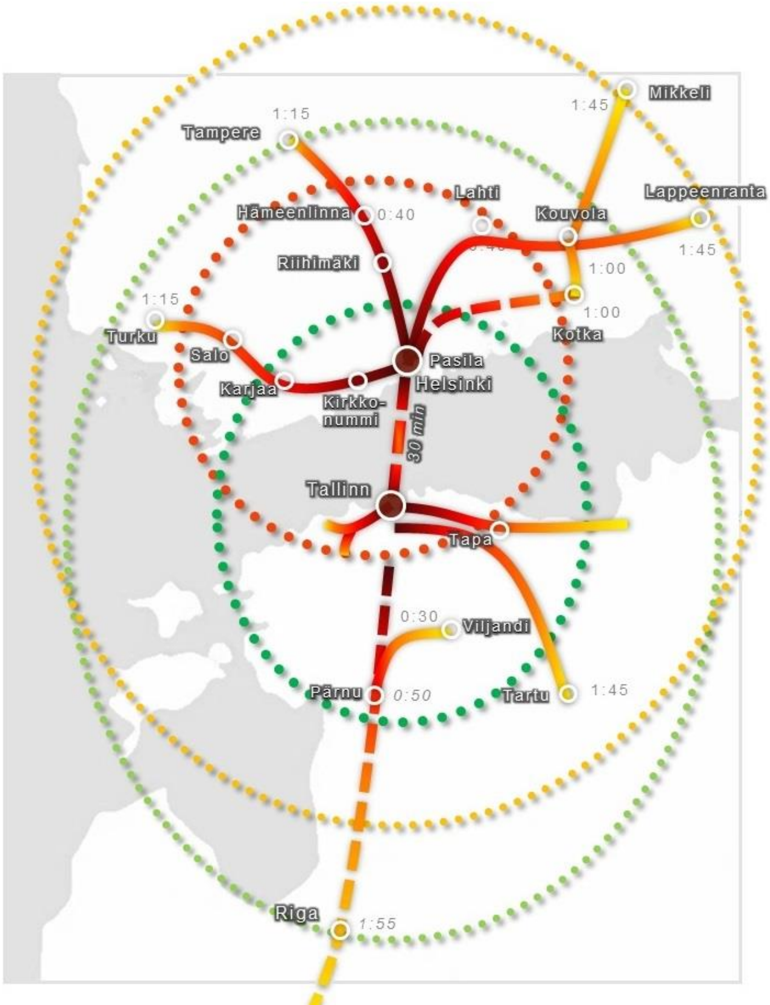
Harju County Government, City of Helsinki, City of Tallinn

Pre-feasibility study of Helsinki–Tallinn fixed link

Final Report



Joint Venture
Sweco Projekt AS, Vealeidja OÜ, Finantsakadeemia OÜ

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0. Executive Summary

The Helsinki–Tallinn fixed link is a growth vision for Finland and the Baltic region, the purpose of which is to reduce travel time, add mobility and create competitiveness in the area. In the pre-feasibility study, the preliminary target year for the completion of the fixed link is 2030–2035.

The Helsinki–Tallinn growth zone is considered as a part of Europe-wide Trans-European transport networks supported by the European Union. The objective of the TEN-T is to promote the European internal market, regional cohesion and sustainable traffic network.

Nowadays, over four million people live in a 200 km radius of both Helsinki and Tallinn. Cargo and passenger traffic between Helsinki and Tallinn takes place by sea. The passenger flow has increased to approximately eight million passengers, increasing by two percent a year. The number of passenger cars has increased to over a million (2013), growing by 10 percent a year. Most of Finland's export and import is carried out by sea. The most important form of transport in cargo traffic between Helsinki and Tallinn is container and trailer traffic.

Both cargo and passenger traffic is estimated to increase via the Helsinki–Tallinn fixed link. Developing the link would have a significant effect especially on commuter traffic but also on tourism. The fixed link would not mean an end to sea traffic – as, for example, cruise traffic will continue and increase in the long term. The fixed link also has a significant impact on the development of other connections (for example railway traffic) as well as on the concentration of residential areas and companies' competitiveness with regard to available work force. Travel time will be shorter and accessibility will improve significantly compared to the present.

The objectives of the pre-feasibility study

The objective of the pre-feasibility study has been to produce an estimate about the most profitable way to implement the link between Helsinki and Tallinn, considering the technical solutions and transport networks of both countries and the financial costs and benefits of creating the link.

The aims of the study were to:

1. find out how the fixed link should be integrated to transport networks in both Finland and Estonia;
2. produce rough estimations of the space the link, and the traffic solutions it requires for general and county planning;
3. study whether it is possible to develop the fixed link in several stages and to serve several modes of transportation;
4. observe the financial terms and passenger and cargo flows that would make the project profitable.

Approach and methods of study

The pre-feasibility study has been prepared by several experts from various fields. Previous studies considering development of the Helsinki–Tallinn link and the relevant statistical material have been used in the project. In addition, experience from the Øresund Bridge and the Channel Tunnel fixed links (impacts and studies) and experience from the Fehmarn Belt project have been taken into account.

Geological analyses were basis for route selections and possibilities for the technical report. Assumed scenarios of the increased traffic based on forecasts of both passenger and cargo transport have been made to support the assessment of financial and economic impacts.

Based on that, estimations of the amount of passengers have been made and a viable operating model for the tunnel has been prepared and used in the calculation of financial profitability. The assessment of impact has been followed up with a socio-economic evaluation and assessment of social impact. At first, optional routes and tunnel technical solutions were studied and the most viable one was selected to further studies. The results of the pre-feasibility study have been concentrated in a report to support detailed planning in the future.

Observed options

Different route and tunnel options have been studied in the pre-feasibility analysis to determine the optimal integration to traffic networks in Finland and Estonia. The objective was to find a solution where the travel time between city centres would be as short as possible and the fixed link technically feasible. This study took a look at five different solutions that were partly covered in previous studies.

As a result of studying different tunnel options, the railway tunnel with two separate rock tunnels is recommended for further planning. Trains would be operated with maximum speed 250 km/h to achieve a travel time of 30 minutes. The European track width would be used and connected to the Rail Baltic line. It was determined that implementing the fixed link also with road would not be profitable and is complicated from the technical and operational point of view.

The fixed link will be integrated to traffic networks in Estonia and Finland

The fixed link between Helsinki and Tallinn is supposed to be connected to the current public transport networks in both countries. The objective is to reduce the travel time between the two city centres as short as possible and to maximize the passenger, especially commuting, potential.

On the basis of the findings of the pre-feasibility study, the fixed link should be connect to the Central Railway station and the Pasila railway station and the airport in Helsinki in order to create a functional traffic network and develop commuter traffic (e.g. a rail connection to elsewhere in Finland, to Russia, bus connections, flight connections); the terminal for the passenger traffic would be situated at Pasila and the terminal for vehicles around Ring III with fluent traffic connections and the cargo terminal enabled by the new fixed link is proposed to be situated at Riihimäki or at Hyvinkää.

In Tallinn, it is recommended that the fixed link be integrated in the city to the traffic network at the Ülemiste (Rail Baltic, to Russia, flight connections and to local rail and bus connections). The cargo terminal is proposed to be situated in Muuga, slightly north-east of central Tallinn.

The completion of Rail Baltic is fundamental for the Helsinki–Tallinn fixed link project. After Rail Baltic is completed, travel time from Tallinn to Riga will be less than two hours. If the fixed link is completed within the 30-minute travel time, the connection to Tallinn from Tampere or Turku would be less than two hours.

Transport and traffic will change

According to rough estimate, four to five million inhabitants will live in the daily working area of the Helsinki–Tallinn fixed link. Nevertheless, the fixed link will impact the whole Fenno-Baltic zone that has about 17 million inhabitants. According to the pre-feasibility study, the amount of passengers between Helsinki and Tallinn could increase from eight million (2013) even to 41 million passengers in the next 70 years. Today 30,000 people commute weekly or monthly from Estonia to Finland. Everyday commuting will be a new segment in Tallinn-Helsinki traffic. It is estimated that number will be up to 25,000 ten years after opening. Travel and business between Estonia and Finland is going to grow significantly when the fast connection opens. Container and trailer transportation via the link is estimated to increase significantly in the first ten years when the link opens. According to the estimate, about half of the cargo traffic will in the future go through the fixed link.

