contracts are mostly feasible for larger, new investments. They state two reasons for this. First, the contracts have to be large enough to be economically beneficial to build an organization around it and to make investments. Second, documentation is lacking for the older infrastructure, resulting in too many uncertainties concerning the condition of the material and components.

Another market-related aspect is the competition in the Swedish rail infrastructure industry, which is already low. An IPSO project is a large project and thus requires a large contractor, which according to the STA would exclude the smaller organizations. Furthermore, one contractor could not realize this type of contract by itself; there is a need for both a general contractor making the foundation and a technical contractor building the actual rail infrastructure and performing the maintenance. The question is which one should be the IPSO contractor. The respondents feel that it would be logical if the technical contractor had the overall responsibility, since that is where the technical competence is located. On the other hand, these companies are in general too small, and a larger general contractor is better
suited to lead such a project. Even though the number of national contractors that would leave tenders for an IPSO contract would be reduced, the respondents think that the number of international contractors would increase, since an IPSO contract is large enough for them to invest in Sweden.

7.3.2.3 Organizational challenges

The Investment Division and the Traffic Division at the STA are two organizations that have little integration and very different ways of thinking. While the Investment Division has a project-oriented work form that follows an investment project, the work of the Traffic Division follows yearly cycles, i.e. fall-winter-spring-summer. Connecting these two divisions will not be done without friction, according to some respondents within the STA.

Furthermore, the respondents describe the STA as a technically-oriented organization with a business culture where the employees, in general, are very interested in all the technical details of the contracts. This fits perfectly with the construction contracts but another approach, where the contractors take the responsibility, needs to be adopted to work with IPSO contracts. The respondents describe this change as a hurdle the STA must pass. Competence is another area that was mentioned, and some stated that having people bound to long-term contracts would result in a lack of competence in an industry that already has a shortage of competence in some areas. According to the respondents, more competence in calculation and risk management is needed within the contractors’ organization. Concerning the competence within the STA, the respondents seem to agree that most of it already exists and that the major challenge is to coordinate it, e.g. the cooperation between the Investment and Traffic Divisions. The importance of improving documentation, however, is emphasized. This is needed since the people procuring an IPSO will not be there during the entire course of the contract.

An additional organizational concern is the relationship with the contractors. Another type of relationship is needed that is built on more trust than found in the current relationship. This is needed since the contractors will take over much of the responsibility that the STA has today, and the STA will have to take a step back. According to several of the respondents, however, this will be difficult due to the business culture at the STA. Despite less control from the STA, the respondents still feel that some type of follow-up is needed, since everything cannot be assigned to the legal framework and the regulations.
8 Risk factors identified for using PSS for rail infrastructure

Table 6 presents the risks and uncertainties structured in three categories: market risks, contractual risks and organizational risks. A more detailed presentation of this table and the risks can be found in [P4] in Appendix 5. The factors in the table have all been presented in Chapter 7, with the exception of pricing. When discussing pricing of these contracts, the respondents seem to prefer one fixed and one adjustable part. It is the contractors in particular that prefer an adjustable part as a way to decrease risk-taking, e.g. if and when traffic volumes change. The STA, on the other hand, is of the opinion that if a contractor has the overall responsibility for the project, the price should be as fixed as possible.

Table 6: Summary of the factors causing uncertainty and risk for the potential use of IPSO contracts. [P4].

