

Feasibility of the Jyväskylä - Lahti Railway connection

Industrial sector

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Abstract <p>There has been a long discussion on the topic of constructing a new rail network from Central Finland to the capital area. Studies on the topic have been conducted by the governmental and local institutions, but most of the information is growing old and obsolete. Therefore, a more modern study on the topic is required.</p> <p>The objective of the present study was to assess the feasibility of the railway connection with as up-to-date information as possible. The aim was to determine the basis and groundwork for a further study on the topic as well as discuss the requirements and applications required in the design and development of a possible future railway connection.</p> <p>The study relied on more recent and industry-based information on the implementation of such a project. This included a thorough search and analysis of publications and other sources in Finnish and European as well as selectively other governmental databases in order to compare and assess what was relevant and noteworthy for the study. While searching for the information, also the possible future applications had to be taken into consideration. Such considerations included, for example, how this project would work with the planned or already implemented projects, such as the TEN-T network or the not yet launched FinEst bay area or the tendering for the Helsinki-Tallinn tunnel projects.</p> <p>The results should reflect the current situation and relevance of the project. They should highlight the reasoning behind a possible binary yes or no answer to the question of feasibility.</p>		
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Miscellaneous		

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1 Introduction

1.1 Preface

The world is still globalizing, and governments and institutions are going to face the issue of infrastructure requirements. Furthermore, many of the world's railways are showing increased capacity requirements for passenger and cargo transportation. The world rail statistics showed a yearly increase of 3,4% in overall railway transportation growth from 2009 to 2010. (UIC World Rail Statistics. International Union of Railways: Paris, 2011). The European Union 2011 White paper on transport states:

“Thirty per cent of road freight over 300 km should shift to other modes, such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.” (Boysen, H. 2012, 99)

Currently, roughly 22% of the Finnish transportation is done with railway transportation. The amount of export railway carriage is expected to raise by 5 million tonnes which would mean an increase of ~13% in railway transportation by 2050. (Traficom, 22/2019) While the amount of material and the numbers of people are increasing, the possibilities for further railway investments should be studied

Railway projects are generally extensive undertakings because in the European Union, railways are basically always subsidized by the EU or by governmental institutions. The initial steps for such massive projects are to evaluate the requirements and essentially the possibilities of success and the further outcome of a finished project.

There are vital statistics of the connection to the research area, as the proposition is connecting the 7th and 8th biggest cities by population in Finland, namely Jyväskylä and Lahti. According to the population forecasts by Statistics Finland Jyväskylä's population in 2018 was 141,305 people with a yearly

increase of 0,8%, and that of Lahti was 119,951 people with an annual increase of 0,3% (Statistics Finland databases, 2020)

1.2 Objectives

While the issues stated in the preface are viable in any part of the world the general objective of the present study was to assess and determine the possibilities for a further railway connection from Jyväskylä to Lahti in the industrial field. The research questions for this thesis are as follows

- What are the railway transportation and infrastructure requirements?
- What are the current amounts of transportation and their direction?
- What is the direction of the current railway projects in terms of effect on the Jyväskylä - Lahti connection?

1.3 Research boundaries

The focus of the study was to discover information required for the assessment of further studies and possibly actual construction projects as well as to aid in the decision on the possible future planning of the Finnish Railway network. The result of the thesis is to help guide the direction of future infrastructure projects. The information gathering should reflect the most up to date studies on the railway topic.

1.4 Research methods

After the decision on the topic and after setting the boundaries, the of research methods must be decided upon. Research methods are derived from two main types, the quantitative and qualitative approaches. While the quantitative method would ensure much more reliable results in statistics, the amount of specific information on topic would be far too large or very difficult to find. This would often make it a herculean task, especially from the perspective of the industrial sector. If the study was made on public transportation, there would be no issues but the amount of industrial sector studies on

the topic is very limited. Even though some statistics are very specific and from trusted publishers, such as the Statistics Finland, finding up-to-date information on most topics from reliable sources proved very difficult even on such a worldwide topic. The present study was based on textbooks, scientific articles, academic journals, data provided by governmental institutes and some newspaper articles on the topic.

1.5 Introduction to Jyväskylä - Lahti Railway connection

For transportation companies the two largest expenses in Finland are manpower and fuel consumption. The steady increase in fuel prices has made the companies consider the reduction of fuel usage, for example, a tractor-trailer combination the fuel consumption costs are around 25% of the entire vehicle's expenses. (Liimatainen, Rauhamäki & Liedes 2009, 11-14) This increase in fuel prices is expected to increase in the future as oil is steadily becoming more expensive. This would be a good motivator for the transport companies to start thinking of more economical options, of which railway transportation is one of the cheapest options but currently lacking the infrastructure. The switch from road transportation has also other benefits, related to the means of transport and social policies, for example the policies used in taxation, road tolls, speed limits and social policy planning. The European Union has also set standards on emission levels with the euro emission standards. (Pöllänen, Mäntynen & Laitinen 2007, 34-36) The transportation sector is ever growing and the requirement for increased infrastructure has been on the table for a long time now. As the first studies on topic were made already in 1912 by the Municipality of Lahti. (Lahden kaupunki, 1912) The Jyväskylä – Lahti connection is one of the bigger infrastructure propositions in the Central-Finland area. The connection would connect two of the largest cities in Finland, both known for their industrial sectors. The Jyväskylä Region is known for metal and other technology companies like Valmet and Valtra. Lahti, meanwhile, has large companies like Stora Enso and Hartwall. Moreover, Lahti already has a sound industrial base it has also grown as a logistics hub due to its central position

and great connections to the capital area and direct connections to the largest import and export harbours in Finland.

2 Transportation system definition

Railway transportation, also often referred to as train transport, means the transportation of material or people on track based (rails or railroads) vehicles. Railway transportation is one of the most cost effective and common modes of commuting and material carriage over long and middle distances. The basic requirement for the railway is the rails themselves, usually made from metals, most commonly iron. The usage of rails has clear advantages to other modes of transport due to the great benefit of reduced frictional resistance, benefitting the entire system to increase load capacity while keeping efficient transport economy. (The Economic Times, 2019) The train itself consists of the engine(s) usually called the locomotive which powers the cargo carrying wagons or carriages. The locomotives are generally powered by diesel or electricity, while other powering methods such as steam powered locomotives exist, the one's stated previously are the most common. The modern railway system also requires a signalling and communication system infrastructure so that the multiple rail connections can be utilized for increasing the capacity. Railways are regarded as one of the safest modes of transportation, when compared to other types of transportation. The increased safety is due to reducing the number of variables that may cause accidents. (European Commission, 2008)

The definition of the modern railway began in Great Britain in the 19th century, as the steam powered locomotive was invented. The new method of powering the trains increased efficiency to a new level. The first public line was commissioned by the Robert's company in 1825 running from Stockton to Darlington. The development of the modern railway system was a key corner stone to the industrial revolution, as the train could transport material in bulk on the main-lines and thusly bulk material was not restricted to waterway transportation on rivers as previously. (Stands4 Network, 2019)

2.1. Railway transportation description

Railway transportation means the movement of passengers and goods, delivered by wheeled vehicles running on tracks. Railway transportation is most often compared to road transportation and often the term train transportation is used in the comparison. The main difference is naturally the lowered friction but most dramatically the combination of multiple carriages. While road transportation is generally used for either passenger transportation or freight transport, railway, while still capable of separation, also has the possibility of the combination of both. Railway transportation is also considered by the Finnish Transportation ministry to be the safest mode of transportation in Finland (Traficom, 2015).

Typically, railways consist of two parallel rails, secured by cross beams made of tempered wood or concrete. The cross beams function is to keep the rails secured at a desired width, known as the trail gauge. The tracks provide a smooth and hard contact area for the train wheels to roll on, which leads to the even distribution of weight on the rail wheels and axles. The combination leads to very high capacity transportation, for example, a single railway wagon can hold up to 130 tons of cargo. As all the advantages compound in the right factors, the railway uses 50-70% less energy in the transportation of tonnages of freight or in the terms of the number of passengers than road transportation. The railway wagons also benefit from the even axle loads as they see less wear than the rubber wheel automotive tyres (Rail Transport Definition for the Freight Industry, 2019). Railway transportation is an efficient way for high levels of cargo utilization and passenger transportation with high energy efficiency, while being less flexible in terms both infrastructure and low utilization.