Socio-economic impacts are substantial

As a part of the socio-economic impacts, the development of passenger flow, change in travel time and its impacts on mobility, impact on commuter traffic and financial impacts have been studied.

After the Helsinki–Tallinn fixed link is completed, mobility will change and accessibility of areas will improve on a larger scale. The attractiveness of neighbourhoods near the traffic network can escalate with better accessibility and connections. The need of new land use planning is emphasized. The economy will benefit from wider consumer markets, shared labour markets as well as from the different cost and regulation levels the two countries.

Direct and indirect benefits from both the constructing and operating period to both countries will be significant. Planning, building and maintaining will create jobs, enable companies to grow and evolve in the twin-city area, enhancing also the need for new services.

The estimated increase in traffic (work, study, business, leisure) will have a strong impact on the competitiveness of the areas. Changes in the traffic system and the development of new appealing areas will reflect on both businesses and inhabitants. For example, when new logistic and tourism services appear, the service structure of the areas can change significantly.

The competitiveness of the twin-city area will be strengthened by improved accessibility, new companies and business, better image and variety in living options. Significant improvement in accessibility via different traffic solutions will influence regional competitiveness as well as the competitiveness of the whole of Finland and Estonia. A benchmark study of the Øresund Bridge shows stimulating effect on business life from the fix link.

Public support is needed to implement the fixed link

The cost estimate of the tunnel and traffic solutions is 9–13 billion euros. According to the socio-economic analysis, income from the tunnel will cover the operating and maintenance costs and a part of investment costs during the operating period. Financial support in the extent of 40 percent would be needed from the public sector (from governments and the EU). The EU funding of the Fehmarn Belt project constructed in Denmark was approximately 40 percent. A possible model for organizing the construction, funding and operating of the tunnel could be corporation-based. In future planning, arrangements based on different corporation models in which a corporation is contracted to implement the construction, operation and maintenance of the tunnel should be studied in more detail. The construction of the tunnel could start approximately 2025–2030, and construction work would take eight to ten years.

When constructing the tunnel, a significant amount of stone material will be generated from mining the rock tunnel. Utilizing the stone material, for example, to build up a new plot of land in water should be studied in more detail in the future. The construction of the tunnel could be partly financed by the possible land usage fees due from the plot of land. Utilizing the stone material as a plot of land could also be a broader question in urban planning and land use planning, which will also require further studies.

Further studies necessary

The preliminary study of route options of the Helsinki–Tallinn fixed link and the assessment of socio-economic impacts shows that the study considering the construction of a tunnel should be continued. The assessment of financial impacts shows that the project would not be profitable without some funding in the investment stage. Regardless, the socio-economic impact (for example the shortening of travel time) will make up a big part of the deficit. The project has a significant positive impact on attractiveness on both regional and national level.

It has been learned for example from building the Channel Tunnel between England and France and also from the Fehmarn Belt project that the technical process of the project takes time. A subsequent study should take a detailed look at the technical options and possibilities of the tunnel, as well as location possibilities for terminals. In addition to financial impacts, the possible environmental, social and cultural effects of the tunnel should also be estimated more precisely. As a basis for the study, the estimates of cargo and passenger traffic should be specified.

Progress of the project is ensured by joint project organisation by Estonia and Finland

In the benchmark chapter of the pre-feasibility study, experience from other planned and implemented tunnel projects and their organization models were collected. Especially based on experience from the Fehmarn Belt project a proposition was made to establish a Finnish-Estonian project organization for further planning. The next phase and the preparation of the studies calls for active actions from the stakeholders, communication within the project and finding possible outside funding, in which case the most recommendable option is a cooperation project with enough resources for work force and financing to implement the project.

1. Introduction

The pre-feasibility study of the Helsinki–Tallinn fixed link is an outcome of TALSINKIFIX project financed by European Union EUBSR Seed Money Facility. Contracting authorities of this study are Harju County Government, City of Helsinki and City of Tallinn.

The main objective of this study is to give an answer for the authorities of Estonia, Finland and the EU: whether the project seems viable enough to justify a full scale feasibility study?

This preliminary feasibility study is based on examinations of studies conducted in regard of the Projects hitherto and also on benchmarking to comparable undertakings. As project development today is in a very early stage, no deep analyses have been conducted yet. Therefore, the outcomes of current analysis are indicative and it can be suggested to conduct further analyses to base decision making on more solid ground.

Background

Finnish and Estonian economies are tightly related. Capitals of both countries are on the opposite side of the Gulf of Finland and the distance between the cities is approximately 80 km. The Tallinn–Helsinki region put together more than two and a half million inhabitants and the potential to become one of the significant centres in Northern Europe. Today, only sea crossing is available, and it takes about 2.5 hours to cross the bay by ferry. There are more than 7.5 million travellers, one million passenger cars and over a quarter of a million trucks using ferry transport between Tallinn and Helsinki annually. Therefore, it is one of the busiest marine traffic lines in Europe, accompanied by environmental and security risks.

The sea crossing between Helsinki and Tallinn is part of TEN-T North Sea-Baltic Corridor and will be strengthened by the new railway line ‘Rail Baltic’, connecting Estonia, Latvia and Lithuania with Central and Western Europe. Rail Baltic is one precondition of the fixed link. Recently the idea to explore the potential of a fixed link between Tallinn and Helsinki has been raised in connection with regional planning on EU level – EUSBSR Priority Area 11 (Transport links), projects RBGC (Rail Baltic Growth Corridor) and H-TTransPlan (Helsinki–Tallinn Transport & Planning Scenarios).

Execution

The pre-feasibility study was executed by a joint venture formed by Sweco Projekt AS, Vealeidja OÜ and Finantsakadeemia OÜ. Experts from Sweco Finland and Sweco Sweden and from Kohateam Oy and Geological Survey of Estonia were also involved.

The pre-feasibility study is meant to:

- identify relevant studies and statistical information;
- analyse geographical and geological conditions of the fixed link and give suggestions for future surveys;
- assess potential alternatives for the fixed link – tunnel, bridge, combination, passenger-only, cargo-only or combination;
- determine the integration of the link to existing transport networks;
- benchmark the best practices of the Femern Belt fixed link project;
- assess the socio-economic benefits and problems of the fixed link.

In addition to the introductory chapter there are 11 chapters in this study report:

Chapter 2 Methodology

Chapter 3 General Approach and Current Situation

Chapter 4	Tunnel and transportation alternatives
Chapter 5	Transport System in Finland and the Baltics in the future
Chapter 6	Benchmarking
Chapter 7	Technical Opportunities
Chapter 8	Cost-benefit Analysis
Chapter 9	Socio-Economic Analysis
Chapter 10	Organization and Funding
Chapter 11	Project risks
Chapter 12	Conclusions and Recommendations

2. Methodology

The methodology of this study was prepared in accordance with terms of reference of this project. The main objective of the study was to find answers to the following questions:

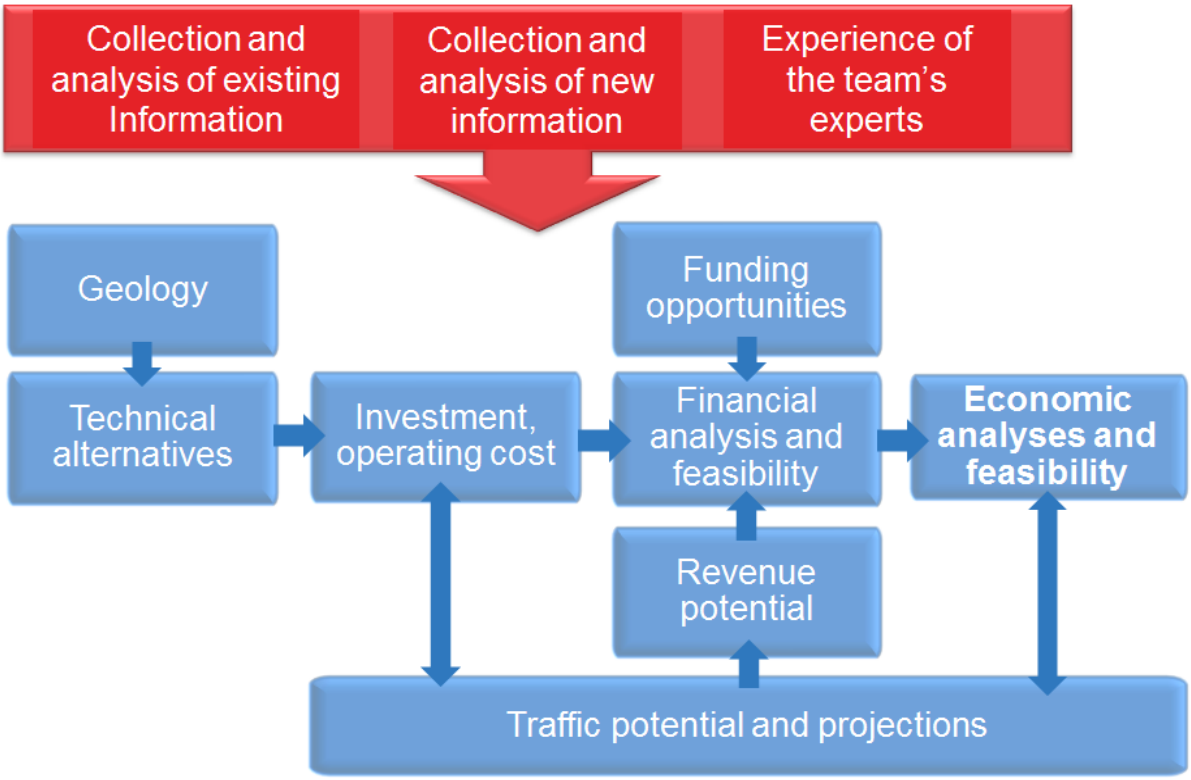
- What would be the best way to connect the cities Tallinn and Helsinki, in the sense of technical solutions (tunnel or combination of bridges and tunnels) and transport modes (cars, trains)?
- How would the fixed link impact environmental and security risks in the situation of heavy and increasing traffic?
- How should the fixed link be integrated into local and national transport networks in both countries?
- What are the expected passenger and cargo flows of the fixed link?
- What are the direct financial costs (investments, operating expenses) and revenues (ticket income) of the project?
- What are the economic costs and benefits (travel time) of the project?
- Does the project seem viable enough to justify a full scale feasibility study and how to complete the full-scale study?

The study integrates the knowledge and skills in different areas of specialisation and experience in combining existing studies with new information to offer a qualitatively new basis for the decision-making process regarding the further steps in the fixed link development.

The following subsections describe the methodological approach in the main areas of the study:

- Geography and geology including topography, bathymetry, geotechnical materials, geophysical materials and ecology;
- Technical analysis of alternatives and opportunities, including route selection, technical solutions, cost estimate and integration;
- Traffic forecasting, including transportation, cargo and passenger traffic;
- Socio-economic analysis, including financial feasibility analysis;
- Funding opportunities.

The following chart explains the work process and interconnections between different areas:



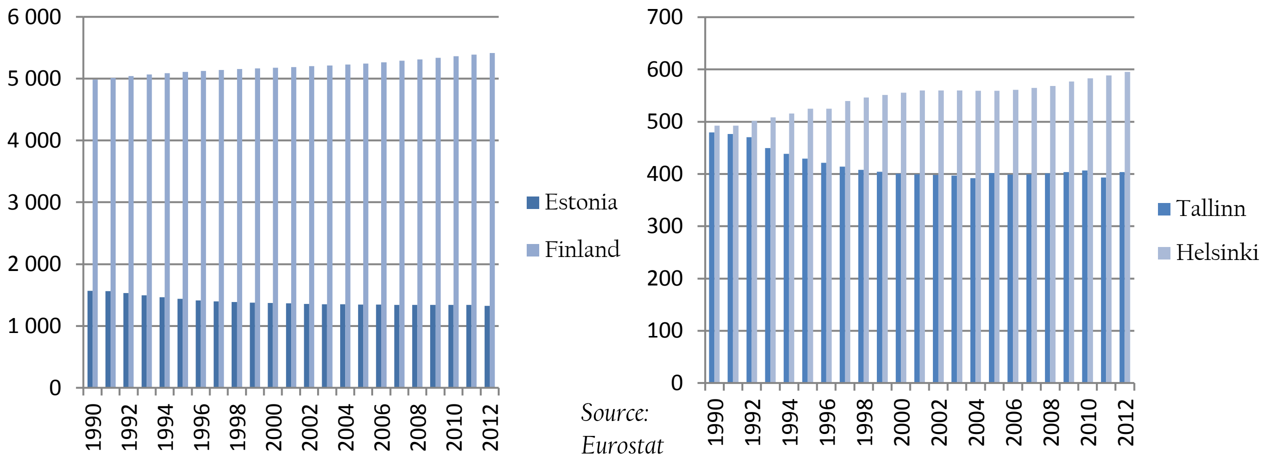
3. General Approach and Current Situation

3.1 Population and Employment

Population and migration

Population numbers in Estonia and Finland have developed by different scenarios since 1990 (see Figure 1); while the Finnish population has increased by nearly 9%, from 5.0 million people to 5.4 million from 1990 to 2012, the Estonian population has shrunk in the same period by 16%, from 1.57 to 1.32 million.

Figure 1 Population numbers of Estonia, Finland, Tallinn and Helsinki in 1990–2012 (in thousands)



Source: Eurostat

The number of inhabitants in the city of Tallinn followed the same pattern as the whole of Estonia and decreased by 15.8%. The city of Helsinki, however, outperformed the growth of Finland by more than 2 times with 20.9% from 1990 to 2012 (Figure 1). When in 1990 Tallinn and Helsinki were very close in terms of population numbers, then by 2012 the difference was close to 200,000 people.

Population of the Helsinki metropolitan area – Helsinki-Uusimaa – grew from 1.23 million in 1990 to 1.56 million in 2012. Population in Tallinn metropolitan area decreased from 0.61 million to 0.57 million in the same time period.

Growth in Helsinki-Uusimaa, the metropolitan region of Helsinki, was even bigger than in the city of Helsinki. With a 27% increase, the population of Helsinki-Uusimaa is now 1.56 million, i.e. close to 29% of the Finnish population (25% in 1990).

With regard to population, both countries follow the pattern of countries with comparable economic and social development: Finland in comparison with the Nordic Countries and Estonia with the Eastern European countries. The best example would be Denmark and Copenhagen, where population increased by 8.8% and 20.3% respectively from 1990 to 2012, i.e. similar rates compared to Finland and Helsinki.

Future population projections by Eurostat follow the trend of the past decades in both countries (see Table 1).

Table 1 Population projections for Estonia and Finland until 2080 (in thousands)

	2013	2020	2030	2040	2050	2060	2070	2080
Estonia	1,320	1,284	1,208	1,162	1,131	1,093	1,055	1,029
Finland	5,427	5,619	5,881	6,058	6,161	6,240	6,323	6,382

Source: Eurostat

Although the natural growth rate has also been negative in Estonia in the past two decades, the main cause of the population decrease is net emigration. According to Eurostat's expectations, emigration will continue to have a relatively strong impact on the Estonian population until 2030. Finland, on the contrary, will continue to be the net receiver of foreign population, with more than 20,000 people a year until 2030.