<table>
<thead>
<tr>
<th>Market risks</th>
<th>Contractual risks</th>
<th>Organizational risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased competition</td>
<td>Contracts content</td>
<td>The STA corporate culture</td>
</tr>
<tr>
<td>• Decrease in nr of contractors</td>
<td>• Suitable projects</td>
<td>• Conservative</td>
</tr>
<tr>
<td>• Market readiness for IPSO contracts</td>
<td>• Material and spare part handling</td>
<td>• Divided into two separate divisions</td>
</tr>
<tr>
<td>Supply chain disruption</td>
<td>Contract length</td>
<td>• Lacking long-term perspective for procurement</td>
</tr>
<tr>
<td>• Long-term survival of contractors and subcontractors</td>
<td>• Payback time vs. risk taking</td>
<td>• Shortcomings in documentation</td>
</tr>
<tr>
<td>Market lock-up</td>
<td>Risk-sharing</td>
<td>Trust</td>
</tr>
<tr>
<td>• Geographical region locked for a longer period of time</td>
<td>• No references for calculations</td>
<td>• Risk-sharing</td>
</tr>
<tr>
<td></td>
<td>Pricing</td>
<td>• Transparency</td>
</tr>
<tr>
<td></td>
<td>• Fixed vs. adjustable price</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Risk for higher prices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td>Competence</td>
</tr>
<tr>
<td></td>
<td>• Long-term</td>
<td>• STA’s capability to judge the tenders</td>
</tr>
<tr>
<td></td>
<td>• Concretize functionality</td>
<td>• Contractors’ design and project management competence</td>
</tr>
</tbody>
</table>
9 Discussion
In this section, the results are discussed and analyzed. First, the current way for procuring rail infrastructure is discussed, followed by the discussion concerning IPSO for rail infrastructure. This part starts by discussing the benefits with this type of contract from the perspective of both the buyer and providers. Thereafter, the challenges, including risks and uncertainties, are discussed from the same perspectives.

9.1 The current situation rail infrastructure procurement
The traditional construction contracts have advantages such as being a familiar business model that is straightforward to calculate for the contractors. This is in line with previous research that states that an advantage with construction contracts is that the distinct roles of the buyer and the contractors are clear (Pakkala, 2002). The STA argues that one of the advantages with the construction contracts is that they know exactly what will be built. On the other hand the STA does not get more than asked for since the contractor only are paid to follow the specifications. Detailed specifications do not optimize the innovation since innovation typically comes through the contractor or supplier network (Pakkala, 2002).

9.1.1 Technological lock-in and lack of information transfer
In the rail infrastructure industry a dominant design for contracts has reached standardization. The focus is on costs and the winning bids are often the ones with the lowest price. The focus in the standardization phase of a technology cycle should also be on efficiency (Schilling & Esmundo, 2009). However, in this case the actors claim the contracting form and the way the work is realized is inefficient and time consuming. This implies that the dominant standard set in the industry might not be the optimal for the work that needs to be executed, however the actors have invested a lot in this work practice (cf. (Ahmed & Shepard, 2010)). The STA states that the solutions suggested by the design consultants are not always feasible for to build. This is not realized until the contractors, that have more operative knowledge about the technology than the consultants do, discover the shortcomings. The construction process then has to be stopped while the design is re-worked wasting time and money while the project is delayed. The contractors have from previous projects gained knowledge of construction but this knowledge is not transferred to the design consultants, this is a type of information asymmetry (cf. (Lingegård et al., 2011)) that will be further discussed below. This can be compared to the design paradox, Figure 1, where product knowledge increases with time in the product life-cycle and modification costs increases. This is an example of the cost overruns that are usual for this type of contracting (cf. (Pakkala, 2002)). The customer, the STA, sets the market regulations and the organization has a conservative culture where the willingness to change sometimes is low, which in itself can lead to inefficiency (cf. (Ahmed & Shepard, 2010)).
Currently the only actor that has the overall view and responsibility of a railway facility is the STA, see Figure 8-10. This means that the STA is the actor that should hold information concerning the condition of the rail infrastructure. However, the information that exists today lacks details and is not complete since there are no incentives for the contractors to deliver this information. This results in that knowledge gained by one contractor during one contract, is not collected and used as input for the next contract. This can be illustrated by Figure 1 where the product knowledge increases during the life-cycle of the product but in this case this information is not transferred back meaning that the next product life-cycle start with the same information level as the previous one. There is no information transfer between e.g. the maintenance contracts since there are no incentives to do so due to the short-term contract lacking in continuity along the lifetime of the facility. This is caused by the breakdown of the life-cycle into several different contract, Figure 9. This causes an information asymmetry between the contractors and the buyer, cf. [P3]. There is however a possibility that the same contractor wins the subsequent contract since this organization has learnt and therefore can provide a more efficient, and cheaper, bid than its competitors. For the building contracts, Figure 8 and 10, it is the same story. The gained knowledge is not transferred back to the STA and the design consultants when they design new projects. Information gained during the life-cycle of the facility is not used by the STA and the design consultants in the next design phase and therefore not increases the product knowledge, Figure 1. This information could potentially result in efficiency gains and technical development, since it is in the design phase the major decisions are taken e.g. about the resource efficiency (cf. (Lewis & Gertsakis, 2001)). The technology and design is locked for the whole life-cycle of the facility, when it has been realized but there is on the other hand room for incremental innovation (cf. (Christensen, 2000). This will however only be possible if the information concerning failures and possible improvements is transferred back to the STA to be incorporated into the design. The same standards are chosen repeatedly since there are no feedback loops bringing back information that challenges the current technology and standards. This is an example of how the existing structures such as behavior patterns and work practice are enabling and reinforcing the existing technology, (cf. (Perkins, 2003)).