The objective of the railway transportation sector is to provide an optimised service level quality with efficient range of infrastructure, mixed with an high-profile productive efficiency. The objective is to be able to add value to the customers' logistical requirements for efficient rail pricing services to the end-users. (OECD, Recent developments in Rail Transportation Services, 2013.) The railway freight transportation sector in Finland was released from the state-owned monopoly in 2007 and the passenger transportation is due to be

released by 2026 (Liikennevirasto 2017). The reforms in the railway sector in terms of other utilization and further policy are still to be determined by the public policy, which is to be sought after by increased competition in the whole transportation sector, be it from the perspective of capacity/efficiency or environmental effects.

Railway systems are generally considered very favourably by policymakers as well as the citizens worldwide due to their efficient impact on mobility, land improvement potential and urban centre development. This is especially related to the high environmental efficiency in comparison to all other modes of transportation. These characteristics lead to governments being highly involved in the monetary and financial side of new railway connections. (International Transport Forum 2013)

3 Infrastructure

Finland is a large and sparsely populated country in Northern Europe. Cargo has generally been mostly transported by trucks through the Central-Finland area. The current railway infrastructure of Finland includes 5923 km of railway of which 3362 km is electrified, the tow or multiple rail lane portion is 642 kilometres long (Liikennevirasto Rautatietilasto 2015 2016). The rail gauge is important to note as many deviations are used worldwide. While the European Union has initiatives to standardize railway transportation to follow the European 1,435mm "Standard gauge", many countries in Europe still use a different gauge, Finland included. The Finnish 1,524 mm "5ft gauge", while still being compatible with the Russian 1,520 mm "Redefined 5ft gauge", is a clear outlier. The rail infrastructure as a definition also includes line sections, structures and equipment required for the operation and maintenance of the rolling stock.

The sub-structure of a railway includes three main elements; the formation, sub-ballast and the ballast. The formation is defined as the ground itself on which the rails are constructed, the formation can be on the level of earth, or it

can be an embankment or cutting. The usage of proper material is of high importance for the right requirements for freight or passenger transportation. The ballast and sub-ballast are the actual built foundation on which the rails are constructed, and they are usually made from stone material, for example granite laid upon layers of water seepage protected by sand. (Railway technical 2019A) The basic electric-rail sub-structure can be seen in the figure below

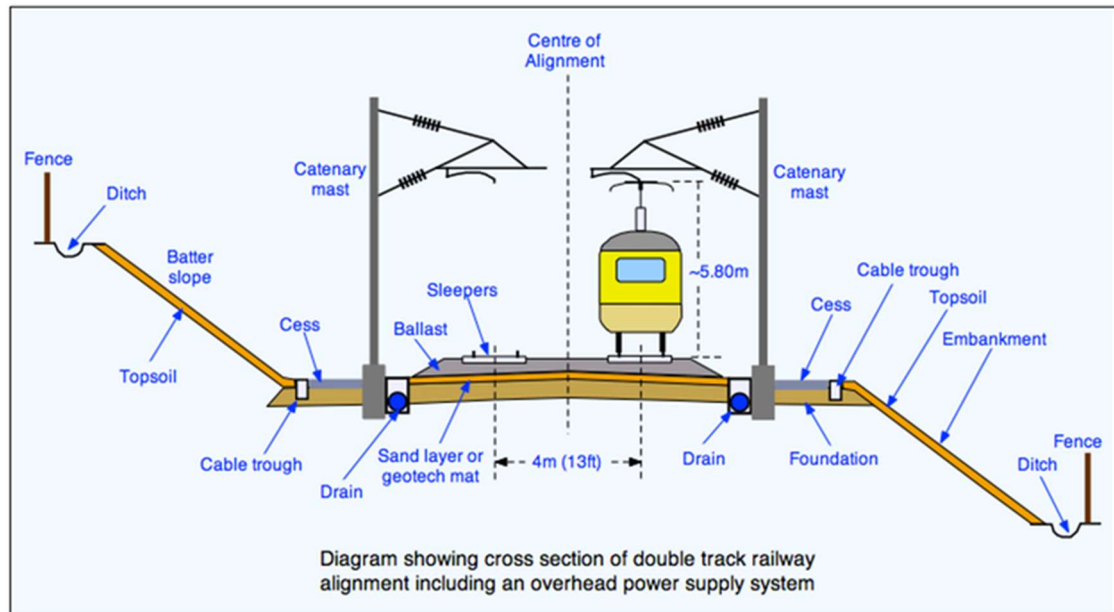


Figure 1. Electric railway sub-structure (Railway technical 2019B)

In the proposition of Jyväskylä - Lahti connection there are a few options of how the railway would be separated from the current connection going through Tampere. The major options for the construction of the railway are the following: Jyväskylä - Jämsä - Riihimäki - Lahti, Jyväskylä - Jämsä - Lahti, Jyväskylä - Muurame - Heinola - Lahti. Yet another option is simply adding a second railway to the current connection from Jyväskylä to Tampere and increase the capacity of the railway which would essentially double the connection capacity.

3.1 Noise

Noise pollution can be explained as a noise that irritates hearing. Noise pollution can cause difficulties in the work and study environment, affect communication and induce difficulties of sleeping. A major contributor of noise pollution is the road network. In the biggest cities there are 496 000 people suffering from noise pollution of over 55 dB which in total is around 21% of each major city's population. Roughly 320,000 people live on the other side of other smaller roads in noise pollution areas. (Kokkonen 2012) The loudest vehicles are of course, heavy trucks and other industrial vehicles. The increased usage and construction of new railway projects would reduce the numbers of population living in heavily noise polluted areas, however railroad connections do not receive a clear pass on noise pollution either, as railway connections disturb roughly 150,000 people (Väylä 2020). The comparison of road and railway connection noise pollution is relatively difficult as railways are such a small portion of the entire material flow of Finland, and most of the noise pollution is caused by public transportation.

Noise pollution in rail transportation can be divided into six different aspects causing different levels of noise pollution.

- Roughness-Induced Rolling Noise
- Wheel Noise
- Rail Noise
- Squeal Noise
- High Speed Trains
- Other Sources of Noise

(Policy Department Structural and Cohesion Policies European Parliament 2012)

As deduced from the European Parliaments study aspects above the noise is mainly caused by the movement of the train itself, and the measures of reducing the amount of noise generated in the railway itself include construction of the railways with sufficient distance to residences, sound dampening soil work

and quality of the construction. The railway should be constructed at least 50 meters or 20 meters with soil dampening, from residences to minimize noise pollution. Table 1 and 2 from the U.S Department of Transportation show the differentiation of different land uses and how the planning of the railroad has to be done to minimize the impact of noise pollution.

Table 1. Noise-Sensitive Land uses (Hanson 2012)

Table 5-1 Noise-Sensitive Land Uses		
Land Uses	Specific Use	Selecting Receivers
Outdoor noise-sensitive areas	<ul style="list-style-type: none"> • Parks with passive recreation • Historic sites used for interpretation • Amphitheaters • Cemeteries 	<ul style="list-style-type: none"> • Select each noise-sensitive site
Residences	<ul style="list-style-type: none"> • Single-family residences • Multifamily residences (apartment buildings, duplexes, etc.) 	<ul style="list-style-type: none"> • Select each isolated residence • For residential areas with uniform noise levels, cluster as described in text
Indoor noise-sensitive sites	<ul style="list-style-type: none"> • Places of worship • Schools • Hospitals/nursing homes • Libraries • Public meeting halls • Concert halls/auditoriums/theaters • Recording/broadcast studios • Museums and certain historic buildings • Hotels and motels 	<ul style="list-style-type: none"> • Select each noise-sensitive building

Table 2. Factors related to Vibration Path, Factors Related to Vibration Receiver (Hanson 2012)

Factors Related to Vibration Path	
Factors	Influence
Soil Type	It is generally expected that vibration levels will be higher in stiff clay type soils than in loose sandy soils.
Rock Layers	Vibration levels often seem to be high near at-grade track when the depth to bedrock is 30 ft or less. Tunnels founded in rock will result in lower vibration amplitudes close to the tunnel. Because of efficient propagation, the vibration level does not attenuate as rapidly in rock as it does in soil.
Soil Layering	Soil layering will have a substantial, but unpredictable, effect on the vibration levels because each stratum can have significantly different dynamic characteristics.
Depth-to-Water Table	The presence of the water table is often expected to have a significant effect on ground-borne vibration, but evidence to date cannot be expressed with a definite relationship.
Frost Depth	There is some indication that vibration propagation is less efficient when the ground is frozen.
Factors Related to Vibration Receiver	
Factors	Influence
Foundation Type	The general rule of thumb is that the heavier the building foundation, the greater the coupling loss as the vibration propagates from the ground into the building.
Building Construction	Because ground-borne vibration and noise almost always are evaluated in terms of indoor receivers, the propagation of the vibration through the building must be considered. Each building has different characteristics relative to structure-borne vibration, although the general rule of thumb is that the more massive a building is, the lower the levels of ground-borne vibration will be.
Acoustical Absorption	The amount of acoustical absorption in the receiver room affects the levels of ground-borne noise.

