PSS for rail and road infrastructure

- a literature study

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Abstract
The productivity development for rail and road infrastructure has been weak for a longer period of time and some explanation can be found in the traditional contracts used with little room for incentives for innovation and development for the contractor. In cooperation with the Swedish Transport Administration a project was launched to investigate the possibility for Product Service System, PSS contracts within the rail infrastructure in Sweden to develop the current praxis. The first step in this study is to investigate benefits and challenges with PSS contracts using a literature study.

The ongoing PSS projects show positive outcomes so far, even though it is too early to evaluate the whole process. The most significant benefits with PSS contracts for rail infrastructure are development of technologies, increased efficiency and cost reductions, potentially new innovations, a life cycle perspective providing incentives for environmental consideration and closer relationships between procurer and contractor. It is not straightforward to change to this new way of contracting and to obtain the benefits several challenges have to be overcome such as changes in the work processes, risk allocation and to find a suitable the price mechanism.
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1 Introduction

The productivity development in the construction industry, such as road and rail infrastructure, has been weak for a longer period of time, possibly due to the traditional form of contracting used[1] and the last years these traditional forms for operation and maintenance have caused increased costs and resulted in an increased interest for new contracting types[2]. Construction contracts are currently used to a large extent in Sweden but this type of contracts has short-comings concerning weak incentives for development of the procedures[3]. Interviews with managers at the Swedish Transport Administration, former the Swedish Rail Administration (more detailed information in Section 3) are in line with this argument claiming the major obstacles for technical development and little room for innovation due to too detailed specification of how to do things[4]. This gives the procurer a reason to design the contracts to produce more incentives for cost efficiency [3]. It is also in the strategy of the Swedish Transport Administration to improve the cost efficiency of the maintenance by improving the conditions already in the development phase and to perform maintenance as efficient as possible considering the whole life cycle of the products[5] . One way of doing this could be with another type of contracting. Performance contracting gives better incentives for contractors to develop the product by e.g. find a better balance between building and maintaining costs [6]. The contractor is responsible to deliver an agreed-on function and can decide how this should be done, and the contractor will have to weight building costs to future maintenance cost which should provide a cheaper solution for both procurer and contractor [6]. This type of contracting, when the customer only pays when outcomes have been delivered instead of traditionally tasks and activities, is also called Product Service Systems, PSS[7]. A more extensive review of this type of contracting can be found in Section 4.

This is the starting point of the DORIS (Development of (Integrated product service) Offerings for Rail Infrastructure Systems) project which was launched in cooperation with the Swedish Transport Administration to investigate the possibility for PSS contracts within the rail infrastructure in Sweden. The aim of this project is to support Swedish Transport Administration to find new ways to improve their procurement of the rail infrastructure. The first step in this study is to investigate possibilities and challenges with PSS contracts for road and rail infrastructure. This paper will focus on the initial literature study and has the following objective.

1.1. Objective

The objective of this paper is to investigate the current state for rail infrastructure procurement for the Swedish Transport Administration as well as look in to issues related to performance contracting for the rail infrastructure. This gives the following research questions:

1. What types of contracts are currently used when procuring rail and road infrastructure?

It is of importance to gain insight of the present way of working with procuring in the area of rail infrastructure on performance contracts or long-term contracts and thereby relate these examples with examples for rail infrastructure.

2. What benefits are there for implementation of PSS contracts when procuring rail and road infrastructure?
What could this type of contracting bring to rail infrastructure procurement when it has created benefits when implemented in other areas such as road construction?

3. What challenges are there in the implementation of PSS contracts when procuring rail and road infrastructure?

   *A new type of contracting implies a new way of thinking and thereby changes are necessary which can prove to be a challenge for the actors.*

1.2. Limitations

A major issue concerning PSS contracts is how to define the performance requirements and subsequently measure the result. These issues will not be the focus of this paper but will instead be discussed in a future paper.

1.3. Paper overview

This paper will start with a section describing the method used to perform the literature study followed by Section 3 presents an overview over the Swedish Transport Administration as well as a brief review of construction contracts and service contracts. Section 4 is presenting a review of the different names for PSS contracts and concludes that PSS contracts are the name that will be used in this paper. Section 5 presents the examples of PSS contracts for rail and road infrastructure. Section 6 introduces the reader to benefits with PSS contracting while Section 7 talks about the challenges for the same type of contracting. Subsequently, Section 8 includes a concluding discussion comparing the benefits and challenges found in the literature with the reviewed examples. Finally, Section 9 presents the concluding remarks as well as suggestions for further research.
2 Method

The starting point for the literature study was an introductory interview with an employee at the Swedish Transport Administration, well informed with the working process in the organization, to gain sufficient knowledge within which areas to start searching for literature for this study. The search was divided into three steps to make sure that the objectives of the study would be fulfilled. The aim for step 1 was broad and focused on gaining knowledge concerning different contracting forms used for infrastructure. Step 2 was more focused on one special type of contracting, namely PSS contracting. The characteristics and examples of this type of contracting were the objective of this step. The final step focused on possibilities and challenges for PSS contracts.