9.1.2 Conservative culture

Little or no interest are shown by the STA for other methods than those specified (Stenbeck, 2004). Even though the construction contracts are most frequently used there are changes in the industry. There is a development taking place towards more life-cycle thinking and functional requirements (Arnek et al., 2007). The Design-Build contracts are a step in this direction. For these contracts the distinct roles for the actors have been an issue and the STA has interfered more than what was initially decided. This has sometimes made the Design-Build contracts similar to the construction contract. Despite this the contractors are positive even though they find Design-Build contracts more difficult to calculate. A significant cultural change is needed to change from an in-house organization to a client-based organization and it is not an easy process (cf. (Pakkala, 2002))
9.2 Potential benefits and challenges regarding IPSO for rail infrastructure

IPSO contracts are not an updated version of the old in-house monopoly that the STA previously had on the Swedish rail infrastructure market. The principal of IPSO is that one provider has the overall responsibility of the design, construction and maintenance (Lindahl, 2006). Even though SJ had the overall responsibility before the market was exposed to competition this was not a form of IPSO since the divisions were structured as their own profit centers and an internal market was created (Kopicki & Thompson, 1995). The different parts of the organization cared more about their internal finances than the overall project, which created sub-optimization. Additionally, even though an internal market was created, there was only one part that constructed the infrastructure and one that maintained it. Thus, there was no competition that could provide incentives for quality improvement or innovation.

9.2.1 Increased value and cost reduction

The rail infrastructure market operates within the laws and regulations of public procurement, which adds certain conditions and a different context to the buyer-provider perspective of IPSO. Hence, the provider in this case cannot change the business model and initiate an IPSO in a way of generating growth and continuous revenue streams (Brady et al., 2005a; Mont, 2002). A more durable railway for a lower life-cycle price would be an increased value for the STA and thereby the society in the form of reduced costs for the railway infrastructure. The costs for the railway are increasing and the STA has an outspoken strategy to improve cost efficiency (Banverket Produktion, 2009; Trafikverket, 2011). From the examples of IPSO contracts illustrated in Section 2.8 state that the lowest cost possible and cost control for the customer are key aspects for the business model (Baines et al., 2007; Kowalkowski, 2008; Sundin & Bras, 2005). The contractors hope that IPSO contracts would make the STA focus less on the initial purchasing price, as they do today, and more on the quality and the best solution for the facility by adopting a life-cycle perspective when evaluating the price. Increased customer value is one of the main benefits for the IPSO business model (Brady et al., 2005a).

9.2.2 Developing a more durable railway

The material use from rail infrastructure has a large environmental impact (Svensson, 2006). An IPSO with a fixed price could provide incentives for minimum input and maximum utilization of the elements in the offering (Meier et al., 2010). This is in line with theories of how dematerialization can reduce environmental impact (Mont, 2000; Öhlund, 2003). The life-cycle perspective was mentioned as an improvement from the current situation. The contractors stated that knowing that they were going to maintain the facility themselves would result in more durable infrastructure since they have the possibility to balance the construction cost to the maintenance cost, which is in line with previous research on infrastructure project (Pakkala, 2002; White et al., 1999). The contractors believe that they can
be more creative and thereby affect the rest of the life-cycle if they are involved in the design phase, as illustrated in Figure 1 where freedom of action is decreasing with time. Additionally, to decrease the environmental impacts from the facilities environmental considerations need to be incorporated in the design phase to be efficient (Sakao, 2007). Taking environmental issues into account in a proactive way will be less costly than doing it later since the modification costs increases over time, Figure 1. Their focus is on cost reduction and process efficiency but this indirectly results in a focus on reduction of environmental impact as well. The contractors will, using the IPSO business model, make sure that the facility is as durable as possible to reduce maintenance and changing of spare parts, which implies less use of resources such as material and energy. This type of incentive are in place at ITT Flygt where the aim of the offerings are e.g. to create reliability and extended product life (Kowalkowski, 2008). Another example is BT Industries that remanufacture their forklifts which provides incentives for a extended life-cycle of the products (cf. (Östlin et al., 2008)). The holistic IPSO view provides incentives for the contractors to optimize the use of resources and realize more economical and environmental development (cf. (Lindahl, 2006; Tukker & Tischner, 2006b)). Increased efficiency and thereby reduced cost and environmental impact is achieved by Rolls-Royce using IPSO contracts for engines (Baines et al., 2007).