3.2 Pollution

Railway pollution in Finland is quite minimal. Most of the pollution is caused by road vehicles and construction vehicles used by VR The Finnish Railway Agency. 90% of the electricity used in the locomotives is renewable energy. (VR group 2018.)

Appendix 1 shows the amounts of greenhouse gasses emitted by an average transportation vehicle. The averages were taken from all EURO emission levels based on their corresponding amounts in use in 2016, and the emission levels are still believed to be on the same level as in 2016 with slight deviations.

The greenhouse effect is a principle requirement for life on earth, but the effect of human interaction has increased the amounts of greenhouse gasses in the atmosphere, which leads to an increase in the mean temperatures, and to the change in climate (Jääskeläinen 2004, 18). The European climate change accords are already planning to change the usage of fossil fuels in transportation. The VR Group, the Finnish government owned rail transportation agency, states that railway transportation has a predominant competitive edge in emission levels in comparison to other modes of transport. (VR Group n.d.)

Trainlines in the past were mainly constructed with wood sleepers impregnated with creosote oil. Creosote oil is a distillation of coal tar, and it has been classified by the ECHA, the European Chemicals Agency as an environmentally persistent, Bio-accumulative and toxic carcinogenic substance (ECHA 2019). The European union is planning to eventually forbid the use of the substance as impregnating agent, which lead to the increasing use of more environmentally and structurally sound concrete sleepers (Luomala 2018).

3.3 Vibration

Railways are known to cause vibrations as the locomotive's drive on the tracks. The effect of vibration is measured as acceleration (m/s^2). Vibration is a harmful side effect comparable to the noise as a type of environmental pollution. Extended periods of being subjected to vibration can cause severe health issues. The Figure from U.S Department of Transportation below shows the factors that influence Levels of Ground-Borne Vibration and Noise.

Table 3..Factors that influence Levels of Ground-Borne Vibration and Noise (Hanson 2012)

Table 6-2 Factors that influence Levels of Ground-Borne Vibration and Noise	
Factors Related to Vibration Source	
Factors	Influence
Vehicle Suspension	If the suspension is stiff in the vertical direction, the effective vibration forces will be higher. On transit cars, only the primary suspension affects the vibration levels, the secondary suspension that supports the carbody has no apparent effect. Similar effects are likely to occur with high-speed trainsets.
Wheel Condition	Wheel roughness and flat spots are the major cause of vibration from steel-wheel/steel-rail train systems.
Track Surface	Rough track is often the cause of vibration problems. Maintaining a smooth track surface will reduce vibration levels.
Track Support System	On rail systems, the track support system is one of the major components in determining the levels of ground-borne vibration. The highest vibration levels are created by track that is rigidly attached to a concrete track bed. The vibration levels are much lower when special vibration control track systems such as resilient fasteners, ballast mats, and floating slabs are used.
Speed	As intuitively expected, higher speeds result in higher vibration levels. Doubling speed usually results in vibration levels 4–6 dB higher.
Track Structure	The general rule of thumb is that the heavier the track structure, the lower the vibration levels. The vibration levels from a lightweight bored tunnel will usually be higher than from a poured concrete box tunnel.
Depth of Vibration Source	There are significant differences in the vibration characteristics when the source is underground compared to at the ground surface.

3.4 Risks

Every time heavy vehicles move there is always a risk of something going wrong. Finnish Railway is comparably very secure and there are very few train accidents, however the main cause of accidents are grade crossings where cars cross the railroad. The amounts have been going down steadily over the years as precautions have been increased. In 2017 a military vehicle carrying conscripts was hit by a train in Raasepori, which is considered the worst Finnish railway accident of the 21st century, causing three dead and three injured. There were 20 grade crossing accidents in 2018 which also only required three lives. (Liikenne- ja viestintävirasto Traficom 2018)

The biggest risk factor considering railway cargo is dangerous goods. The transportation of hazardous chemicals for example needs to be tightly monitored as it is done in Finland. The latest big accident was in Mäntyharju where two MTBE (Methyl tert-butyl ether) containers ruptured and released 35,000

litres of the substance to nature (Ibid.). Finland's ecosystem is very sensitive to massive amounts of dangerous liquids, especially in the groundwater areas. The railway project in question will run through multiple groundwater areas around the lake Päijänne which is one of the most important ground water areas in Central-Finland. Therefore, the needs and precautions on possible spillages must be accounted for.

3.5 Energy consumption

Energy consumption of railway vehicles varies depending on multiple factors including train weight, terrain slopiness and driver skills. Air resistance is one of the most important factors when taking into account the railway transportation energy consumption. In his report to Strategic modelling of combined transport between road and rail in Sweden project Flodén (2011) reports that "Empty timber wagons with many poles are known to create a great deal of drag. Some operators report that, under extreme circumstances, they might even have more energy consumption on an empty train than on a full one".

When calculating the energy consumption of the railway vehicle the most common way of measurement is linear addition of one extra tonne of weight adds a certain amount of energy consumption. While being a very crude estimation, not taking account of many of the fundamental forces experienced is the best option for normal operations. The same basic calculation is also used for the energy usage calculation for each locomotive as weight over time is measured in kWh (energy consumed over time) to energy consumption/kilometre as shown from Sr2-locomotive energy consumption (kWh/km) in appendix 2

4 Transportation model

4.1 Capacity

Capacity is often defined as the capability to perform or produce, while it is very imprecise on the topic of railway transportation, the basis of railway capacity is the amount of trains being able to run through the railway system in a given time period. The primary aim and reasoning behind a railway is to

transport freight or passengers, or in some cases be a value increasing part of other logistical services.

Rough railway capacity can be calculated through figure below.

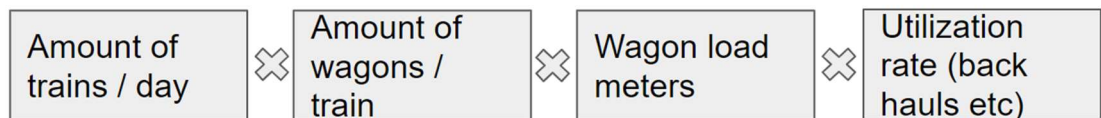


Figure 2. Railway capacity general calculation

From the figure it is clear to see that while railway transportation follows the same framework on capacity as any other transportation mode it has one clear benefit, as the number of wagons per train is very flexible and thusly optimizable. As an example, the 2018 "mega train" run from SSAB Raahе to Hämeenlinna having 52 wagons and 3800 tons of cargo (Kaleva 2018).

The transport capacity, while being able to be optimized by the amount of material needed for transportation still hinders from the same problems as normal truck transportation. Utilization suffers from the amount of different materials being transported. Either the hindrance comes from low density material eating up the cargo space or vice versa the material being high density eating up the carrying capacity of the modules. This problem has been mostly mitigated by the usage of different type of loading and carrying devices designed to the needs of the transportation in question, for example, using Finnish current railway usage as the basis. The previous SSAB transportation carried Steel rolls which are extremely heavy, leading to the rail bed being able to carry just a few coils per rail section. While on the opposite side Valmet produces tractors and ships them from their Central-Finland factory to ports with railway transportation, the tractor does not weigh even close to the maximum carrying capacity but being a large piece of equipment by volume, it requires an individual track bed.