2.1 The literature search

The literature search was performed in databases such as Science direct and Scopus as well as in journals available through the Linköping University library. Information from the Swedish Transport Administration, from e.g. former Swedish Rail Administration and the former Swedish Road Administration has been used. Furthermore, home pages for other organizations of interest, both in Sweden and abroad, have been used to retain information. No geographical limits have been used when searching for literature, instead the search has included literature from several continents even though some of it is not included in this paper. This is partly due to the difficulty to judge the quality and partly since the conditions for the contracts were far from the ones in Sweden and therefore not relevant in this study.

The references used are published scientific papers, reports and books.

2.2 Quality of literature

Literature reviewed includes several different kinds of sources; scientific articles, reports, home pages, master thesis as well as doctoral and licentiate thesis. The information has, when it was possible, been triangulated using different sources. However, the information concerning the use of PSS contracts for rail and road infrastructure is limited to just a few sources. This could imply that the information is biased but the main information is retrieved from the Swedish National Road and Transport Research Institute which states on its web site: “VTI, Swedish National Road and Transport Research Institute, is an independent and internationally prominent research institute within the transport sector.”[8]

2.3 Analyzing the literature

Before analyzing the literature an overview of the Swedish Transport Administration is presented followed by a brief discussion of the different concepts of contracts, where PSS was decided to be the concept to proceed with, as well as a short description of the examples of PSS contracts found in the literature search. The literature is presented and analyzed in two separate section; benefits as well as challenges for PSS for rail and road infrastructure. For some areas discussed only one or a few of the examples provided specific information and the others are therefore left out. The section analyzing the challenges is significantly longer than the one concerning the benefits depending on the more extensive and detailed information for this area. The challenges are however mostly concerning the implementation of the contracts and are not questioning the benefits.

Subsequently the concluding discussion has the ambition to answer to the research questions posed in the introduction by drawing conclusions from the comparison between the examples presented. The difference in the level of details between the presented examples of projects
results in them not being entirely comparable. On the other hand the comparison still is feasible for most of the issues and provides an overview of issues for further research.
3 The Swedish Transport Administration

During this literature review major changes have occurred for the organization of the Swedish Rail Administration. The organization is now part of a larger administration called the Swedish Transport Administration where the Swedish Road Administration, the Swedish Maritime Administration as well as the Swedish Institute for Transport and Communications Analysis also belong as from April 1st 2010. In total the Swedish Transport Administration employs 6500 people and has regional and local offices all around Sweden and a main office in Borlänge. [9]

The Swedish Rail Administration is responsible for 80% of the total rail system in Sweden[10]. Since 2001 the Swedish Rail Administration has exposed its maintenance contracts to competitions, before only the internal organization, Banverket production, performed the maintenance contracts. In the end of 2009, 88% (measured in track distance) of the maintenance had been exposed to competitive procurement [11], but Infranord (former Banverket production) is still the dominate actor[10]. The competitive procurement has resulted in reduction in costs for the maintenance [11]. Despite this the maintenance costs are increasing and in 2008 the maintenance costs and the re investment cost made up over 50% of the cost for new investments [11]. In 2009 the Swedish Rail Administration procured a large part of the operation and maintenance with performance contracts where a defined performance level is set before and then it is up to the contractor to determine what activities to realize [12] but this only concerned the maintenance and not the whole life cycle of the tracks.

It has been concluded in a doctoral thesis[13] from 2006 concerning the former Swedish Rail Administration that there has not been significant pressure on the organization, internally or externally, to use life-cycle environmental management and the work has been focused on environmental issues found locally and not on life-cycle perspectives. Furthermore, the railway needs to adopt new perspectives to start working with environmental management of the products and to set environmental requirements already when designing new products, before introducing them in the material supply chain. [13] Arlandabanan, a railway stretch which included building and from 1999 subsequently run the operation for 45 years before the facility will return to the government[14] is the only example of a PSS contract for railway infrastructure in Sweden that could be found in the literature.

3.1 Construction contracts

Construction contracts are the most common contracts within the infrastructure construction industry in Sweden [15]. The concept is based on the procurer specifies what, how and the volumes for the project [6]. This includes the choice of technology, materials and functions. The tenders are made in unit prices and the choice of tender is mainly based on the lowest price. [2] Construction contracts imply that the procurer carries all the risk. 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. Furthermore, it also increases the incentives for the contractors to make additional orders to increase their profitability or even present a low tender and then make the money on the additional orders. [6]

3.2 Service contracts

The Swedish Transport Administration has since 2005 used performance contracts for the maintenance[5] meaning that “…the Swedish Rail Administration procures a functionality of the track that has been set in advance. The contractor subsequently decides what measures to
take with aspect to the performed reviews and regulations for maintenance.” [12] The length of the contracts is 5 years with an additional 2 years option with bonuses for improvements, such as a lower number of errors, and with penalties when the contractor has not reach the levels of e.g. delays[5].
4 Product Service System: once concept – several names

The focus for this paper is the PSS contracts where the procurer requests a function instead of a specific execution [15]. This kind of functional buying/selling has many different names and during this literature study several different names for the concept of buying a function have been revealed. The most commonly occurring is presented in Table 1. The concepts in the tables have no intergroup order.

Table 1: Different names for performance-based contracts.