The contractors are however concerned about the material handling monopoly. This is a type of technological and market lock-in from the STA where the material and products are set in advance (cf (Perkins, 2003)). The contractors believe that an open market for material handling would improve their competitiveness against the other contractors. A possibility for the contractors to more freely choose the material to use would further expand the benefits for the IPSO since the innovation potential could increase when the offering would not be locked to a certain selection of material and components. The drawback, according to the STA, is that different types of construction and mixed systems would be used making it hard to manage the material supply. If the STA would procure a traditional maintenance contract after the IPSO contract, this would include the STA being in charge of the material supply, which could be expensive if it involved non-standard material. There is however no evident reason for why the contractor would choose to use non-standard material with odd spare-parts since this would increase the maintenance costs. The STA’s concern about the material could on the other hand also be a matter of attitude and competence. The question is why the STA is in charge of the material supply in the first place? This is a remain from when all activities were performed in-house, including the material supply.

IPSO contracts would also provide incentives for documentation since the contractor has to demonstrate the value of the facility in the end of the contract as well as to have measures for evaluation during the contracts. For all the examples presented in Section 2.8, BT-Industries, ITT FLygt, Danfoss and Rolls-Royce, information is a key factor to the implementation and realization of their offerings (Baines et al., 2007; Kowalkowski, 2008; Matzen, 2009; Östlin et al., 2008). For a provider of rail infrastructure upgrading or redesigning is not easy due to the
technological lock-in. On the other hand, the processes for maintenance can be developed during the contract using the knowledge and experience gained during the use phase of the IPSO contracts (cf. (Meier et al., 2010)). For long-term IPSO contract within the UK defense industry the information flow is stated to be a major benefit providing data such as equipment usage pattern, cost data and network wide information (Datta & Roy, 2011).

9.2.3 Competition and supply chain

Another important issue for the STA is the potential increase in the competition from international contractors. In a mature industry IPSO could be part of a growth strategy (Mont, 2002) but since the respondents believe that larger international companies would be interested in the IPSO contracts there might not be room for the national companies to grow. The respondents also stress that smaller contractors would not be able to bid on large contracts like this and that long-term contracts could potentially freeze the market. Therefore the packaging of the contracts seems to be of utmost importance since it potentially affects the competition and thereby the number of offerings participating in each bidding process.

Another market-related issue is the possibility of supply chain disruption, and this fact has to be accepted and accounted for from the supplier’s side (Erkoyuncu et al., 2009). To be able to realize the efficiency needed for the IPSO contracts a key factor for Rolls-Royce is to develop the supply chain (Rolls-Royce, 2011). It has also been stated that a formal relationship is not enough for an IPSO contract, and for the partnership to be successful there is a need to align the profit incentives between them (Lockett et al., 2011). This implies the importance of transparency.

9.2.4 Organization and culture

Only changing the business model and contracts would be insufficient, since the relational issues are required and determined by the business needs (Thompson et al., 1998). A major hurdle in this case seems to be the organization and culture at the STA, which lacks a long-term overall perspective in combination with an internal reluctance to change and develop the process of contracting. This type of internal resistance has in previous research been described as preventing the change needed to develop new product-service mixes (Cooper & Evans, 2000). The challenge is related to the change of mindset within the organization and the need for internal marketing (Sundin et al., 2009). This type of cultural challenge has been observed within the defense industry in the UK, where customer and the provider had different ways of thinking about maintenance routines resulting in extra costs to make up for this difference (Datta & Roy, 2011). This implies the importance of working together and understanding the other parties’ perspective. For the rail infrastructure industry, as for the defense industry in the UK, a massive cultural change is needed (cf. (Datta & Roy, 2011)).