4.2 Shareholders

The shareholders of the transportation of goods are Infrastructure manager(s), Train operator(s), Freight consignee and the Passenger as seen in the figure below

Shareholder	Most important shareholder values
Infrastructure manager(s)	Costs, reliability, infra utilization, capacity, maintenance,
Train operator(s)	Costs, operating reliability, equipment utilization, capacity, maintenance access
Freight consignee	Costs, timely delivery of consignment and empty container for loading, delivery capacity, damage avoidance
Passenger	Costs, travel time, line frequency, comfort, reliability

Table 4. Shareholders and most important shareholder values

Costs are always an important factor for every shareholder usually no matter the discipline, be it a private or customer or a company. While the study is not on passenger transport, the most important function for train routes in Finland is public transportation so passenger transportation cannot be omitted from the shareholder list.

4.3 Railway transportation encouraging and hindering forces

The railway industry is under stress to change for the future. The railway infrastructure and locomotion has seen much progress through the years, however as environmental and economic stress is increasing, the industry must be able to become more flexible and environmentally friendly. The European energy demand for rail sector is forecasted to increase by 2050 based on two different scenarios, The 'Base Scenario' of how policies have currently been set would increase the energy demand by 24% while a more ambitious 'High Rail

Scenario' which is aiming to minimize costs per passenger/tonne-kilometre moved, leading to increase of 41,1% from the current 7 Million tonnes of oil equivalent units [Mtoe] (International Energy Agency 2019)

The Finnish Ministry of transportation opened the previously governmentally owned railway transportation monopoly for private corporations in 2017. The change was brought forth after the European Union's fourth railway package legislation was legitimized in 2016. (Finnish Ministry of Transport and Communications 2017A) Further the progress of door to door transportation, electrification of transportation, ICT and co-operation of corporations is giving traditional transportation systems trouble. Appendix 3 shows major forces affecting the Finnish Railway industry currently.

4.4 Finnish railway goal hierarchy

Finnish railways are administrated by the Finnish Transport Infrastructure Agency [Väylävirasto] that works directly under the Finnish Ministry of Transport and Communications. The Transport Infrastructure Agency has goals that have been set for the railway infrastructure. The goals are set through social goals, which are divided to general, social and industrial goals. The goals are further divided into different aspects seen in Table 5. For railway cargo transportation the requirements for the infrastructure has large deviations for different material types and also within the different subcategories. The main service level performance indicator is the transportation cost level. From the industrial perspective the most important factors thusly are cost efficiency and supply chain reliability, to ensure constant supply of production materials. To fulfil the industrial requirements the transportation system must be able to transport reliably throughout the year (Finnish Transport Infrastructure Agency. 2017B)

Table 5. Goal hierarchy (Finnish Transport Infrastructure Agency 2017B)

	Contents	Importance
Definitive goals	Functional and safe everyday life <ul style="list-style-type: none"> • Competitive business • Smart movement • Emerging regions • Sustainable community structure and transport system 	Importance and effects of the general level
General goals	<ul style="list-style-type: none"> • Functionality • Safety • Sustainable development • Economy and responsibility • Intelligence 	Basis for Service Level Goals
Service level goals	<ul style="list-style-type: none"> • Predictability, reliability, safety • Attractiveness • Accessibility 	Clarify overall objectives from the perspective of freight and passenger transport
Defining and developing service level on the rail network key factors	<ul style="list-style-type: none"> • Maintenance, overhaul • Infrastructure development • Nodes and services 	Harmonize rail design, maintenance, improvement and development and provide a basis for planning transport services

4.5 Transport statistics

The Finnish government publishes statistical yearbooks in association with Statistics Finland Stat.fi, Tilastokeskus. The previous yearbook has been published in 2014, the following information is picked according to the railway transportation topic.

The general statistics of goods transport and capacity in railway transportation of Finland include 456 railway goods wagons with the capacity of 1,000

tonnes. The number is expected to be similar today following the trend of the past three years of the study 2010-2013 with slight reduction of 1-20 units per year. These units are handled by only three corporations on Finnish soil, of which the vast majority is run by VR the Finnish railway corporation.

Maintenance of the railway network has stagnated between 358 to 454 million euros from 1990 to 2014 while the maintenance costs of roads has nearly tripled from 559 million to 1435 million euro in the same time span. The governmental yearly investment for the Finnish transportation system in 2013 was 4,144 million euros covering 9,7 percent of the domestic economy. Of the investment 2,269 million which equates to 54,8% of the investment was in 'other construction' which includes land and water construction, while 1508 million (36%) was invested in equipment and machinery. The railway operations employ 8186 people.

Goods transported in domestic railway transportation equates to 22,8 million tonnes and has stayed within a margin on two million for the past 13 years of the study. Road transportation in comparison has decreased during the same time span from 415,5 million tonnes to 269,5 million tonnes measured from the wagonload tonnes. Taking the amount of weight transported to tonne-kilometres Railway transportation has domestic amounts of 6502 million tonnes and road transportation 20,967 million tonnes with over 3,500 kg lorry capacity in 2013. the amounts by commodity group can be seen in the Figure below

2.5.7 Tavaraliikenteen tonnit tavararyhmittäin, 1980–2013
Tonnes in goods transport by commodity group, 1980–2013

Milj. tonnia - Mil. tonnes	1980	1990	2000	2009	2010	2011	2012	2013	2013 (%)
Yhteensä - Total	28,9	33,0	40,5	32,9	35,8	34,8	35,3	36,4	100,0
Kasvis- ja eläintuotteet <i>Vegetable and animal products</i>	0,6	0,4	0,4	0,1	0,1	0,1	0,1	0,1	0,3
Kivennäistuotteet <i>Mineral products</i>	7,1	8,4	7,6	7,0	7,6	8,1	7,9	9,2	25,3
Puu ja puuteokset <i>Wood and woodworks</i>	8,5	10,1	15,7	12,0	13,5	12,3	12,3	13,2	36,3
Paperiteollisuustuotteet <i>Products of paper industry</i>	5,2	6,3	7,9	7,0	7,2	7,2	7,2	6,8	18,7
Metalliteollisuustuotteet <i>Products of metal industry</i>	3,6	2,9	3,8	2,0	2,3	2,3	2,1	1,9	5,2
Koneet ja laitteet <i>Machines and equipment</i>	0,2	0,4	0,6	0,6	0,5	0,3	0,2	0,2	0,5
Kemian teollisuuden tuotteet <i>Products of chemical industry</i>	3,3	3,9	4,3	4,0	4,5	4,4	5,2	4,8	13,2
Muut tuotteet - <i>Other goods</i>	0,5	0,7	0,2	0,2	0,1	0,1	0,3	0,2	0,5

Figure 3. Tonnes in goods transport by commodity group, 1980-2013, Transport and Communications Statistical Yearbook for Finland 2014, Statistics Finland

The turnover for VR shows a growing for the passenger transport going from 410 million euro in 2008 to 458,4 in 2013. While the passenger sector has grown by 48,4 million, in the meantime the freight transport sector has seen a decline of 28,5 million from 361,2 to 332,7 million.