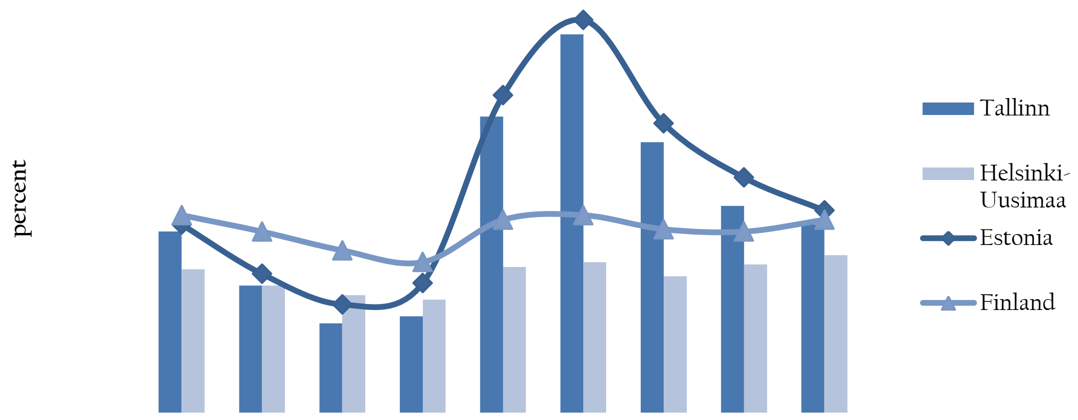
Finland has also been the main destination of Estonian emigration in recent decades. It has been estimated that in 2013 nearly 40,000 Estonian citizens lived in Finland (10,700 in 2000), making up 20% of the total number of foreign citizens living in Finland. The increase accelerated in 2012 and 2013 when the number grew by more than 10,000 within two years.

Labour market

It was estimated that in 2013 about 60,000 Estonians worked in Finland, with 70% of them holding their main job in Finland and paying social taxes to the Finnish state budget. (1)

The unemployment rates of Estonia and Finland were relatively similar in 2013 (8.6% and 8.2% respectively), whereas the Estonian unemployment rate has been more volatile in recent years.

Figure 2 Unemployment figures in Estonia and Finland, Tallinn and Helsinki-Uusimaa



Source: Eurostat;

Tallinn and Helsinki-Uusimaa show slightly lower unemployment rates compared to the average of each country.

In 2011, 44% of the total Estonian population and 47% of the Finnish population were employed. By 2013, this difference had diminished slightly, as unemployment in Estonia decreased. According to Eurostat, the relative employment level in Helsinki-Uusimaa and Tallinn (North-Estonia) was higher, with 53% and 52% of the total population in 2011 respectively.

The employment situation and the salary and real estate price differences are important drivers of commuter traffic, as shown in the example of Øresund fixed link (see section 6.2).

3.2 Land Use and Transport System

The transport sector in Finland is road oriented. In total, the Finnish road network is approximately 454,000 kilometres long. It includes around 350,000 kilometres of private and forest roads and 26,000 kilometres of municipal streets. There are approximately 78,000 kilometres of public roads in Finland. Highways and main roads comprise more than 13,000 kilometres, 700 kilometres of which are motorways.

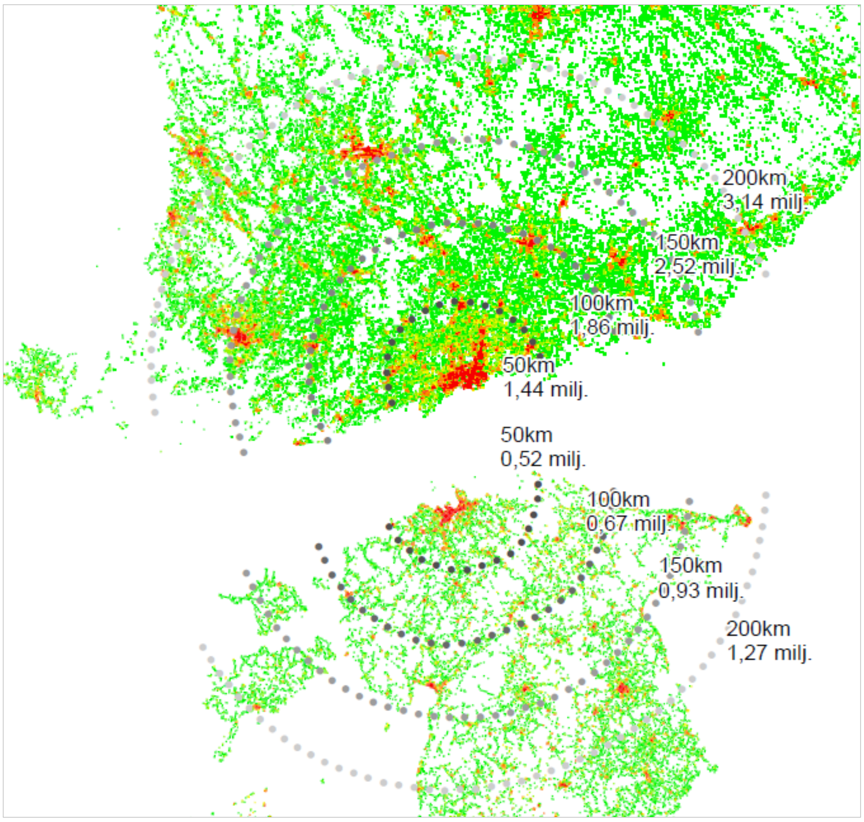
Most of the total road length of 64,900 kilometres consists of local and connecting roads. However, these represent just over a third of all traffic.

Finland has 5,944 kilometres of railways in use, of which 3,067 kilometres are electrified lines. The maximum axle weight of the railway network is 25 tons. The speed limit is 220 km/h for passenger trains and 120 km/h for freight trains.

Length of public railways in Estonia is 918 kilometres, out of which 132 kilometres are electrified. The speed limit for passenger trains is 120 km/h and 80 km/h for freight trains.

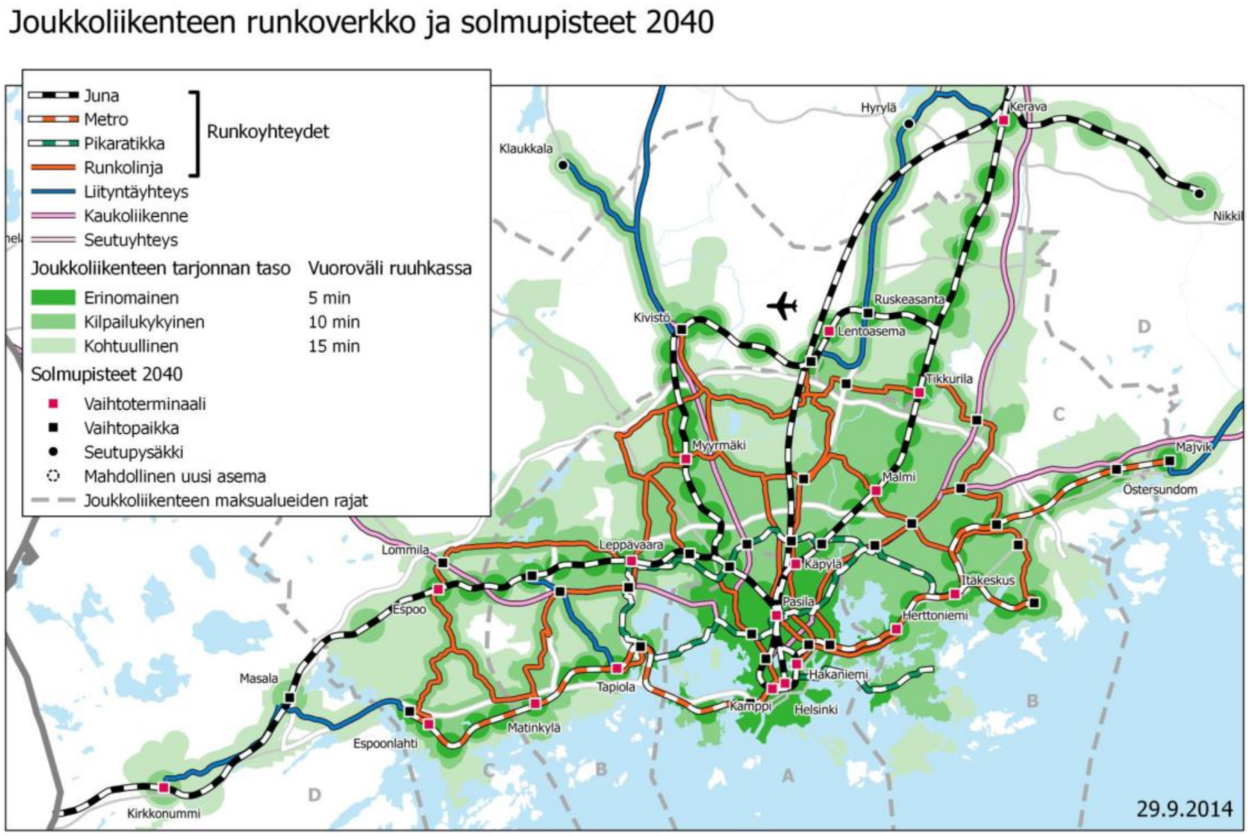
Today, a total of 4.41 million inhabitants live in the impact area of 200 km from Helsinki and Tallinn. All the main national connections, main roads, railways and flight routes are oriented to the capital cities.