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition/description</th>
<th>Reference (Name, year, page)</th>
</tr>
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<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[16]</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[3]</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[17]</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[18]</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[19]</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[20]</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[7]</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 [21]</td>
</tr>
</tbody>
</table>
From this table it can be concluded that even though the names of the concepts differ it still include the same content, namely that the focus on the output and not how the output is achieved. In this paper the concept will be called Product Service System, PSS, since this is the most common name of the concept. The PSS for the infrastructure include planning, construction and subsequently maintenance of the construction when the usage phase has started [15].

One way of PSS contracts commonly used in the procurement of rail and road infrastructure is the Public Private Partnership, PPP, which is a PSS contract with a specific financial solution. The contract is between a public and a private part where the private part, a company or a consortium, form a project company responsible for the infrastructure project funded by its own capital in combination with loans [1].

4.1 Benefits and challenges with PSS
PSS offerings have a lifecycle perspective and the combination of products and services can be combined to an optimized solution for the customer [21] and a possibility for the manufacturing company to have control over the product throughout its whole lifecycle[19]. PSS provides the supplier with a possibility to increase the value of the solution for the customer by integrating components in new ways[19] and is thereby a driver for development of technical solution[21]. Incentives for the supplier to realize a more economical and environmental development when considering the whole lifecycle[21]. Companies acting in a mature industry can use the PSS as a growth strategy and compete with their core competence rather than with physical assets[22]. The PSS require a closer and improved relationship with the customer and the customer does no longer necessarily have to be the owner of the product[22].
5 Examples of PSS for procurement of infrastructure

This section will provide examples of infrastructure projects where types of PSS contracts have been used. The examples are collected from both Swedish and international cases as well as from rail infrastructure and road infrastructure.

5.1 Rail infrastructure

5.1.1 Arlandabanan: Public Private Partnership

Arlandabanan is a 20 km long railroad section with double tracks between Stockholm city and Arlanda airport. The section also includes 7 km tunnel and several underground stations. The winning tender for this PPP contract was a consortium constructed by six companies. Swedish based companies NCC, Siab and Vattenfall managed the building of the tracks while the British companies John Mowlem dealt with the tracks and gears and GEC Alshom managed the trains and signal system.

The consortium later formed the company A-train AB to finance, build and subsequently run the train traffic. The build started in 1995 and was finished in 1999 when the ownership of the facility was transferred back to Arlandabanan Infrastructure AB, former A-banan AB. At the same time A-train got the right to use the tracks for traffic until 2040 as well as the responsibility to run and maintain the facility during the same time period. The ticket revenues from the end customers serve as revenues for A-train in this contract. Arlandabanan Infrastructure AB has the possibility to cancel this agreement as from 2010 if A-train is not fulfilling the requirements of the contract.

Financing

Two thirds of the construction costs were funded by the consortium while the last third was a conditional loan from the government. All the income risk is carried by the consortium as well as most of the cost risk in the project. A-train had the right to a penalty from Arlandabanan Infrastructure AB in case it would not be possible to construct a double track within the time that was agreed since this would delay the traffic start. Other causes for refunding for A-train were e.g. the discovery of archeological findings, incorrect technical information or project changes from the procurer and other causes that were beyond the control of A-train. On the other hand the consortium had to carry the risks for other additional costs that were seen as normal for this kind of construction. A-train got the freedom to balance the cost for the initial investment and the cost for maintenance and did then choose to use another solution for the tracks than the original idea of the procurer.

5.1.2 UK: The Northern Line train service contract

In 2003 three long-term contracts including maintenance and upgrading of infrastructure of the London Underground network came in place, dividing the network into three parts e.g. the Jubilee, Northern and Piccadilly, JNP, Lines. These PPP contracts span over 30 years with opportunities to review the contracts and requirements every 7.5 years.

For the Northern Line the contract includes leasing of train, an area of 50 stations, and full responsibility for the design, manufacturing and cleaning of trains and related equipment. The contract was formulated so that 80% consisted of capital works and 20% of service elements the first years while the service made up 100% from 5 years and forward.
The goal with the contracts was to gain improvement through long-term commitment using experts from the private sector at the same time as reduce backlog of investment and financial limitations[27]. The contracts are output specified and the required performance levels are measured with the following three factors:

- Availability: counting delays and disruptions lasting longer than two minutes. This counting takes into account when and where this disruption occurs and effects the penalties subsequently.
- Capability: measuring the capacity of the line.
- Ambience: measuring the quality of the customers’ travelling environment.

[27]

These measurements were all set in 2003 before the contracts started and a level of around 5 % worse than the historic data of the London Underground was decided to be the benchmark for the first five years and then subsequently become more challenging with time. Bonuses and penalties are used as additional adjustment for the performance. Furthermore, liabilities for environment and safety are included. [27] The availability for the JNP Lines have improved on a whole since the start in 2003/2004 and in 2010 the measure was 55 % better than the start value and 42 % better than the set benchmark[27]. This has on the other hand not been consistent for all the lines, e.g. the availability measure for the busy Northern line was 48 % worse than the benchmark in 2005/2006[29]. The parties then agreed upon a change in the contract to solve the problem, the program for renewable the tracks was accelerated and initiated two years earlier than stated in the initial contract[29].