5 Routes & Directions

Finnish Railway transportation access is set in the railway transportation act of Finnish law, ([304/2018, Finlex](#)). The access to railways needs to follow the legislation of TraFi, Finnish transport safety act and the Finnish Transport Safety Agency

There are four main development routes to consider in the planning of the railway, three of which continue or run alongside current connections. The fourth option would go from the east side of lake Päijänne, which has the prospect of

introducing completely new connections to the current Finnish railway network. Table 6 shows the basic information from route selection to travel time (Jyväskylä-Helsinki) and investment levels

Table 6. Route, travel time, new track and investment amount.(Keski Suomen Liitto 3/2011)

Route	Travel time	Total new track	Investment
Jyväskylä - Jämsä - Lahti	1:55:00	128km	970mil€
Jyväskylä - Jämsä - Riihimäki - Lahti	2:00:00	125km	965mil€
Jyväskylä - Muurame- Heinola - Lahti	1:55:00	148km	915mil€
Jyväskylä - Tampere improvement	2:32:00	-	580mil€

The main idea of the new construction project would be to increase logistics possibilities in Central-Finland and Lahti area and reduce stress on Tampere - Helsinki railway connection. While most of the stress relieved would be in public transportation numbers especially as the amount of passenger transportation is expected to increase of roughly 14% from 950 thousand annual passengers to 1,1 million passengers by 2035. The biggest issue for the industrial sector is when public transportation increases, the window of transportation for industrial purposes decreases. When the only feasible main way for timely railway transportation is through the same connection as the already clustered passenger route, the prospect of increased transportation efficiency is hindered (Regional Council of Central Finland 3/2011B). The current connections are shown below in Figure 4



Figure 4. The Finnish railway network in 2010. Lines marked in green are freight- and passenger routes, brown are freight-only routes, blue is heritage railway, and grey are no longer in use. (Räisänen 2010)

5.1. Jyväskylä - Jämsä - Lahti

The connection would be the shortest and cheapest new line to fulfil as it does not require large stops along the way. After Jämsä there are three possible locations for stops, Kuhmoinen, Padasjoki and Asikkala. While Asikkala would be the largest stop on this route it is restricted to a narrow route and special issues would not let the connection travel through the town. Leading the railway on the west side of Kajaanselkä lake. This connection while being the fastest and shortest connection from Jyväskylä to Lahti has the least possibility of increasing industrial capacity along the route.

5.2 Jyväskylä - Jämsä - Riihimäki – Lahti

This connection would run directly from Jämsä to Riihimäki, besides that change in the route it is basically identical with the previous route suggestion. The positives of this route would be that the amount of new track to be laid is

relatively small. Only having to lay down roughly 150 km of new railway. It would be the second shortest route using the already made Riihimäki – Lahti connection.

5.3 Jyväskylä - Muurame - Heinola - Lahti

The Jyväskylä - Muurame - Heinola - Lahti connection would both be the fastest and meanwhile connect new towns to the main railway infrastructure. The route currently is one of the main corridors of truck transportation of entire Finland. The current railway connection runs on the west side of lake Päijänne, this connection would attach two new important industrial locations to the railway network.

This connection could cut through Eteläportti industrial sector that already could have a use for the connection through Moventas Gears Oy which manufactures industrial gearboxes, the company could transport the gearboxes on rail wagons instead of the current truck transportation. The gearboxes are so heavy that a truck cannot load two per load, but a railway wagon has the load capacity of 69,5 tons (VRtransport 2019) which is sufficient for transportation of two units. This would already cut the costs of transportation in Finland by half as the units could be loaded directly to wagons and sent to the port which transports the gearboxes further to customers. Eteläportti has been primed to be a forefront of Central-Finland high industrial sector with the prospect of 60 new companies. The investment proposition at the moment is 300 million euro and from the companies invested in 70% of the production would be to export. (Jykia 2019)

5.4 Development of Jyväskylä - Tampere - Lahti connection

The current connection is currently the main option for the next development in Central-Finland railway operations, with the estimated costs of 580 million euros the connection would be enhanced with a double rail to allow

simultaneous movement to both directions. There would not be a noticeable decrease in travel times, but transportation capacity would almost double.

5.5 The current connection

The latest study on the Jyväskylä rail yard operations was done by the Finnish transportation agency and municipality of Jyväskylä in 2016 published as the Report of Jyväskylä rail yard operations. Currently the Jyväskylä railway junction is one of the fundamental railway nodes in Finland of which there are 10. There are two main railway connection nodes, which are situated in Tampere and Kouvola. From Jyväskylä there is a direct or indirect connection to basically anywhere in Finland within 24 hours. The southern connection from Jyväskylä to Tampere services 19 passenger trains within a working week. The number of passengers on this route is believed to be increasing from 2520 passengers/day in 2013 to 3020 passengers/day in 2035.

The railway transportation side in 2016 saw 138 freight trains per week which service the industrial sectors of Jyväskylä, Suolahti-Äänekoski and Jämsänjokilaakso industrial sectors. The simplified as main transportation material flow to Jyväskylä railway terminal

- Raw forestry products from Pieksämäki and Tampere
- Produced forestry products are transported south to through Tampere to other industrial sites or exported through ports
- Container transports arrive from south for forestry and metal sector refinement
- Cellulose and tractors are transported through Tampere to Vuosaari port

Each material listed generally has their own type of transportation wagons which lead to the empty return containers which lead to halved transportation efficiency

VR Transpoint is expecting an increase of four to eight new freight train connections from the new Äänekoski factory even further increasing to ten freight trains by 2035 as production efficiency increases. The freight rail yard has had no study on the capacity usage percentage but is said to clearly not having

any issues with the capacity of freight train loading and unloading. (Finnish Railway Network Statement 3/2017, 2019)

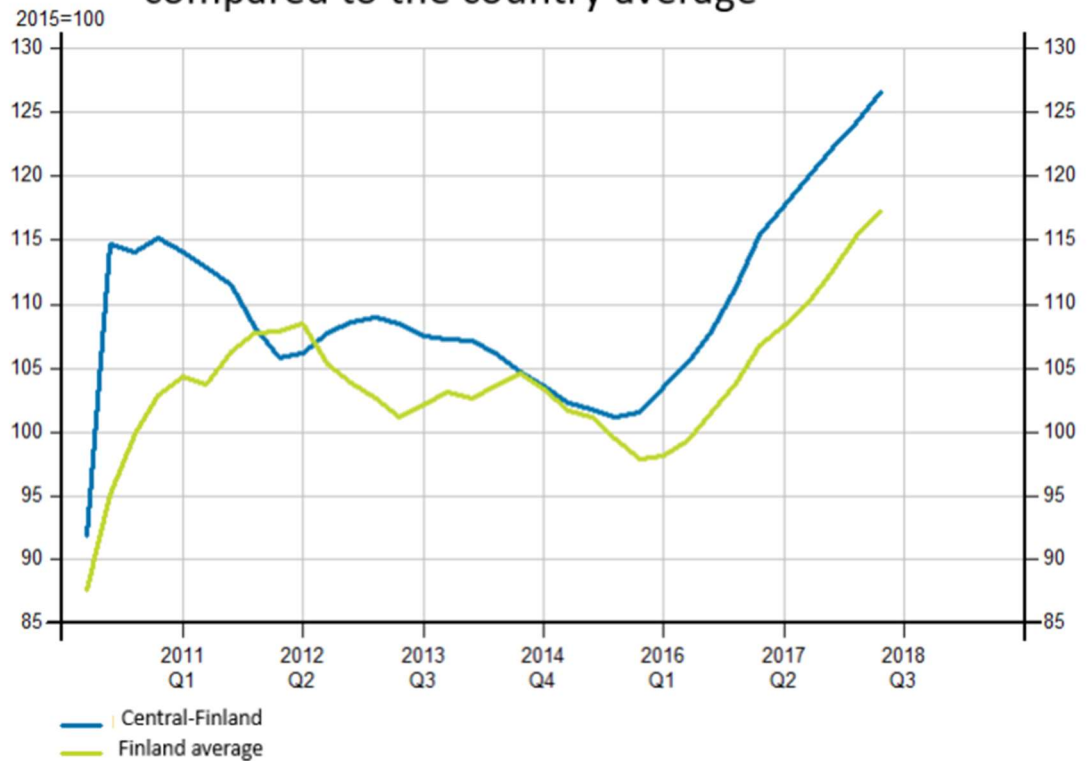
5.5 Migration effects

Finland is the seventh largest country in the European continent by land mass. While still being fourth most sparsely populated. A recent study from the Consultancy of Regional Development of Finland is forecasting that by the year of 2040 there would be only three growing major urban areas, Helsinki, Turku and Tampere. (MDI, Consultancy of Regional Development 2019) While the forecast is not saying that the main city of Central- Finland, Jyväskylä is going to lose a large portion of its inhabitants, actually it is still growing marginally until 2030 when the effect of downward natality is going to take place. The change in the Census must be thoroughly accounted for as said previously passenger transportation is the first priority of railway connections.