Figure 3 Inhabitants living in the impact area of 200 km from Helsinki and Tallinn today



Finland's economic locomotive is the Helsinki region which is growing strongly. It is estimated that in 2050 the region will have about 2 million inhabitants and a work force of 1.05 million employees in total. This means that in the main metropolitan area 5.7 million daily trips are made. Even in the future, when public transport is made more efficient, it is estimated that 16% of all vehicle trips are made by public transport. The land use plans and traffic system plans for the Helsinki region promote public transport. Rail transport will also be developed actively and metro, tram and train systems are developing fast.

Figure 4 Core public transport network and nodes 2040 (44)



Source: www.hsl.fi/sites/default/files/uploads/joukkoliikennestrategia_hlj2015_raportti.pdf

3.3 Passenger Transport and Cargo

3.3.1 Passenger Transport

Both Finland and Estonia are quite sparsely populated and passenger transport is operating mainly on the roads by cars and buses. The total vehicle fleet is about 3 million units in Finland and 0.8 million units in Estonia.

Finns make 5.2 billion domestic trips and travel 74 billion kilometres annually. An average member of a Finnish household makes an average of three trips per day, spending around 66 minutes and travelling approximately 41 km.

In the Helsinki region there is a good public transport system based on trains, metro, trams, buses and even a couple of ferries. Helsinki Region Transport (HRT), which is responsible for the transport system in the Metropolitan Helsinki area and for procuring public transport services, has a user-friendly route planner system, making travelling and combining different modes of transport, including walking, very easy. Public transport ridership has been increasing steadily year on year. The ticket prices are quite low, because about 50% of the total costs are subsidised.

In Tallinn there is a good public transport system based on trams and buses. The city of Tallinn operates a system of bus (64 lines), tram (4 lines) and trolley-bus (7 lines) routes to all districts. There is also possible to use train services within the city. Starting from January 2013 public transport for citizens registered to live in Tallinn is completely free. That includes buses, trams and trolleybuses, and also the rail services within city limits. The subsidy level is therefore above 90% of the total costs, since only non-inhabitants pay for the service.

About 43% of the work travel is performed by public transportation in the city of Tallinn as of 2011 (46% by personal car).

3.3.2 Sea transport, ferries and road transportation

Total passenger flow between Helsinki and Tallinn has in ten years grown from 5.5 million passengers to 8 million passengers a year. The yearly growth rate has been about 2.4%.

At the same time the number of cars has grown from 0.5 million cars in 2005 to 1.04 million cars in 2013. The growth rate has been nearly 10% per year.

The total number of buses and trucks has grown from 212,000 in 2005 to 336,000. In 2013, the number of buses was 86,000 and the number of trucks 250,000, including trailers.

The volume of the see transportation between Estonian and Finnish ports was over 6 million tons in 2012 (see table below). About half of this is ro-ro cargo and another half bulk (dry and liquid).

Table 2 Maritime transport between Finnish and Estonian ports in 2012

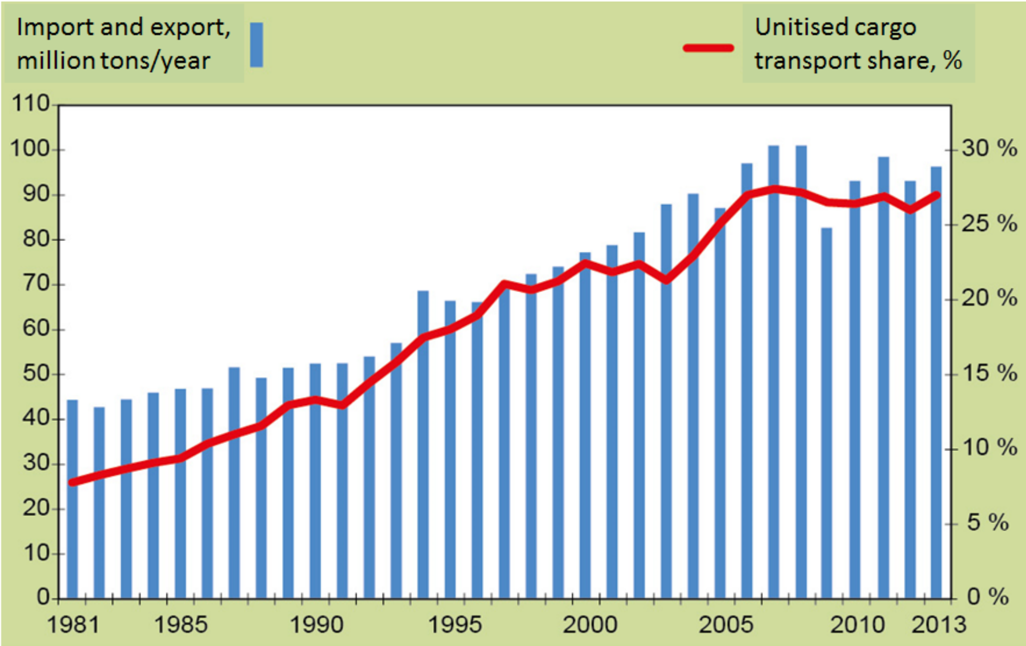
Cargo type	From Estonia to Finland, thousand tons	From Finland to Estonia, thousand tons
Liquid bulk goods	232	490
Dry bulk goods	1,405	711
Ro-Ro, mobile self-propelled units	1,445	1,509
Ro-Ro, mobile non-self-propelled units	119	179
Other cargo not elsewhere specified	17	31
TOTAL	**3,218**	**2,920**

Source: Eurostat

3.3.3 Cargo transportation

Although Finland is connected to mainland Europe, for international transport Finland is like an island – meaning that it is totally dependent on marine transport. The Baltic Sea is also an emission control area. The Sulphur Directive is estimated to increase transport cost on the Baltic Sea in the short term, but the price of oil and new techniques of ships engine developments may reduce the directive impact of transport cost. The total volumes of Finnish export and import are 100 million tons a year. Import was about 43 million tons a year in 2000 and 50 million tons a year in 2011 and export increased respectively from 37 million tons a year to 50 million tons a year. The average change is about 1.8% a year. In 2011, 88.5% of export and 82% of import were carried out by ship.

Figure 5 Import and export volumes in cargo transport between 1981–2013



Source: http://www.ulkomaankaupanreitit.info/kuljetukset.htm

Between Helsinki and Tallinn, unitised cargo is the most important type of cargo. The total volume of unitised cargo in Finnish sea transport is 22 million tons a year.

3.4 Economy

Wealth and income

Although the economic gap between Estonia and Finland is narrowing, there is still a considerable difference in the living standards of the two countries. When compared in nominal terms, the gross domestic product (the **GDP**) per capita in Finland exceeded that of Estonia 2.9 times in 2011, compared to 5.7 times in 2000 (Table 3). The difference between North-Estonia (Harju County, dominated by the City of Tallinn) and Helsinki-Uusimaa is 2.5 times. Thus, the gap has been reduced by more than 2 times in 11 years.

Table 3 Comparison of GDP in nominal terms and in purchasing power parity

	GDP in nominal values		GDP in purchasing power parity	
	2000	2011	2000	2011
Finland / Estonia	5.67	2.89	2.59	1.67
Helsinki-Uusimaa/North Estonia (incl. Tallinn)	5.24	2.50	2.39	1.44
Hovedstaden (Copenhagen; DK) / Skane (SE)	1.42	1.50	1.37	1.41

Source: Eurostat;

Upon taking into account the cost of living, the difference in wealth is reduced remarkably. Helsinki-Uusimaa's GDP is 1.4 times higher than that of North-Estonia measured in purchasing power parity. This indicates that living costs (i.e. level of prices) in the Tallinn metropolitan area made up only 57% of the living costs in the Helsinki-Uusimaa area in 2011. This relative difference in wealth between North-Estonia and Helsinki-Uusimaa is similar to the difference of Danish (Hovedstaden) and Swedish (Skane) side of the Øresund region.