Providers need to develop new skills for understanding long-term risk as well as being able to identify, evaluate and manage risk (Brady et al., 2005b). In this case, this goes for both provider and customer due to the complex relations between the actors and the structure. A
multi-skilled and cross-functional team is needed to produce the offering (Brady et al., 2005b). The contractors can already identify potential synergies within their own organizations as a result the holistic work practice and the cross-functional approach. The construction and maintenance phases would benefit from the fact that the all knowledge would be in the same organization and solutions could be discussed from a life-cycle perspective. Previous research has shown that project with an integrated process such as IPSO projects for infrastructure results in that projects are completed faster (Pakkala, 2002). Other changes needed are more cooperation between the Investment and Traffic Divisions at the STA and the need for both a general contractor and a technical contractor to fulfill the cross-functional skills.

The actors see themselves as parties with opposing interests. Long-term cooperation, however, calls for common interests, shared risks and flexibility rather than making one side take all the risk (Nystén-Haarala et al., 2010). Within the defense industry in the UK, where similar contracts are used, risk-sharing and transparency are explicitly encourage by the buyer (Johnsen et al., 2009). The same research concludes on the other hand that this is not easily implemented in practice due to the lack of trust between the actors. The actors in the UK defense industry suggested open books relations as a solution to gain trust but this type of relationship requires high levels of trust to be implemented (Johnsen et al., 2009).

9.2.5 Contracting

The packaging of the project is very important, both in terms of contract length and volume. The length is connected to the risk assessment possibilities for both the supplier and buyer perspective (cf. Alonso-Rasgado & Thompson, 2006). For long contracts the contractors are concerned about the possibility to estimate the costs, which is something that has to be done in the bidding stage (cf. Erkoyuncu et al., 2011)). The length of the life-cycle for a rail infrastructure is very much dependent on the elements used for the construction and which elements that are decided to be the ones steering the length of the contract.

Related to the length and volume of the contracts is the contractors’ concern about their increased responsibility, including a large part of the life-cycle for the infrastructure, and increased responsibility equals increased risk according to the contractors. A key characteristic of IPSO is the reduction of unpredictability and variability of demand during the contract time, making risk reduction a driver for the business model (Mont, 2004; Oliva & Kallenberg, 2003). The contractors want more flexibility on one hand, but are on the other hand reluctant to take more responsibility that could lead to an increased risk. However, risk does not have to be seen as something completely negative, it all depends on how the contractors choose to deal with it. They can either develop the necessary skills and competence needed to identify and handle the risk in a strategic manner, or take the problems as they come in more of an ad hoc way.

Other industries has managed the uncertainties with long-term contracting by adding flexibility to the contract using soft elements such as renegotiation (Nystén-Haarala et al.,
There are factors that the contractor cannot predict such as changes in traffic volume that would have a great effect on the wear and degradation of the tracks. Innovations and constant improvements can sometimes be dampened by long-term contracts, since the provider is protected from competition for a longer period of time (Panesar & Markeset, 2008). Renegotiations could be seen as a fresh start within the contracts to maintain quality.

Another precautions for risk are performance indicators and the pricing structure (Nystén-Haarala et al., 2010). Both parties have indicated that the evaluation, both during the contract and afterwards, will be difficult. Operationalization of the functional result of the contracts needs extra attention; one important part of the contracts is to specify precise parameters so that it can be determined whether or not the IPSO is satisfactory delivery (Alonso-Rasgado & Thompson, 2006; Tukker & Tischner, 2006b). Due to the length of the contract, it will take time before the entire project can be evaluated, and a residual value has to be determined so that the two parties can work towards the same goal. Challenges for the providers are e.g. assumptions concerning equipment failure, prediction of maintenance routines and communication problems with the customer (Datta & Roy, 2010). Risk of unpredictable costs can be reduced by access to resources, and the trust in a relationship can be helped by sharing information (Ng & Nudurupati, 2009). This shows how important transparency and information sharing will be for the IPSO contracts to work. The need for improved information management has already been discussed earlier in this thesis. However, the actors’ reluctance to use IPSO contracts for reinvestment is also related to the lack of information. This reluctance is confirmed in the literature where it is stated that lack of historical data causes unpredictability (Ng & Nudurupati, 2009).
10 Conclusions and future research