5.6 Central-Finland industrial exports

Central-Finland's industry has been growing since the year 2015, the combined turnover of companies grew by 4,8% in first quarters of 2018, which is slightly behind the national average of 5,6%. The regions exports are also growing strongly by 6,8%. (Päivänen, 2018; Tilastokeskus 2018A) The amount of exports has been growing since 2016, in 2017 the exports of central Finland grew by 17% and is expected to grow by another 6,8% in the first half of 2018. Central-Finland is known for exporting wood products and technology, both are currently transported by rail and road. (Tilastokeskus, 2018B)

The development of Central-Finland exports, compared to the country average



Tilastokeskus / Asiakaskohtainen suhdannepalvelu

Figure 5 The development of Central-Finland exports, compared to the country average. (Tilastokeskus 2018/10)

SKAL the Finnish Road haulage and logistics service sector representor studies and creates a logistics study and compiles a barometer each quarter. Quarter four of 2017 shows that Inland Finland's logistics companies have seen an increase of 34% in ton haulage during the year, while 19% has seen a decrease. (SKAL, 1/2018) The increase has been positive for the past couple of years, which is great for function of the regions logistics needs. The change also shows that the local industrial sector is doing well.

5.7 Lahti as a logistics hub

Lahti is a great location for logistics, being one of the growing industrial spots in Finland. Valuable connections to the capital, Central-Finland and South-Eastern Finland's ports including connection to Russia. Make it an ideal location for logistics centres. Lahti is currently on the main road transportation route and a large portion of Central-Finland's exports go through Lahti as a region and as a logistics hub. The current railway connections from Lahti go to Riihimäki, Helsinki and Kouvola. Having great connections to Eastern-Finland through Kouvola in one and a half hours and one-hour connection to the capital in Helsinki.

5.8 Effect of Passenger transportation Jyväskylä - Helsinki

The European Union has standardized passenger transportation as the top priority in European railway connections, and it should be a top priority in the planning of the new railway connection also. The current railway infrastructure causes some issues for the industrial sector especially at the moment for companies like UPM in Kaipola, Jämsä, the Kaipola factory produces paper and most of it goes to export from Rauma port. The company is mainly using railway transportation but due to the scheduling of the passenger transportation, there is only a narrow transport window between 23:00-04:00 for railway transportation.

6 Railroad opposed to current road transportation system

6.1 Political aspects

Currently the railway transportation is monopolized by the Finnish government, which leads to politics having a large impact in the national railway operations. The Finnish railways are operated by VR, Valtion Rautatiet.

Aspects to consider in railway transportation costs are mostly legislative actions for controlling the transportation, and these include taxes and tax related costs or compensations for the usage of the national railway infrastructure. A good example of control costs is the political decision to keep the electricity production tax out of electrical railway usage. (FinLex [20.12.2010/1396](#)). Similarly, the railway tax is smaller for electric locomotives, in comparison to diesel locomotives, due to environmental impact costs.

National defence is a key issue in every major infrastructure project in Finland. The Finnish Ministry of Defence has oversight of every relevant infrastructure project in the country. For Example, transport connections need to be made according to the guidelines created by the Defence Ministry so that they are functional during international crisis or emergency situations (Ministry of Justice, Finland. [1080/1991](#)). Some of the proposed connections would also increase the capability of the Finnish Defence Forces to use railway transportation for the military material currently transported on the main roads of Finland. The Jyväskylä -Heinola – Lahti connection is especially important as it would connect the largest Military training facility in Kouvola to the airforce base in Jyväskylä, drastically reducing the amount of the costs of material transportation and emissions.

6.2 Political Demographics

Politics must always be taken into account in a large government backed undertaking, such as a new railway connection. Central-Finland has been politically inclined to the Green League, Vihreät, a party which drives forward green directives as of 2019. A better electrical railway system would be taken well by the majority of the local population, decreasing emissions while reducing the connection time to the capital. The connection, furthermore, increases the availability of public transportation using renewable energy. In addition, some of the proposed routes will connect relatively large towns to a new efficient network.

6.3 TEN-T & EU

The European Union's railway project, Trans-European transport network has also plans for the Finnish railroad network. The current plan for the "two-sided south-north" connection includes a railroad connection going through Helsinki-Tampere-Oulu all the way to Luleå in Sweden. The road connection of the network would run through Central Finland along the east -side of Lake Päijänne,

and from Oulu-Jyväskylä-Kouvola-Lahti to the Helsinki and Kotka ports.

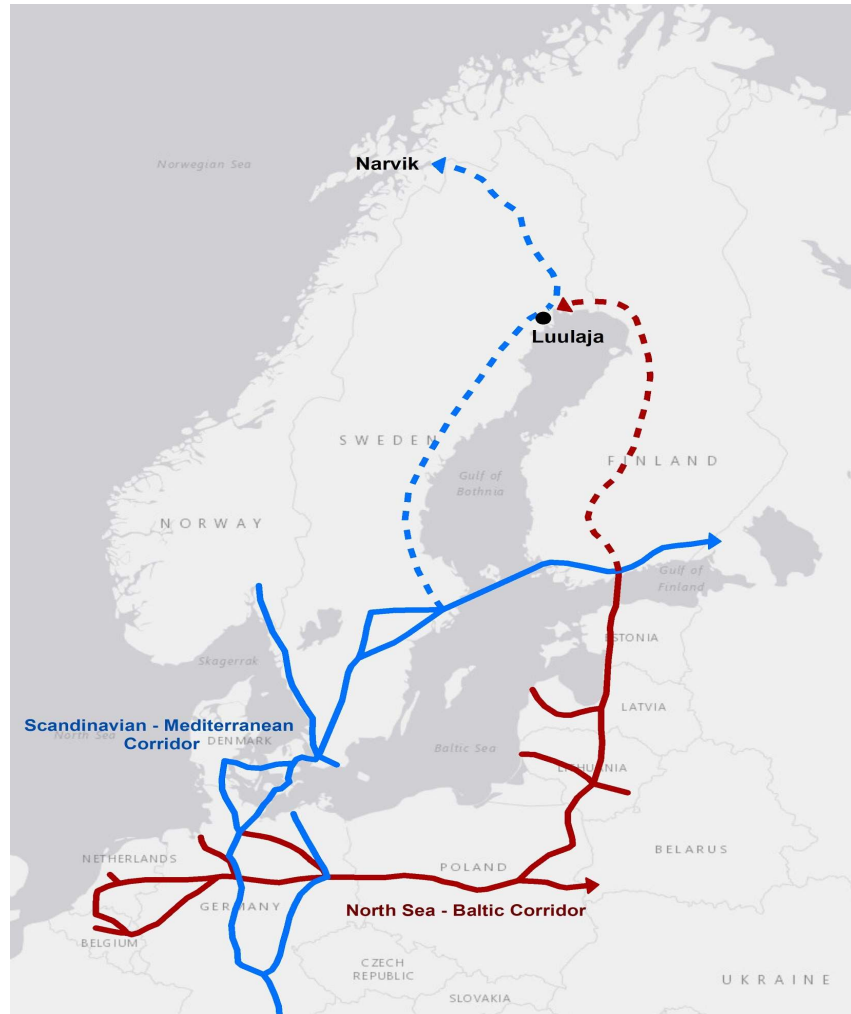


Figure 6 Proposed TEN-T network by the European Union (Väylä 6/2018)

The TEN-T network connected with the Baltic Corridor would be one of the most extensive infrastructure efforts in the history of the Baltic region. This would also benefit the Finnish industry in co-operation with the possible FinEst project addressed later in this study. The possibility of a direct railway connection from Finland to mainland Europe would greatly increase the capacity of quick moving products, as currently the only feasible way of transport material to/from Finland to mainland Europe is with air transportation.

“There is a old saying that Finland is an Island. This statement is still very true due to the fact that about 80 percent of the Finnish foreign trade takes place by sea” – Meriliitto, The Finnish Maritime Society.

Finland is the only coastal country where all the country's ports freeze completely during normal winters. Despite being a fore runner in ice breaking technology and industry a direct connection to mainland Europe through the Baltic region would give Finland a year-round connection without the requirement of icebreakers.