The last row of Table 3 also shows that the gap between the Danish and Swedish parts of the region has not decreased after the fixed link was opened (in 2000).

The current situation is a good driver for commuting traffic, as the difference in nominal GDP also indicates a big difference in the salary level. The model which combines living in low-cost Tallinn and working in high-income Helsinki could be a strong driver of commuting. About 2/3 of commuters in the Øresund region mentioned a higher salary as the main reason for commuting (see section 6.2).

The difference in the average monthly earnings in Finland and Estonia is even higher, as is indicated by the difference in nominal GDPs (see Table 4).

Table 4 Monthly earnings in Estonia and Finland (in euros)

	Estonia			Finland		
in euros	2006	2010	Growth	2006	2010	Growth
Business economy	642	822	28.0%	2,566	2,958	15.3%
Industry and construction	626	813	29.9%	2,748	3,186	15.9%
Services of the business economy	659	828	25.6%	2,412	2,807	16.4%
Education, health, arts, entertainment etc	477	661	38.6%	2,255	2,638	17.0%

Source: Eurostat;

As provided in the table above, the earning difference by main activities varies between 3.4–4.0 times. Although salary growth was higher in Estonia from 2006 to 2010, the growth in euro terms was about 2 times higher in Finland: less than 200 euros in Estonia compared to 400 euros and more in Finland.

Real estate market

In Q4 2013, the average price of old dwellings in Greater Helsinki was EUR 3,549 per square meter[1] in, while in Tallinn it was EUR 1,334[2] i.e. about 2.7 times lower. The Global Property Guide also indicates a big difference in rental prices in Tallinn and Helsinki (see Table 5).

Table 5 Price and rental level of apartments (75 m²) in Tallinn and Helsinki in 2013

	Sales price (EUR)	Monthly rent (EUR)	Rental yield
Helsinki	487,275	1,719	4.23%
Tallinn	146,925	648	5.29%

Source: Global Property Guide

However, a large part of the residential premises in Tallinn is made up of morally obsolete Soviet era buildings and the general quality of the living environment in Tallinn also needs improvement to be attractive for Finnish people.

The rental prices of prime real business space differ by several times between Tallinn and Helsinki. According to Colliers International, the high prime street rental level of office spaces was around 170 EUR/m² in Helsinki and 29 EUR/m² in Tallinn in 2012. Prime shopping centre rent was 140 EUR/m² in Helsinki and 44 EUR/m² in Tallinn.

An important change in the Øresund region after the opening of the fixed link was that many Danish people moved to Sweden due to the lower real estate prices and started to commute to work in Copenhagen (please refer to section 6.2). Given the differences in real estate prices, some preconditions for such a process are present also in the case of Tallinn and Helsinki.

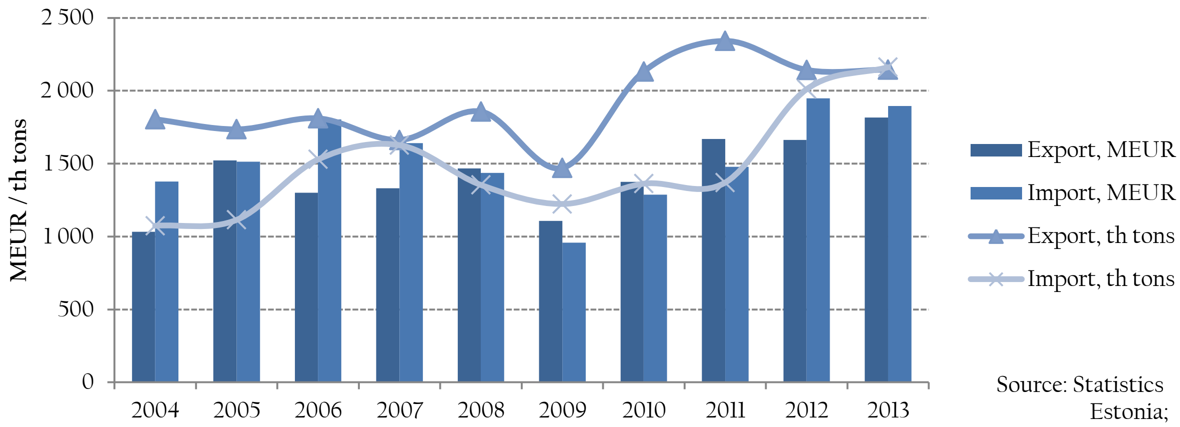
Trade and investments

Besides Sweden, Finland is the leading economic partner to Estonia, also in terms of trade and investments.

[1]Source: www.globalpropertyguide.com
[2]Source: Statistics Estonia

By 2012 the trade volumes have recovered from the crisis and have exceeded the high of the boom years in 2005 and 2006 (see Table 6). Trade between two countries is relatively balanced: Estonia did have excess in the years of deeper crisis (2009–2011), after which the balance turned negative again. Although the volumes have recovered, the share of Finland in Estonian foreign trade has decreased from above 20% in 2004 to 15% in 2013.

Figure 6 Estonia's trade with Finland in 2004–2013



Source: Statistics Estonia;

For the transportation corridors the trade quantities in terms of weight are of importance.

In 2013, both Estonian export to and imports from Finland exceeded 2 million tons. In 2012 and 2013 the quantity of import experienced a considerable leap. The main source of growth was the import of gravel and crushed stone (+400 thousand tons in 2 years), used mainly in road construction. In 2012, the volume of petroleum oil import increased by 200 thousand tons and remained on the same level in 2013. The share of those two cargo groups in the total import quantity from Finland was 57% in 2013.

In terms of weight, 50% (over 1 million tons in 2013) of Estonian export to Finland is made of wood and wood products.

The Finnish direct investments stock in Estonia has grown by 1 billion euros to 3.5 billion euros from 2008 to 2012. This made up ca 24% of all foreign direct investments into the Estonian economy and was in the second place after Sweden (27% share)[3]. A simplified estimate[4] shows that around 45,000 employees can be attributed to this investment volume. The Estonian direct investments stock in Finland was 160 million euros in 2012 (60 million euros in 2008).

Finnish hinterland

The planned fixed link would give Finland direct railway access to Central Europe; today, there are direct links only to Russia and Sweden. It is therefore important to consider the trade volumes from and to potential hinterland countries of the planned fixed link. In this analysis, the following countries have been taken into account in that regard:

EU from Eastern-Central Europe (CEE)	Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, Slovakia
EU from Western Europe	Austria, Germany, France, Italy
Other countries	Belarus, Switzerland, Kazakhstan, Moldova, Ukraine

[3]Source: Bank of Estonia
[4]Number of employed people divided by the fixed assets of the enterprises, derived from Statistics Estonia;

When measured from Helsinki, only Estonia remains within the range of 300 km, which is regarded as a distance where the freight shipment will in a considerable extent remain on trucks also in the future.(2)

Railroad would be of high importance for longer distances, as of the transportation policy of EU. (41)

Traded quantities with the above countries amounted to more than 21 million tons in 2013 (see Table 6), of which 11.5 million tons are Finnish exports and 10.0 million tons imports. A detailed table with trade volumes and quantities from and to individual countries is provided in Appendix 1.

Table 6 Finnish trade with selected European countries

	Value in million euros			Quantity in thousand tons		
	2000	2013	Growth	2000	2013	Growth
EU CEE countries						
Export	3,687	4,774	29.5%	2,120	4,178	97.1%
Import	1,851	4,765	157.4%	4,961	4,916	−0.9%
EU Western Europe countries						
Export	11,645	8,935	−23.3%	9,157	6,891	−24.8%
Import	8,344	12,097	45.0%	3,470	4,067	17.2%
Other countries						
Export	972	1,352	39.0%	439	434	−1.3%
Import	572	997	74.2%	448	1,050	134.4%
TOTAL	**27,072**	**32,920**	**21.6%**	**20,594**	**21,534**	**4.6%**

Source: Eurostat;

As can be seen in Table 6, the imports of Finland have grown considerably faster compared to exports. In the case of EU Western European countries, export contracted in terms of both value and quantity. It can be related to both the downturn of Nokia (in terms of value) and the crisis in the paper industry (in terms of quantity).