IPSO has the potential to provide an opportunity for the rail infrastructure industry to decrease its economic costs and environmental impact e.g. through improved innovation, resource efficiency and accessibility of the infrastructure. However, while the economic benefits are the main driver for the industry itself, the potential environmental benefits are seen as a positive side effect. The conclusions for the specific research questions are presented below.

10.1 RQ1 – How is rail infrastructure management currently procured?

The railway infrastructure is a mature industry where standardization, cost focus and a long-term use phase are the main features. The contracts currently used have advantages such as being a familiar business model that is straightforward to calculate for the contractors. However, they are not optimal for innovation due to e.g. detailed specifications, standards and technological and market lock-in effects.

Construction contracts are mainly used for building the facilities but Design-Build contracts are slowly introduced as an attempt to involve the contractors in the design phase. Performance contracts are used for maintenance and are formulated similar to the Design-Build contracts. However, the intent behind these contracts are not always fulfilled since the buyer controls the process more than needed due to a conservative attitude that is difficult to change.

Technological and market lock-in, in combination with a lack of information transfer between different contracts and actors, are major disadvantages with the current procurement process. The breakdown of the life-cycle results in several short-term contracts lacking in continuity along the lifetime of the facility, and thereby a lack of incentives for information transfer. This implies that the same standards are chosen repeatedly, since there are no feedback loops bringing back information that challenges the current technology. The technology and design are locked for the whole life-cycle of the facility, and only incremental innovation is possible. Another technology and market lock-in is the monopoly the buyer holds on the material and products used for industry.

10.2 RQ2 – What are the potential benefits and challenges from the provider and buyer perspectives regarding IPSO for rail infrastructure?

A benefit with IPSO is the holistic life-cycle perspective that provides incentives for dematerialization, resulting in a more resource-efficient and durable infrastructure. IPSO requires improved information transfer, which in turn stimulates innovation as well as processes for evaluation of the contracts. Further benefits are potential incentives to get contractors involved in the design phase, where major decisions about the life-cycle are made, in order to reduce the infrastructure’s environmental impact and total life-cycle cost.
The contractors hope that IPSO contracts will make the buyer focus e.g. less on the initial purchasing price, as they do today, and more on the total life-cycle cost in relation to quality in order to get the best solution.

The organization and culture at the STA has been identified as a barrier for IPSO, since it lacks a long-term overall perspective in combination with an internal reluctance to change and develop the process of contracting. A cross-functional approach within the organization is needed, e.g. between investment and maintenance. Even though the contractors are part of the same mature market, the organizational changes needed for them to fulfill IPSO contracts are not seen as a barrier. The contractors can already identify potential synergies within their own organizations as a result of the holistic work practice and the cross-functional approach.

The actors see themselves as parties with opposing interests. At the same time, IPSO will most likely imply more long-term cooperation, something that calls for common interests, shared risks and flexibility. The innovation possibilities with IPSO could benefit from loosening up the material handling monopoly that the buyer currently holds. Furthermore, the IPSO contracts would provide incentives for documentation for the contractors since they need to be able to prove the quality of the facility.

Since the buyer is a dominant actor within the industry, this organization has major possibilities to introduce changes that the other actors would have to conform to. This also implies that the packaging of the contracts, i.e. their length and volume, has to be carefully thought through since it could affect market conditions such as competition and potential market lock-ins. A market-related issue the contractors have to consider is the risk of supply chain disruption during the course of the contracts.

10.3 RQ3 – What potential risk factors can be identified when using IPSO for rail infrastructure?

Several challenges have been discussed, and most of them derive from the risk and uncertainty aspects that come with long-term contracts and the inexperience of a new business model. The contractors want more flexibility on one hand, but are on the other hand reluctant to take more responsibility that could lead to an increased risk. The increased responsibility also equals increased risk-taking, but even so, IPSO reduces the unpredictability and variability of demand for a long period of time for the contractors. However, risk does not have to be seen as something completely negative; it all depends on how the contractors choose to deal with it. They can either develop the necessary skills and competence needed to identify and manage the risk in a strategic manner, foster a competitive advantage, or take the problems as they come in more of an ad hoc way.