5.2 Road infrastructure

5.2.1 Sweden: Norrortleden – construction and maintenance of 7 km highway

An ongoing contract for the former Swedish Transport Administration includes design, construction and then maintenance for 15 years. The project comprises 7 km of highway including a tunnel and several road bridges. The public procurement process started in 2003 and three companies applied for approval and could later send in their tenders. The differences in price for the contracts concerning the design and construction were minor while there were significant differences in the pricing concerning the maintenance phase. The winning contractor, NCC, had similar price level as the one calculated by the procurer based on traditional pricing. NCC, built the construction during a period of 3, 5 years (2005-2008) and is currently responsible for maintaining the construction. [30]

The technical requirements were mostly formulated as functional requirements, examples follow below translated directly from Swedish:

“*The road and the tunnel should be designed for a dimensioned speed of 90 km/h.*”

“The road body,…, should by the transfer have a remaining lifespan (residual value) of at least 25 years.”

“The design of the bridges should follow an overall coherent formation concept for the whole of Norrortleden.”

(Fia, 2005, p. 20[30])

During the construction phase the role of the procurer was the one of an advisor since the operation was lead by the contractor. The two organizations were built to mirror each other to ease the cooperation. [31] A fixed annual payment for the built with a special arrangement for
the tunnels where the contractor classifies the quality of the mountain as well as what activates that are needed and this then serves as a guidance for the pricing. Any sums above or below this price is shared by the two parties. [30] The compensation to the contractor for the maintenance phase is paid as a fixed sum very year. This sum is adjusted by an index based on nine weights specified in the contract, e.g. amount of traffic[30]. The risk of project was decided to assign the part that is in the best position to manage it which in this case it was the contractor. [31]

5.2.2 Finland: Highway section Muurla-Lohjanharju

In Finland 2005 a performance contract was signed for a 51 km long road section, including 7 highway tunnels and 76 bridges [32], concerning design, build, operate and finance [3]. The section, Muurla-Lohjanharju, is a cooperation between the public and private sector and the Finnish Road Authority, Finnra, buys the entire project from Tietyhtö Ykköstie Oy, a company formed by Skanska Infrastructure Development AB (Sweden), Laing Roads Ltd (UK) and Leminkäinen Oyi (Finland). This company deals with administration and financing and manages agreements concerning building and maintenance together with a consortium created by Skanska Tekra and Lemcon. [33]

The tenders of the contract were apart from the price judged on e.g. experience of similar projects preliminary plan for building and maintenance, plan for reassuring quality, plan for handling technical disturbances and the contractors’ financial situation. These parameters influenced the pricing + 10 %. [3] The contracts lasts until 2029, equal to 21 years [32] and as from the opening of the road in 2008 Finnra pays a service fee depending on the availability and service level of the road including several quality criteria [33]. The fee is connected to a yearly index regulation and the procurer carries the risk for an increase in price for different components used. The maintenance costs are based on a calculated value for the extent of the traffic and the contractor does not carry the risk for increase in traffic. There is a deduction in fee for e.g. if the availability is not satisfying. Furthermore, the traffic safety is measured every year to give the contractor incentives to work for accident reduction. Innovations that bring a decreased number of accidents are rewarded while an increase in the yearly accident count results in a deduction from the yearly payment. The contractor is also refunded for the initial investment when the road is ready for traffic providing incentives for fast opening.[3] At the end of the contract period the road section will be transferred and Finnra will be in control of it [32]. This will be done without any additional fees and the road section must be in the condition agreed upon [33].

5.2.3 Norway: Three PPP road projects

Three road projects have been procured by PPP contracts[25]. The three projects where 27 km, 38 km and 38 km respectively, and they have similar characteristics so the description will be limited to one of them, namely the first section E39 Klett- Bårdshaug [34]. Four potential tenders were competing for the contract[25]. However, before the potential contractors where to send in tenders they had to apply for a pre-qualification questionnaire to determine that the contractors fulfilled requirements such as;

- necessary technical and professional knowledge
- financial strength to complete the project
- documented experience of experience and competence
- list of reference projects

[34]
The construction started in 2003 and two years later the road opened, two months before the scheduled time. The contractor is responsible for financing, building and maintenance over a period of 25 years and after that the Norwegian public roads administration take over the maintenance. [25]

The responsibility of the contractor is the safety and the availability of the road and for standards such as environmental standards. Furthermore, the contract includes more detailed requirements such as quality and performance standards and quality routines for which the NPRA can survey to make sure they are being followed. The public part carries risk for events that the project company have no or minor possibility to influence, such as changes in legislation while risks related to financing, planning, construction, operation and maintenance are allocated to the project company. [34]

The project company receives an annual payment depending on the availability, performance, safety and amount of traffic on the road but out of these availability and performance are the major contributions to the payment while the rest are seen as additional payments [34]. These traffic payments increase with increased traffic as well as the safety payments that are seen as bonus related to the number of and the character of the accidents that occur compared to an equivalent average road. The Norwegian public roads administration has introduced a toll system for the roads for the first 15 years, from which the income will cover part of the costs for the project. [25]
6 Benefits with PSS for rail and road infrastructure