For comparison, the nominal GDP growth was 136% in the selected EU CEE countries, 36% in the selected EU Western European countries and 46% in Finland in 2000–2013. Economic growth is considered as the main driver of trade and *vice versa*. However, the growth in quantity terms is unlikely to follow the speed of growth in value terms.

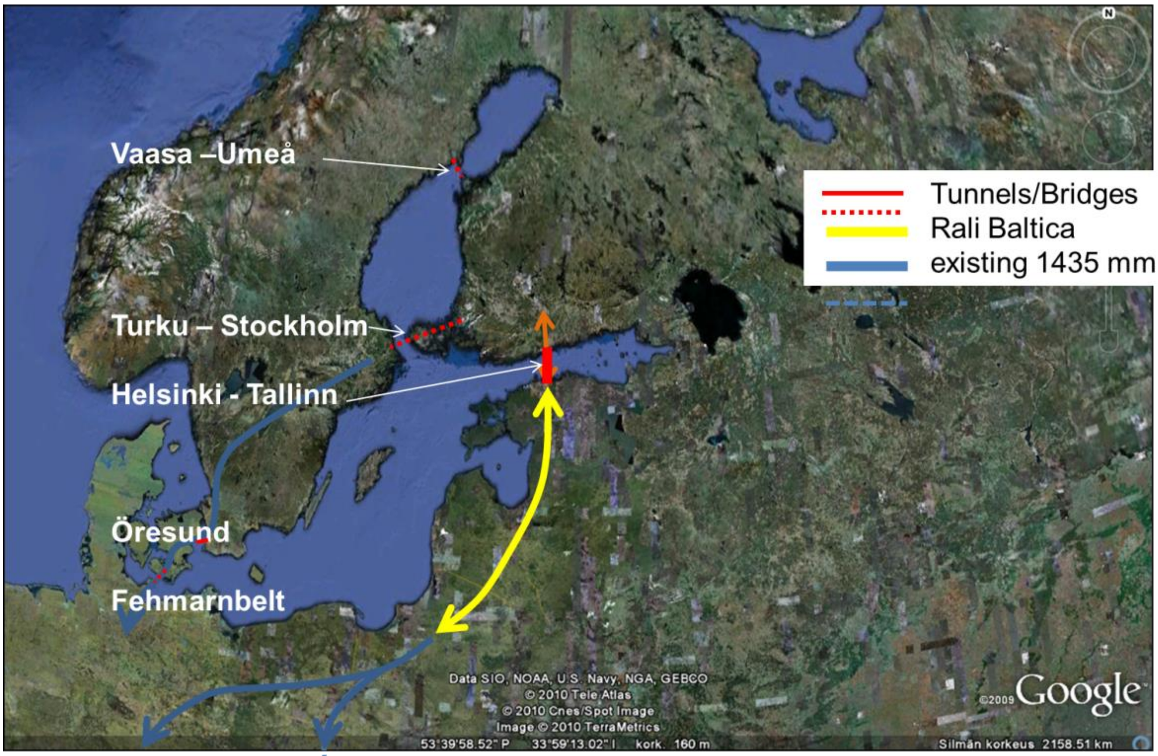
4. Tunnel and transportation alternatives

4.1 "Old" alternatives and options

This chapter includes a 'short review' of existing studies and ideas about a tunnel between Helsinki and Tallinn. A key finding is that former studies approach the case more from a technical perspective.

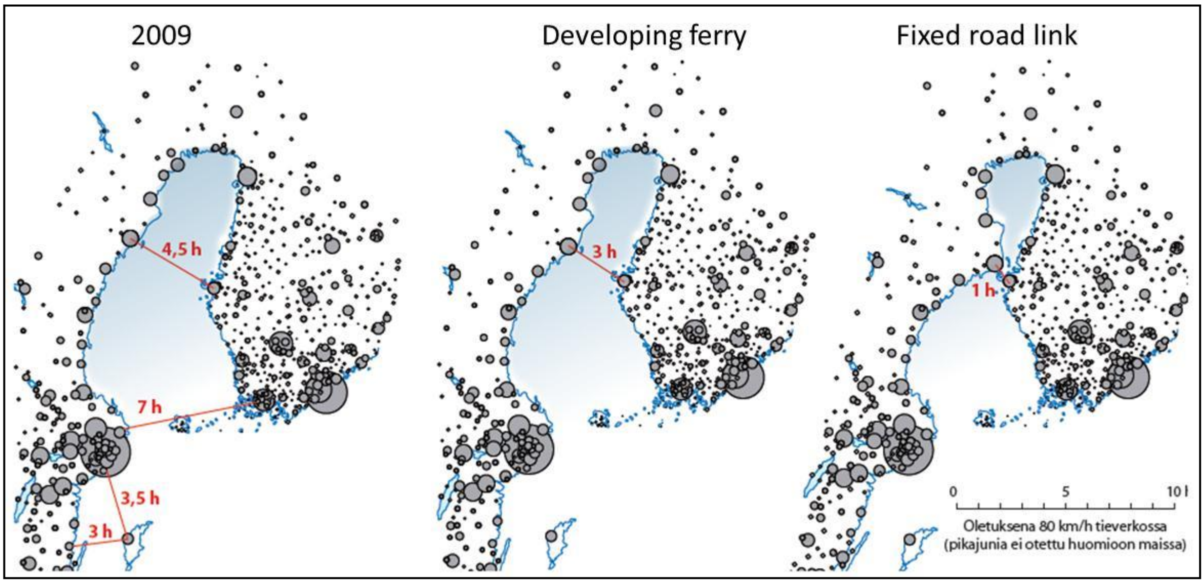
During the past fifty years many ideas have been presented concerning fixed links like the Turku–Stockholm combined tunnel and bridge, the Vaasa–Umeå tunnel/bridge and of course the Helsinki–Tallinn tunnel alternatives. Some preliminary studies have been performed, but serious planning and studies are missing.

Figure 7 Different fixed link ideas from previous studies



In the last study from 2009, based mainly on the border regional potential, the benefits of the Umeå–Vaasa fixed link for car traffic are estimated to cover approximately 30% of the investment. The figure shows that although the fixed connection brought great advantages to the society, it still has difficulties in finding socio-economical justification (45).

Figure 8 Different tunnel options for Finland



Some studies and impact estimates of the Helsinki–Tallinn fixed link idea were included in Rail Baltic projects. Even before that, Baltirail Association had been actively presenting the tunnel ideas. For the first time, the idea was probably presented by Usko Anttikoski. Some preliminary technical drafts of Anttikoski were presented in the years 1993…2008 in different articles of professional journals and in a preliminary feasibility assessment in 2007 (46).

4.2 Improved ferry traffic

As can be seen from the overview of the Øresund Bridge project, the main impact of the fixed link comes from the traffic of daily work and study related commuters. The key for this traffic segment is the speed of the connection. It is crucial for daily commuting to shorten the travel time between city centrums to 30–45 minutes, which is not possible by ferry.

As the time matters when having in mind integration goals and a twin-city concept, the ferry has not been considered as a real alternative to the fixed link and has therefore not been analysed further. Also, the authors of this study have identified analyses which focus on possibilities of improving the ferry link between Tallinn and Helsinki.

However, it is assumed in the financial model that ferry traffic will survive also after the fixed link is opened. This has been the case for both the Channel Tunnel and the Øresund Bridge[5]. Especially in the leisure passenger segment – which is the biggest segment today in Helsinki–Tallinn traffic – the ferry is expected to remain competitive.

[5] Although between Helsingør–Helsingorg and not on Malmö–Copenhagen line.