A way to reduce risk and uncertainty could be to include some type of renegotiations during the contract time since not all factors, e.g. changes in traffic volume, can be estimated in the design phase. The contractors are concerned about estimating costs, and it is therefore important through operationalization of the functional result to facilitate both pricing and
evaluation of the delivered quality. Furthermore, focusing on transparency between the buyer and provider as well as information sharing is a way to reduce risk. Improved information transfer could also open up IPSO contracts for reinvestments, where the current lack of information about the facilities causes too much unpredictability for IPSO contracts.

10.4 Concluding Remarks

This research has focused on IPSO for rail infrastructure management, using the Swedish rail infrastructure as a case to discuss the considerations and feasibility of such an implementation. The conclusions are therefore valid for rail infrastructure in other geographical locations as well.

10.5 Future research

This thesis presents current practice and opinions from the actors in industry concerning IPSO for rail infrastructure. The conclusion is that there are potentially both economic and environmental benefits in using this model. The next step in this research will be to show this improvement potential in a quantitative way using life-cycle assessment and life-cycle cost analysis for environmental and economic calculations. This will be realized using scenarios relating to both current and IPSO contracts. Furthermore, one part will focus on the overall system on a general level, while the other part will investigate an example of changing a material or a product to see the potential effect on cost and the environment.

Additionally, the industry is requesting further investigation and analysis of the functional requirements needed for an IPSO contract. How can these be formulated, and on what level is it feasible to set them? These are questions that are essential for the successful implementation of an IPSO contract.
11 References


Exchange (SCORE!) Network (www.score-network.org), supported by the EU’s 6th Framework Programme, Copenhagen, Denmark.


Zietlow, G. (2004) Implementing performance-based road management and maintenance contracts in developing countries-an instrument of German technical cooperation: German development cooperation.


APPENDIX 1

Interview guides
Interview guide: The Swedish Rail Administration

The term functional contract (funktionsentreprenad med helhetsåtagande) was used for IPSO contracts during the interview.

Introduction

1. What types of contracts are used in the current situation for "train-related" procurement i.e. track, maintenance, etc?
2. What is your definition of a functional contract with overall commitment?
3. What obstacles and challenges are there in the current situation when it comes to procurement contracts? For each type of contract?
4. What obstacles and challenges are associated with the functional contracts?
5. What advantages would there be with the functional contract?
6. How would functional contracts affect the use of technology?
7. What problems with the current construction would a change solve?
8. Do you see the function of procurement as a future scenario?
9. What would be required for the Swedish Rail Administration to start with function contracts with overall commitment (design, construction, maintenance)?

Contracts

10. How long are the contracts today?
11. How long should the contract be for the functional contract?
12. Are there regulations on contract length with regards to public procurement?
13. Do you see any problems with the length of this type of contract? What?
14. Do you think the tendering process will take a longer or shorter period of time?
15. In some contracts in the UK, renegotiation of some parts at regular intervals (5 years) was introduced; is this something that you think might be necessary? How long should the intervals be? What would need to be renegotiated?
16. Are there risks associated with the contract length? For the contractor/client?
17. What are the advantages and disadvantages of using such long contracts?

Cost, reimbursement and risks

18. How does the funding look today?
19. What should the funding look like?
20. How are reimbursement costs for offers (contracts) in use calculated (should be calculated)? What are the difficulties in this?
21. Are there regulations for compensation etc. by public procurement? (how compensation is calculated, etc.)
22. How does the contractor set a fixed price that covers the risks, but at the same time is competitive?
23. What degree of transparency would be needed to assess offers on price etc?
24. How should interest rates and profits be handled?
25. Where should the line be drawn between client and contractor? Risks, responsibilities, etc?
26. What is needed to determine risks and compensation?
Organization

27. What functions or parts of the organization are involved in procurement work today?
28. What organizational changes will be required at the Swedish Rail Administration?
   - Which parts of the organization will need to change? How?
   - What is the interplay between the involved parts today? Will the interaction between the parts change?
   - Will new skills be required in the organization to implement functional contracts? Which ones?
29. Are there routines in place to preserve knowledge within the organization?
30. The Swedish Rail Administration’s organization will have less detail control over the functional contracts. Will this create any problems in the corporate culture?
31. Does the Swedish Rail Administration’s have the organization necessary to implement functional contracts?