6.1 Reduced costs and increased efficiency

As mentioned in the introduction a way of increasing productivity is to use contracts with incentives for innovation for the contractors. There are good reasons for using PSS contracts where the work and the contract design can be adapted after the specific situation since projects differ from each other in conditions and requirements. One example of this is a decision taken by the contractor in the road construction project in Norway where the company identified the risk for landslides and built a tunnel there even though that construction cost was higher than building an open road. The contractor was also responsible for the maintenance and therefore realized that the total cost would be lower using a tunnel. [25] Two arguments for the transition from construction contracts towards PSS contracts are decreased costs, illustrated in the example above, and increased strive for innovation [3]. When using a traditional construction contract there are no incentives for the contractor to make the work more efficient since that would imply less pay using the unit prices. On the other hand if the project requires more work than expected the contract has to be re formulated and there is therefore an incentives for the contactor to make additional work to improve the profit. This argument provides a need for contracts offering better incentives for cost efficiency. [6]

When the road construction project for Norrortsleden was evaluated it turned out that the construction was realized in time and under budget at the same time as the quality was high. The contractor had realized the build cost efficiently. [35] This form of contracting proved to be cost efficient which benefited both parties [31]. This efficiency gained through a life cycle perspective including design build and maintenance since the overall are seen as a whole and there are incentives to build from a long-term perspective and secure the lowest total cost during the whole life cycle. [25] The length of the contract should include the maintenance as well as the construction since this would provide a longer perspective and benefit innovative solution [3]. The possibility to come with own ideas and implement them was appreciated from the contractor side in the case of Norrortsleden but it did not consider new inventions but development [31]. The conclusion from the project Norrortleden described above is that both procurer and contractor agree that the PSS contract will develop the industry and both parties believe they have obtained valuable experience for future contracts [30]. Furthermore the fact that the focus was on maintenance as well provided increased attention on quality and had an impact on the technical solutions [31]. The project with the highway section Muurla-Lohjanharju in Finland shows evidence of both better incentives for innovation and higher efficiency, the road was constructed and ready for opening one year before the initial time the procurer had in mind [33]. Another example of the benefits of this contracting form is the contract including the JNP section of the London Underground network that has improved the quality of the availability with more than 50 % in seven years [27].

6.2 Organization and co operation

The contractor for the project Norrortsleden claims the co operation with the procurer was closer than usual and had a more open atmosphere. The two parties had co located their offices and the contractor feels that had an major impact on the relationship. [31] For the projects realized in Norway similar experiences have been reported; a good co operation and significantly less conflicts than usual [25]. Additionally the two parties involved in the project Norrortsleden had mirrored their project organization to facilitate the work. Still the contractor called for more co operation and more room for ideas. [31] The Swedish Transport
Administration found the project Norrortsleden had a stimulating working process for both procurer and contractor[35] and the project was more engaging than usual [31]. The long-term commitment with a flexible contracts as in the case of the London Underground has proved to improve quality as a whole since there was flexibility in the contract and changes could be made when a dip in quality was helped by a acceleration in a program for renewal of the tracks[29].
Challenges with PSS for rail and road infrastructure

Traditional forms for operation and maintenance have caused increased costs and there is an increased interest for new contracting types. However, compared to the road sector the rail sector, which is more regulated by rules, is more limited when it comes to the competence machine resources and establishment time. These factors contribute to the difficulties for new contractors to establish themselves on the market as well as to test new technical solutions. [2] Even though the road sector are ahead of the rail sector when it comes to PSS contracting there are still issues to be solved for this sector. For example a change of the technical regulations has been suggested to improve the technical development after the project Norrortsleden. The Swedish Rail Administration had expected to see more innovation from the contractor while the contractor felt a need for a longer period of time between contract date and start of construction to make room for creative thinking. The contractor used already experienced methods since there was no time to develop something new. Another suggestion was to remove all types of penalties or share the risk for one particular stretch of the road and thereby be able to try new methods there. [31].

7.1 Contractual issues

It is impossible to write contracts that encompass every single detail but this creates opportunities for opportunist behavior. Therefore it is of importance to be able to share costs but this is easier said than done since many disagreements end up in court[3]. Complicated projects result in complicated contracts and in the case of Arlandabanan this gives margins for interpretations concerning rights and obligations[36]. A difficulty with PSS contracting is the need to define performance requirements [4]. To actually measure what the contractor has realized becomes a lot more difficult [6]. A long dispute between the parties involved in the contracts for the Northern Line in London Underground concerned the specifications for the performance measures[37]. The requirements need to be distinct and the contract has to clearly specify what the contractor can decide and not concerning contract such as Norrortsleden where most of the requirements were functional but not all. [31]

These types of contracts imply a long-term commitment from both sides and the possibility that changes in conditions and requirements will occur over time is significant. Therefore it can be problematic if the contract is to strictly written since this reduces the possibilities for the public part to adjust if the conditions in the transport sector changes. Instead there is a need for the possibility to create new and flexible solutions. [25] This type of flexibility was demonstrated in the London Underground contract when changes in the initial contract were made to improve quality[29].