6.4 Arctic Corridor

The Arctic Corridor project has been an interesting proposition for a new maritime connection from Asia to Europe through the Arctic Sea. It would run through the Kirkenes harbour town to the Finnish mainland and have a connection to Sweden from the Tornio area.



Figure 7. Arctic corridor (DailyFT 2018)

The connection would be the fastest and shortest route from Europe to the Chinese markets, which would show a drastic increase in the North European

logistics sector. The increase of land transportation through all of Finland would be quite dramatic as not only Finnish companies would have interests in shortening the supply chain to Asian markets but also most of Central and Eastern Europe would be able to use the new connection.

Northern Finland has a long history of forestry and mining. "Local products include reinforced steel, paper, gold, lithium, uranium, vanadium, cobalt, zinc, nickel and other raw materials — most of which the local business community expect will sell well in Asia." (EU-observer 2018). The Arctic corridor combined with the FinEst connection could make Finland the best import export direction for the most of north-eastern Europe.

The project has been in the works for some years now, but lately the Norwegian authorities put the project in ice due to the monetary viability of the project. Without Norwegian support the connection will never be implemented. The connection itself would be a major step in the globalization of the Fennoscandinavian countries as a direct connection to Asia from the north would open new possibilities for the transportation sector, reducing the handling and transportation time compared to the current south European voyage through the Mediterranean.

7 Connections abroad

Finland is historically an export-oriented country, thusly the connections abroad are highly critical for the gross domestic product. In 2018 the value of Finnish exports increased by 5,5% compared to the previous year, increasing to 91 billion euro. The export sector covered 39% of the Finnish GDP in 2018, the balance of trade has been negative since 2010 but currently the deficit is only caused by the amount of service sector imports. The balance of trade on merchandise has been positive for many decades. (Confederation of Finnish Industries 2019) Most of the Finnish exports travel to European area and Russia. The connections are generally maritime transportations due to the

seclusion of Finland in geographical sense, making harbours the corner stone of Finnish exports

7.1 Russia

The amount of containerized cargo going from Finland to Russia in 2017 was 409,000 containers which has depressed slightly from past years growth. 25% of the container cargo transferred between Finland and Russia goes through the land border, which shows that even though maritime transportation is by far the largest contributor to exchange between the countries, land transportation is still a very viable option. (Finnish customs 2018)

Finland and Russia have a very special agreement compared to other EU-countries. The agreement states that with rail transportation the duty is not exchanged directly at the border, but instead the duty is exchanged in the corresponding countries hub where the cargo is landing, thusly the cargo coming from St.Petersburg does not stop to be tolled at the border crossing but, instead, for example in Kouvola railway hub Cargo East Terminal/CET -terminal. The most common material running through the terminal is paper, pulp, plywood, other wood-based products the second largest sector is steel rolls. (VRtransport n.d.) Which are one of the main exports from Finland and a big part of Central-Finnish exports also, including paper from Kaipola, pulp from Äänekoski and plywood from Suolahti.

7.2 Baltic sea

The Baltic sea is the most important geographical logistics point for Finland as 90% of the current export operations is done through maritime transportation, thusly functional inland logistics is crucial for international trade. Finland is described as an island due to its remote location and poor land connections compared to the rest of Europe.

Finnish exports by mode of transport (Mt) 30-50Mt/a

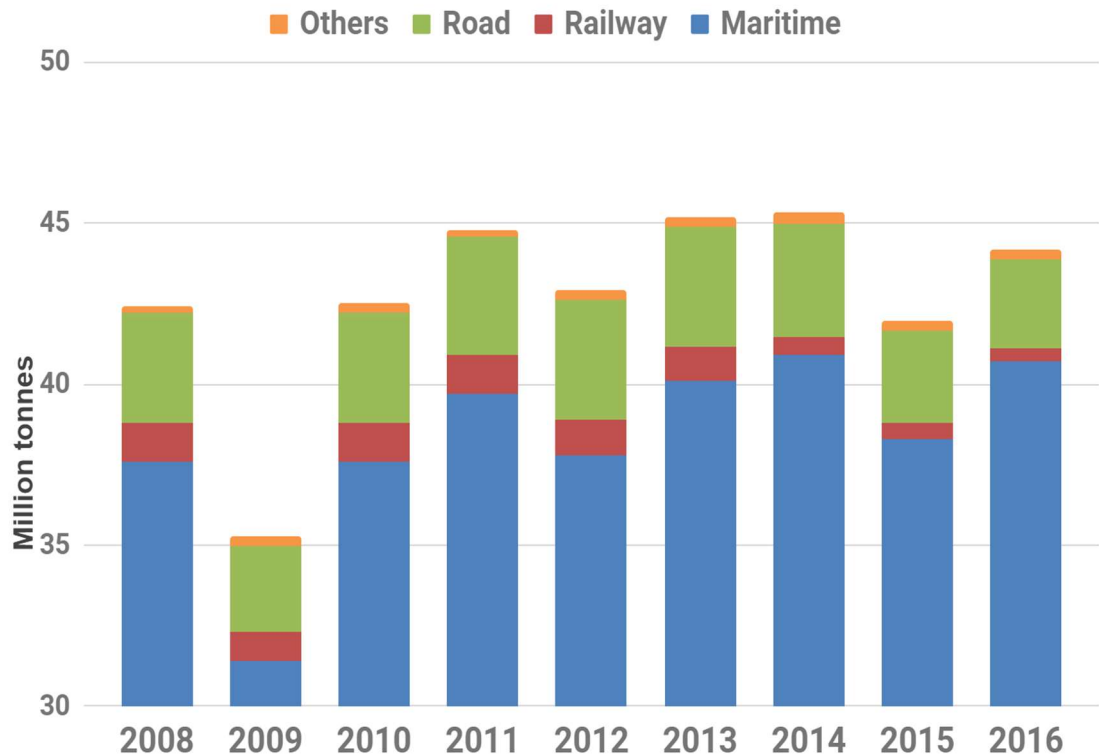


Figure 8 Finnish exports by mode of transport (Mt) 30-50Mt/a 2008-2016 Data collected from Tulli.fi/tilastot 2019

7.3 Helsinki port

Helsinki port is one of three main ports importing and exporting Central-Finnish industrial goods. Majority of technology exports go through Helsinki and Kotka while the third important one is Rauma port which mostly exports paper and some other bulk goods. A direct connection to both of the Southern-Finland ports could be achieved with the Jyväskylä-Lahti Railway connection, following the current material flow directly. Railway operations could transport the goods directly to the port where it can be loaded for maritime transportation cutting road transportation from the equation. Helsinki port is also the main import port of Finnish imports with share of 41.9% of loaded containers in 2017 (Rajaliikennetilasto 2018).

7.4 Kotka Port

The Kotka-Hamina port is the largest cargo port in Finland. The port transported 176437 containers in 2017 which equates to roughly 43% of the total export from the Finnish ports. (ibid.) It is the main location for many of the Finnish manufacturing industry exports, housing many production and refining facilities. The case for Jyväskylä – Lahti connection would create nearly direct connection to the port of Kotka boosting infrastructure connection for the entire logistics chain. Currently the transportation from Central-Finland - to Kotka port is mainly done by trucks.

7.5 Future FinEst

FinEst project is one of the biggest ventures planned in North-European logistics, the direct rail connection from Helsinki to Tallinn, connecting Finland directly to the European network through the Baltic, with further connections to the major Russian economic hubs of St. Petersburg and Moscow. The connection would benefit the Finnish export procedures in a major way as currently there is no direct European land connection from Finland to other EU states besides the connection from Malmö to Copenhagen which is relatively negligible in the sense of logistics due to the distance from Finland to Denmark and the perspective logistics chains.