Contractors

32. What will be required of suppliers, contractors and subcontractors, as opposed to today?
33. Do the contractors have the organization necessary to implement the functional contracts?
34. What organizational changes will be required of the contractor?
35. What requirements must be placed on the contractor’s organization in the tender?
36. Will the relationship between client and contractor change?
   - How? What are the challenges?
37. How do functional contracts potentially affect the contractor market?
38. How many contractors are there today in Sweden and abroad who could perform a functional contract?
   - Number of contractors who are capable of a functional contracts?

Contracts

39. Do you have any contact with other employees within the Swedish Rail Administration’s that I could contact to get their perspective on the functional contracts?
40. Do you have any contacts with contractors who I could contact to get their perspective on the functional contracts?
Interview guide: Contractors

The term functional contract (funktionsentreprenad med helhetsåtagande) was used for IPSO contracts during the interview.

Introduction

1. What types of contracts are used in the current situation for "train-related" procurement, i.e. track, maintenance, etc?
   - Functional contracts? With overall commitment?
2. Has Company X performed any type of functional contract yet?
3. What is your definition of a functional contract with overall commitment?
4. What obstacles and challenges are there in the current situation when it comes to procurement contracts? For each type of procurement (contract)?
5. What obstacles and challenges are associated with functional contracts?
6. What advantages do you see with the functional contract?
7. How would the functional contract affect the use of technology?
8. Have there been problems in the past that have been solved with the help of changes in the contract form?
9. What type of contracts in the future? What problems with the current construction would a change solve?
10. Do you see the function contracts as a future scenario?
11. What would be required for the Swedish Rail Administration to start with functional contracts with overall commitment (design, construction and maintenance)?

Contracts

12. How long are the contracts today?
13. What would the business model look like for a functional contract with overall commitment?
14. How long should the functional contract be?
15. Are there regulations on contract length with regards to public procurement?
16. Do you see any problems with the length of this type of contract? What?
17. Do you think the tendering process will take a longer or shorter period of time?
18. In some contracts in the UK, renegotiation of some parts at regular intervals (5 years) was introduced; is this something that you think might be necessary? How long should the intervals be? What would need to be renegotiated?
19. Are there risks associated with the contract length? For the contractor / client?

Cost and compensation

20. How does the funding look today?
21. What should the funding look like?
22. How are reimbursement costs for offerings (contracts) in use calculated (should be calculated)? What are the difficulties in this?
23. Are there regulations for compensation etc. by public procurement? (how compensation is calculated, etc.)
24. How does the contractor set a fixed price that covers the risks, but at the same time is competitive?
25. What degree of transparency would be needed to assess offers on price etc?
26. How should interest rates and profits be handled?
27. Where should the line be drawn between client and contractor? Risks, responsibilities, etc?
28. What is needed to determine risks and compensation?
29. What are the advantages and disadvantages of using such long contracts?

**Organization**

30. How does the organization work today? What functions or parts of the organization are involved in offers at the Swedish Rail Administration?
31. Would changes in the organization be required?
32. Will new skills be required in the organization to implement this type of overall commitment? Which ones?
33. Are there routines in place to preserve knowledge so that it remains within the organization?
34. Could it require cooperation with other contractors to offer overall commitment?
35. Does the Swedish Rail Administration have the organization necessary to implement functional contracts?
36. What requirements must be placed on the contractor’s organization in tender?
37. Will the relationship between client and contractor change?
   • How? What are the challenges?

**Contractor market**

38. How does the function of contractors potentially influence the contractor market?
39. How many contractors are there today in Sweden and abroad who could perform functional contracts?
   • Number of contractors who are capable of a functional contract? Minimum number that is acceptable for competition?
40. Problems with having multiple subcontractor companies that are dependent during the entire life-cycle? If a vendor retires / goes bankrupt etc?