7.2 Responsibility and risk sharing

When procuring performance the public part no longer controls and runs the project since the details are decided by the contractor. This implies that issues concerning responsibility can cause problems if the boundaries are not clear and this is especially true for issues that cannot be regulated in a contract,[25] It would prove to be difficult to agree upon the conditions for the project Arlandabanan showed by the dispute occurred. One of the sub contractors employed by A-train demanded payment for events beyond its control and A-train forwarded the demand to the procurer, Arlandabanan Infrastructure AB, who rejected the claim and instead demanded increase control from A-train’s side. Eventually a deal was met between the parties and the procurer compensated A-train. [14]
In traditional contracts the procurer holds all the risk but one suggestion for the new contracts is that the part that best can handle the cost for the risk should be carrying it and thereby be able to minimize the risks and milder the consequences [25]. This could especially be fruitful when unexpected problems occur that can be dealt with by adapting the work process [3]. These types of projects involve a great deal of complexity and that makes the risks difficult to calculate [31]. If the contractor takes responsibility for the technical solutions this gives incentives to seek more cost efficient solutions [6]. On the other hand differentiation between small and larger contractors needs to be made where larger companies carry a larger part of the risk than what smaller actors would do [3]. The public part should take responsibility for the risk the contractor cannot influence such as archaeological findings, permits, changes in traffic and laws. The contract between the Arlandabanan Infrastructure AB and A-train that operates Arlandaexpress is different since it is the contractor that leases the tracks and the recession in travelling in the beginning of the 21st century had a major impact of the income for A-train. [25] The company did not show a profit until 2005, a risk the company took when signing the contract [38]. Regarding PPP contracts the loan taken by the project company or consortium are taking with a higher interest rate than if the public part would have taken the loans and this have significant effect on the profit of the project. Furthermore, the transaction costs for the projects are higher than regular contracts since the consortiums use extensive resources for preparing the tenders. [25]

7.3 Option for compensation and payment

There are several options for how to formulate the compensation in the PSS contracts. Time, risk, organization, competition, complexity and regulations are factors that have to be regarded when choosing the form of compensation [25]. The most common way for compensation is with a fixed price based on the tender. This motivates the contractor to make an effort to minimize its costs; on the other hand it is the contractor who bares all the risk [3]. Another issue with a fixed price is the fact that the contractor could cut corners to save money and time but on the other hand a variable cost payment gives no incentives to finish on time [25] and the contractor bares no risk [3]. There is another risk concerning fixed price contracts, the price could be raised sufficiently to cover all the risk for the contractor [39] and that would cause very expensive contracts. The middle ground is a so called incentive contract with a fixed price where the deviation is split between the parties. This gives weaker incentives but the risk is shared. [3]

7.4 Organizational aspects

The relationship between the procurer and the contractor radically changes when using PSS contracts since technical and also economical if it is a PPP contract, requirements now are the responsibility of the contractor. [3] Much of the knowledge of procurement has been collected from years of experiences and by using a new type of contract this knowledge will have to be reconsidered which can prove to be difficult for the public organization [25]. All these new requirements and responsibilities changed the contractor organization in the Northern Line case, both in size and in shape. The company now had to act as a system integrator, previously the role of the procurer, and develop new skills such as for contract administration. Moreover the procurer had to sharpen up the communication and team working skills and all communication to and from the contractor was managed by certain levels of authority within the organization. The two organizations involved in the Northern Line contract had to make sure they were optimizing a system optimum and not two different sub optimums, which can easily happen if not controlled. [28] A lesson learnt from the project Norrortsleden was among many that it is of importance to specify the involvement and the responsibility of the individual of the procurer and the contractor organization in advance.
The problem that arises during the projects was that the people involved had not worked with this type of project before and were therefore not sure of their specific roles which caused insecurity. Good cooperation and trust is not built on a day but takes time to create. [31]

Another issue that can arise when working in a new type of project and organization structure is the process of too extensive documentation which occurred in the project Finnra procured as a PSS contract. The procuring organization was new to PPP and this as well as the magnitude of the project contributed to the complex documentation procedures where details were documented just in case. [32] The same problem is highlighted for rail procurement when the soft parameters, the organization issues etc., tend to become predominant and the actual focus of the procurement drowns in documentation[4].

A final remark from the literature is the fact that with these types of contracts the average project size is increasing, which in a long-term perspective will decrease the competition[25]. Only relatively large companies have the possibility to carry all the responsibility a performance contract requires[6].
8 Concluding discussion
In this section the result from the literature review is discussed and an attempt to answer the research questions and the objective is made. Furthermore, the future use of the study is described.

8.1 What types of contracts are used when procuring rail and roads infrastructure?

8.1.1 Rail infrastructure
As shown above, the most common contract today for rail infrastructure is construction contracts and even though the Swedish Transport Administration uses performance contracts for procuring maintenance that is still far from a PSS contract. There are few examples of PSS contracts for rail infrastructure procurement found in the literature, especially for European examples and with special focus on the Nordic countries. The two examples reviewed in this paper, Table 2, both concern projects where a private party has financed the whole or part of the project. The project Arlandabanan was formed as a PPP and is a long-term contract including a major part of the life-cycle of the construction. The Northern Line contract focused on service and the construction part mainly included trains and reconstruction work. Here on the other hand, the requirements were defined in performance measures. Whether this was done or not for the first case has not been clarified by the literature review. This means that this literature review has not succeeded in finding a long-term performance contract undertaking design, construction as well as maintenance for the rail infrastructure. The conclusion is that either no such contracts have been realized for the rail infrastructure or they are yet to be documented.

Table 2: Contracts for rail infrastructure.