The Helsinki-Tallinn connection currently transports nearly 300,000 trucks yearly, and the traffic has been steadily climbing by some tens of thousands of trucks per year (Liikennevirasto 2012). The future connection would make logistics operations through the Baltic sea much more competitive by unlocking a completely new sort of transportation system for the direction as currently almost all the cargo is delivered by Ro-Ro maritime transportation. A 2015 study done by the City of Helsinki is forecasting 8,4 million tonnes of cargo to be transported through the tunnel in 2042 (Ulla Tapaninen 2016)

8 Discussion

The logistics sector specifically in the transportation has originally started forming out of necessity to trade goods, through convenience, cutting corners and making the entire process much more efficient. Think of forest pathways forming or the paths formed on grass areas by pedestrians cutting corners. Nowadays transport has moved past comfort, transitioning to other value-added services. The construction of this kind of railway is out of necessity, giving some convenience to both public and private sectors. Most important factors for the project, especially in industrial sector, would be in adding value to the supply chain. Increased transport effectivity, greener supply lines, easy access to eastern transport sector with a land connection, direct connection to two of the biggest ports in Finland. All the points are increasingly important as the European union is moving towards transport efficiency.

As to the possible routes, while the development of Jyväskylä – Tampere double track seems to be the opinion which the government is going towards, is not necessarily the most interesting proposition. While it will more than double the effective transportation capacity on that route, which still is the biggest transport route from Central-Finland. The question is how the delimiter of capacity should be done, should the route have double capacity, or should there be another route giving both increased capacity in north-south transportation. If there would be another more efficient corridor for movement of goods and public transportation from the capital area to Central-Finland. The capacity requirement of the current corridor would be reduced drastically.

Following the current news about infrastructure developments and projects in Finland, the major development areas are on the coastal regions of the country. Following the TEN-T project according to the European union planning, the second major area is connections from Helsinki to Turku and Tampere which are currently the most important railway sections in transportation of both goods and people. Central and Eastern-Finland are currently only developing their own provincial road transportation systems.

The connection from Central-Finland to the capital area would be a great project for transportation efficiency on the route, also possibly adding new industrial hubs and towns for the national transport system, possibly making it a much more viable option for cargo as the amount of public railway transportation can be either doubled on the Jyväskylä - Tampere section or even further divided on the Jyväskylä - Heinola connection. Greatly increasing the capacity and capability of the transport network as the current system of public transportation first, cargo second, limits the efficiency of cargo transportation greatly.

Environmental effects of the railway would even further reduce the amounts of emissions as expanding a more ecological & efficient transportation infrastructure option would reduce the extent of private- along with industrial requirements of mostly fossil fuel running vehicles. Especially in medium to long range applications as the new route would not only prove a viable option for the local transportation but also raise the possibility of longer-range movement on the Finnish north - south axis.

Infrastructure is one of the most important decision points for companies, the requirement for the movement of material is a key indicator for many of the companies. Notably for larger companies using tools like the Gravity analysis, for the planning of the placement of new industrial sites. Thusly increasing the infrastructure while already having the positive effect of aiding the current companies in the development areas, the advances in further infrastructure would also increase the “pull” factor of these locations in Central-Finland and along the proposed routes.

The relevance of the railway development for the routes is currently seriously overshadowed by the previously stated developments. While the influence for the expansion of the routes has been a topic of discussion in Finland for over a decade, the time does not seem to be ripe for a project of this magnitude yet. While the reasoning and requirement are there, the progress of current infrastructure projects is paramount compared to smaller connections as the one under this study. While this project is not yet ready to be undertaken, further developments of the current infrastructure is not a hinderance for the

development of the Jyväskylä connection, quite the contrary the development of the projects only increases the interest and potential of the possible future connection.

9 Reflection

As a topic the study is very interesting and further studies should be made, this study was done to assess the feasibility of a new railway corridor for the Finnish mainland industrial sector, especially studying the Central-Finland and leaving the study mostly on the area while not going too deeply in other sectors, which are a great topic for further study also. Further study should be done always focusing on one topic and not as broad study area as this study, due to information while being plentiful but outdated and most of the time out of proportion for this exact route. The previous studies also basically only study the public transportation side to which this study is not counter argument but focusing on the less publicized industrial side. The information gathered is mostly from international organizations such as the European union and Finnish governmental institutions such as Statista. The other major background information is gathered from a handful of topic related master's thesis studies, while still using some references to some news article reports. The further study should include an extensive study on the transportation companies and capabilities required by local industrial companies, while it is easy to already see many of the goods transported from Jyväskylä region it is clear to see that the current capacity is exhausted and there are not big possibilities for other medium to large companies to fully utilize railway transportation over truck transportation.

The reliability of the sources available are varying, there are differences in data and the way that the data is presented even in studies done by same governmental organisations. Which lead to difficult selection of comparable data that is timely, reliable and related to the study topic. Especially as this is a large governmental theoretical project, the information in many cases should be redone to assess the actual improvement potential be it environmental

effects or infrastructural efficiency. As the research of public transportation side has already been made, while being almost five-year-old data, shows that the importance of the direct connection is not in the scope of near future connections. The conclusion of the discussion came very clear already in the infant stages of research done, which is unfortunate but reality with current regulations and prioritisation of personnel transportation over industrial needs. There still is the requirement for improved efficiency over Central-Finland's transportation network.

During the research the amount of current investments to the Finnish railway infrastructure really shows that it is currently being taken seriously. The amount of railway and other infrastructure projects really shows how important the infrastructure is to the wellbeing of public and industrial sectors. The part which should be of concern is that while there are governmental projects in Finland also the European union is pushing the TEN-T network and other infrastructure projects along. The functionality and management of both projects to work under the same roof must be considered. While the progress is there some other governmental side projects need to be slowed down to fulfil the European Union's requirements.

The development process of infrastructure needs to be given time, rushing multiple projects on the same time will lead to complications as seen in other fields of technology. At certain stages of infrastructure projects, the situational requirements are very high, which leads to the need of flexibility and foresight to direct resources to where they are needed. The improvement projects need to be assigned to motivated teams which are able to effectively process the work stages, which leads to higher potential of success.

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Appendices

Appendix 1 Comparison of greenhouse gasses, data gathered from
Lipasto, VTT 04.04.2019

Emissions	Co₂ (g/tkm)	CO (g/tkm)	NO_x (g/tkm)	CH₄ (g/tkm)	N₂O (g/tkm)
15 t Lorrie Urban driving	74	0.12	0.48	0.0015	0.003
15 t Lorrie highway driving	49	0.031	0.29	0.00046	0.0029
Semi trailer Highway driving	38	0.016	0.21	0.00018	0.0012
Full trailer 60t Highway driving	0.013	0.013	0.16	0.00014	0.00073
Electric general cargo Train	0	0	0	0	0
Electric container train	0	0	0	0	0
Diesel mixed cargo	25.3	0.079	0.65	0.0014	0.00041
Diesel container train	18	0.056	0.46	0.001	0.00029

Comparison to mixed cargo, diesel train					
15 t Lorrie Urban driving	411.11%	214.29%	104.35%	150.00%	1034.48%
15 t Lorrie highway driving	272.22%	55.36%	63.04%	46.00%	1000.0%
Semi trailer Highway driving	211.11%	28.57%	45.65%	18.00%	413.79%
Full trailer 60t Highway driving	0.07%	23.21%	34.78%	14.00%	251.72%

Appendix 2. Sr2-locomotive energy consumption by different rail weight and average speed, data gathered from (Liikennevirasto 15/2013)

Train Mass (t)	Consumption (kWh/km)				
	50 km/h	60 km/h	70 km/h	80 km/h	90 km/h
200	7	7	7	7	8
300	8	8	9	9	10
400	9	10	10	11	12
500	11	11	12	13	14
600	12	12	14	16	17
700	13	14	15	17	19
800	15	16	17	19	21
900	16	17	19	21	23
1000	17	19	20	23	26
1100	18	20	22	25	28
1200	20	22	24	27	30
1300	21	23	26	29	32
1400	23	25	27	31	35
1500	24	25	29	33	37
1600	25	28	31	35	39
1700	27	29	33	37	42
1800	28	31	34	39	44
1900	29	32	36	41	46
2000	31	34	38	43	49
2100	32	36	40	45	51
2200	34	37	42	47	54

Appendix 3 Progressive and hindering forces of railway operations
 (Liikennevirasto, Rataverkon kokonaiskuva [Finnish Transportation agency, Railnetwork overall picture] 2017)