<table>
<thead>
<tr>
<th>Project</th>
<th>Section length</th>
<th>Content</th>
<th>Contract length (years)</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arlandabanan</td>
<td>20 km</td>
<td>Finance, build, operate and maintain.</td>
<td>45</td>
<td>Public privat partnership. Contractor leases the tracks.</td>
</tr>
<tr>
<td>(SWE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Northern</td>
<td>50 stations</td>
<td>Design, manufacture and service.</td>
<td>20</td>
<td>Public and private financing. Leasing contract based on reliable service, a guaranteed number of trains and 11 % performance improvement of the trains.</td>
</tr>
<tr>
<td>Line (UK)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.1.2 Road infrastructure
Three examples of long-term PSS contracts including design, construction and maintenance have been reviewed in this paper, Table 3. They all originate from Scandinavia but are realized in three different countries. The contracts vary in size, meaning the length of the road section included in the contract. One thing worth highlighting here is the fact that only one of the Norwegian projects is illustrated in Table 3. The Swedish road section is significantly shorter than the other two which could be explained by the fact that it was a pilot project. On
the other hand one can ask if the section is long enough to serve as a pilot project, are the parameters the same as for a larger project? Is it possible for a contractor to make the maintenance work profitable for such a short road section? If the contractor does not also have the surrounding maintenance contracts there is a risk that the section will be too compartmentalized to be profitable and the contractor could then outsource the maintenance to a sub contractor and then the purpose of the PSS contract is lost. This is still yet to be evaluated since the contract is still running.

The length of the contracts ranges from 15 to 25 years, and again it is the Swedish project that has the most precautious approach with 15 years. The importance here is to make sure the length of the contracts actually make it possible for the contractor to fulfill one of the key purposes of a PSS contract, namely to achieve a low total cost over the whole life cycle. This can only be done if the length of the project is long enough to recover some of the contraction cost in the maintenance costs and vice versa depending on the strategy of the contractor. As mentioned above, none of these projects is completed and there is no evaluation or recommendation concerning the absolute length of the contracts yet.

The way the payment is regulated also differs but here it is important to take in to account the fact that the level of detail is different for each case. More detailed information was e.g. retrieved concerning the E18 project concerning payment specifications than for Norrortsleden. For all three projects the payments were regulated by factors and one of them is the amount for traffic on the roads. The Finnish and Norwegian projects also include the availability of the road and this could also be true for the Swedish project but this information is lacking.

Table 3: Contracts for road infrastructure.

<table>
<thead>
<tr>
<th>Project</th>
<th>Section length</th>
<th>Content</th>
<th>Contract length (years)</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norrortsleden (SWE)</td>
<td>7 km</td>
<td>Design, construct and maintain.</td>
<td>15</td>
<td>Fixed yearly sum to contractor based on nine index based weights. Special payment model for tunnels based on a classification from the contractor.</td>
</tr>
<tr>
<td>E18 (FIN)</td>
<td>51 km</td>
<td>Finance, design, construct, operate and maintain.</td>
<td>21</td>
<td>Initial investment and service fee to contractor depending on availability and service level of the road. Maintenance costs depend on the traffic. Penalties if the availability is not satisfying.</td>
</tr>
<tr>
<td>E39 (NOR)</td>
<td>27km</td>
<td>Finance, design, construct, operate and maintain.</td>
<td>25</td>
<td>Payment to contractor depending on availability and standard of the road. Bonus for safety measures. Toll system for procurer.</td>
</tr>
</tbody>
</table>
8.2 What benefits are there for implementation of PSS contracts when procuring rail and road infrastructure?

Giving the actor that is realizing the work the authority to adapt the working processes and activities to make the project as efficient as possible and to keep the costs down would seem as a straightforward way of thinking but it is not the way the construction contracts work. This is where the PSS contracts offer a possibility to improve the contracts and provide this way of working. But this life cycle perspective only provides better incentives for cost efficiency if it is matched with an appropriate contract length to provide the benefits above as discussed in section 6.1. Having a life cycle perspective and working towards more efficient technologies would also have a potential positive effect on the environmental impact. Furthermore, from the reviewed projects it can be concluded that the PSS contracts have not resulted in any significant new innovations but all the more development and adaptation of current technology and working processes. Does this mean that that the benefits of a PSS contract are overrated or is this due to the novelty and inexperience of the involved actors? Will the innovations occur gradually when the contractors have adapted to the new way of working?

Concerning the cooperation between the procurer and the contractor for the road projects the evidence is clear; closer relationship and significantly less conflicts than usual. Creating relationships takes time and effort but if this is done in the beginning of a contract the rest of the contract time will probably be easier and more fruitful. Unfortunately no information concerning relationships was found in the literature for the rail projects which does not mean it did not occur in a similar matter as for road projects. The results can still be valid for rail projects since they describe the cooperation during the work process and a rail project is at least or not more complex in its nature and would therefore benefit from the same effects.

In summary, the most significant benefits with PSS contracts for rail infrastructure are:

- Adaptation and development of technologies and working processes that leads to efficiency and cut of costs
- Potentially new innovations
- Provides a life cycle perspective giving incentives for cost efficiency and indirectly environmental consideration
- The longer contracts require more interaction between the procurer and the contractor which potentially result in closer relationships and, from the reviewed projects, thereby less conflicts.

8.3 What challenges are there in the implementation of PSS contracts when procuring rail and road infrastructure?

As mentioned above in section 8.3 the rail sector is more complex than the road sector and therefore has more rules and limitations. This could be one reason for why the road sector is ahead in the using of PSS contracts. As the examples with Norrortsleden showed it is not enough to only write a new type of contract to obtain the benefits from a PSS contract. The work process also needs changing and some activities might need to be prolonged to enable time for innovations. Could this possibly explain the lack of innovations that was discussed in section 8.3? Another hinder for development could be the penalties and fees in the contract even though some regulation is needed. A suggestion was made to remove these from some sections of the road and try new methods there. With this new type of contract there is a lack
of experience and knowledge and with little time and the risk of penalties it is natural to choose methods you are familiar with but this also implies that possibilities are lost.

More freedom for the contractor means less control for the procurer which could cause problems since that means changing the way of working. Complications with exceptions from the performance requirements were reported for one of the projects which caused confusion with the contractor. It is then essential to make sure all parts agree upon the boundaries for each organization is to avoid unnecessary conflicts. On the other hand evidence show that there have been fewer conflicts than normally when using these contracts. Another issue related to these boundaries is the risk allocation between procurer and contractor and one way suggested is to allocate the risk to the part that best can handle it which makes sense since that would benefit the overall efficiency of the project. In construction contract the procurer carries all the risk and to allocate risk with the contractor is essentially about trust. Does the procurer feel it can trust the contractor with the risk? Since penalties are discussed above as a hinder for innovation it is likely that the answer to that question is no.

But to be able to allocate the risk it has to be calculated or at least estimated first, and this requires new skills. Either this competence is already within the organization but has to be used in a different way or new competence is needed. Another important factor is the financial stability of the contractor. This is shown by the example of Arlandabanan where the contractor did not show a profit until six years after the start of operating the tracks. This also shows the importance of the length of the contract that needs to be adequate for the contractor to make up for investments and early losses. On the other hand what does the current financial situation of a contractor say about the same situation 25-50 years later?

To be able to lower the total life cycle cost it is important to choose the payment mechanism that will make this possible. The balance between a fixed price and a variable price is important to consider since this affects the outcome of the contract as well as the efficiency of the work. The literature advises an incentive contract with a fixed price and additional bonuses or penalties which also is what has been used in the examples reviewed.

Organizational changes seem inevitable regardless if they are large or small. It could concern new competences or a reorganization of certain parts. A new way of working can cause conflicts within the organization between the old and the new way but on the other hand the examples reviewed in this paper reveal nothing of this. The Swedish Transport Administration now includes both the rail and the road administration meaning that there are opportunities for synergies between them. The road administration already have some experience of PSS contracts while the rail administration so far only have used performance contracts for maintenance and then not to hundred percent, still there are specific requirements in addition to the performance requirements. This is a step towards PSS contracts but there are still several large steps to take but for each step the organization have the possibility to adapt and grow into its new role. The contractors will find themselves in a similar situation where changes have to be made to fulfill the new conditions. This could be a necessary development since only financial stable companies with enough experience and knowledge can take on projects of this scale. A possibility could be smaller companies forming a cluster and cooperate during the PSS contract but this on the other hand involves several difficulties such as coordination and trust.

In summary, the challenges that reoccurred during the review are listed below:

- To reach benefits such as new innovations the right conditions are demanded. Time needs to set off for development and the contractor have to take a risk by using new technology. This could be the reason that development and adaptation of existing technology is common rather than new innovations.
• How and where are the boundaries to be set between the procurer and the contractor organizations? This concerns responsibility issues and risk allocations which can serve both as incentives and hinders.

• The price mechanism is also of great importance for the contracts and the main question seems to be how to find the balance between fixed and variable price components to reach the desired outcome of the contract. The price is also connected to the risk and responsibility allocation and the financial stability of the contractor is therefore important. On the other hand, what does the current financial situation say about the situation in 25 years?
9 Conclusion and further research

In general, this type of contracting is new and there is much to learn for all involved actors but the learning curve is likely to level which is beneficial in the current contract as well as for future contracts. It is not straight forward to change the whole process and the way of contracting which can be concluded from the literature and reviewed projects. The PSS contracts have significant advantages but several challenges have to be overcome to obtain the benefits. The reviewed contracts all have the life-cycle perspective and include both products and services, however they do not all have the overall performance level that is asked for by a PSS contract. However, the buyers still have detailed requirements even though most of the contracts reviewed are output specified.

The contracts for road infrastructure are more developed than the ones for rail infrastructure. This could be due to the complexity of the rail structure implying there are more issues to handle than when building roads. The ongoing projects show positive outcomes so far, even though it is too early to evaluate the whole process. Only two of the five reviewed projects derive from the rail infrastructure and the remaining project are examples from the road infrastructure. On the other hand the way of thinking is similar as well as the conclusions. It is therefore likely that the rail infrastructure can benefit from the experience from the road infrastructure and this is presumably going to be easier now after the merger between the Swedish Rail Administration and the Swedish Road Administration in the spring of 2010.

The conclusions from this literature review are based on secondary data and the next step is to proceed with interviews to receive primary data concerning these issues. The results and conclusion from this literature review will be used to develop an interview guide where PSS contracting for rail infrastructure will be investigated with the perspectives of the Swedish Transport Administration as well as from some of its main contractors.
References