5. Transport System in Finland and the Baltics in the future

5.1 Background and goals

The basic idea is to connect the Helsinki–Tallinn fixed link to key public transport hubs in both counties. The main goals are:

- Minimize travel time in travel chains – travel time between cities is 30 minutes. Train operating 250 km/h;
- Cover maximum population and working places in both countries, large potential commuter population is covered under 1:00, 1:30 and 2:00 h total (return trip) travel time;

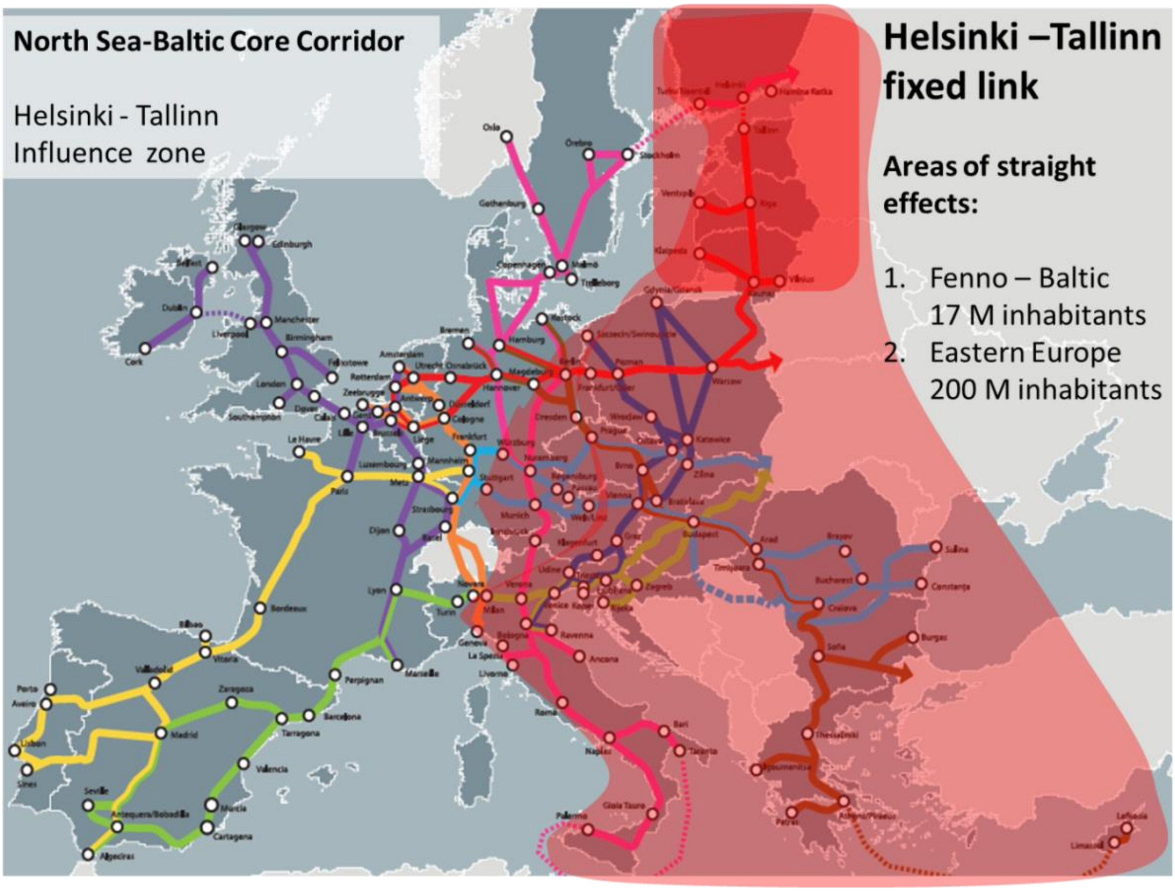
The population of Finland will grow by about 1 million inhabitants until 2080. The growth is located in the impact area of TALSINKIFIX in Southern Finland. The population of Estonia might decrease, but the population of Tallinn region may grow (see Table 1).

In Central Europe, environmental charges will be applied to car traffic and more transportation may transfer to trains.

The future salary growth will be higher in Estonia than in Finland, but in euro terms a considerable difference will remain for a long while. The cost of living in Estonia will remain lower than in Finland even if the costs in Estonia increase.

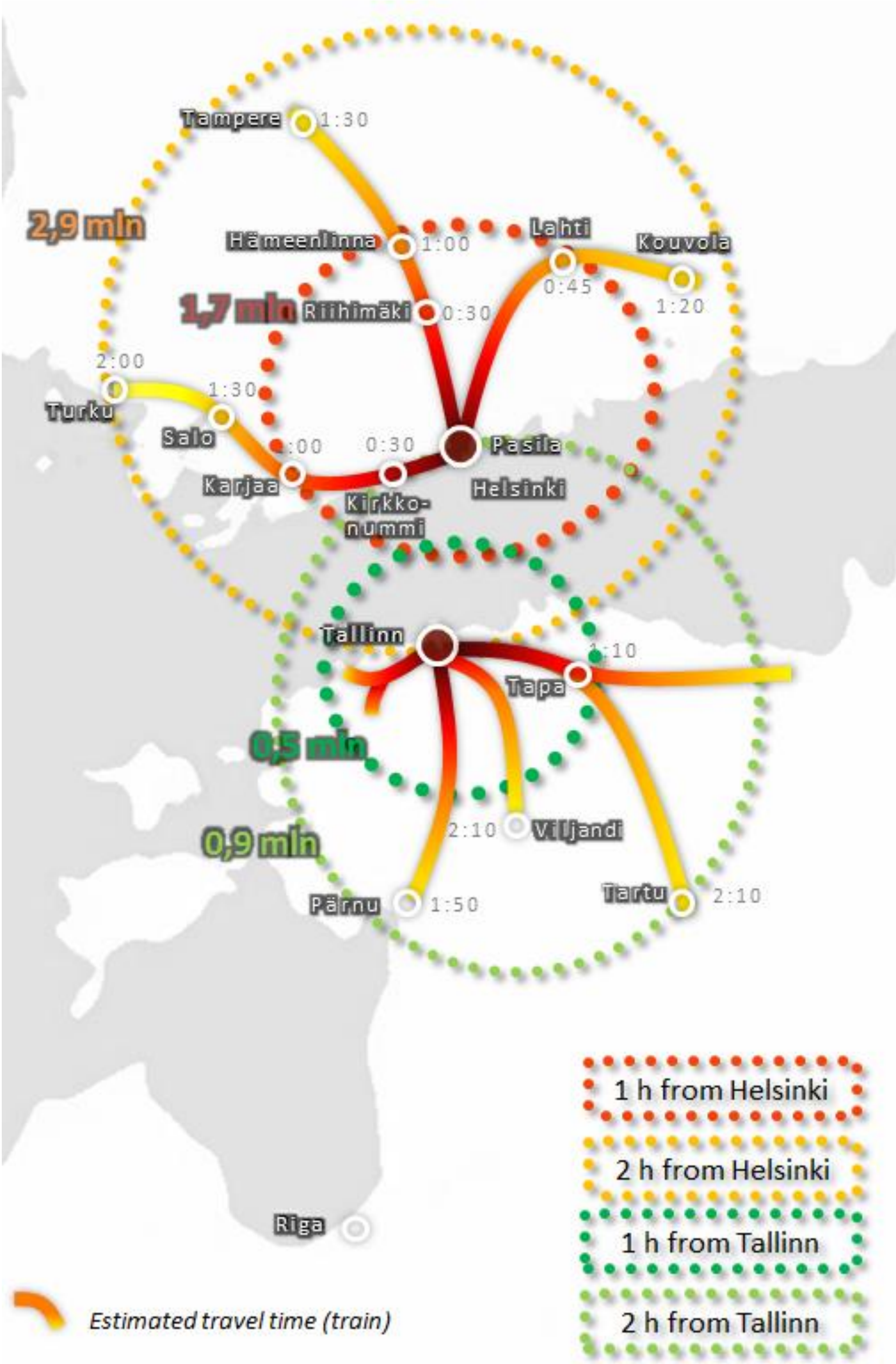
As 4–5 million inhabitants will be living in the commuting area of TALSINKIFIX, the area will be exposed to direct impacts. But the effects will be seen in the whole Fenno-Baltic zone of 17 million inhabitants. A cheaper and faster transport connection to Eastern Europe will improve the competitiveness of the Finnish economy (see Figure 9).

Figure 9 TALSINKIFIX influence zone



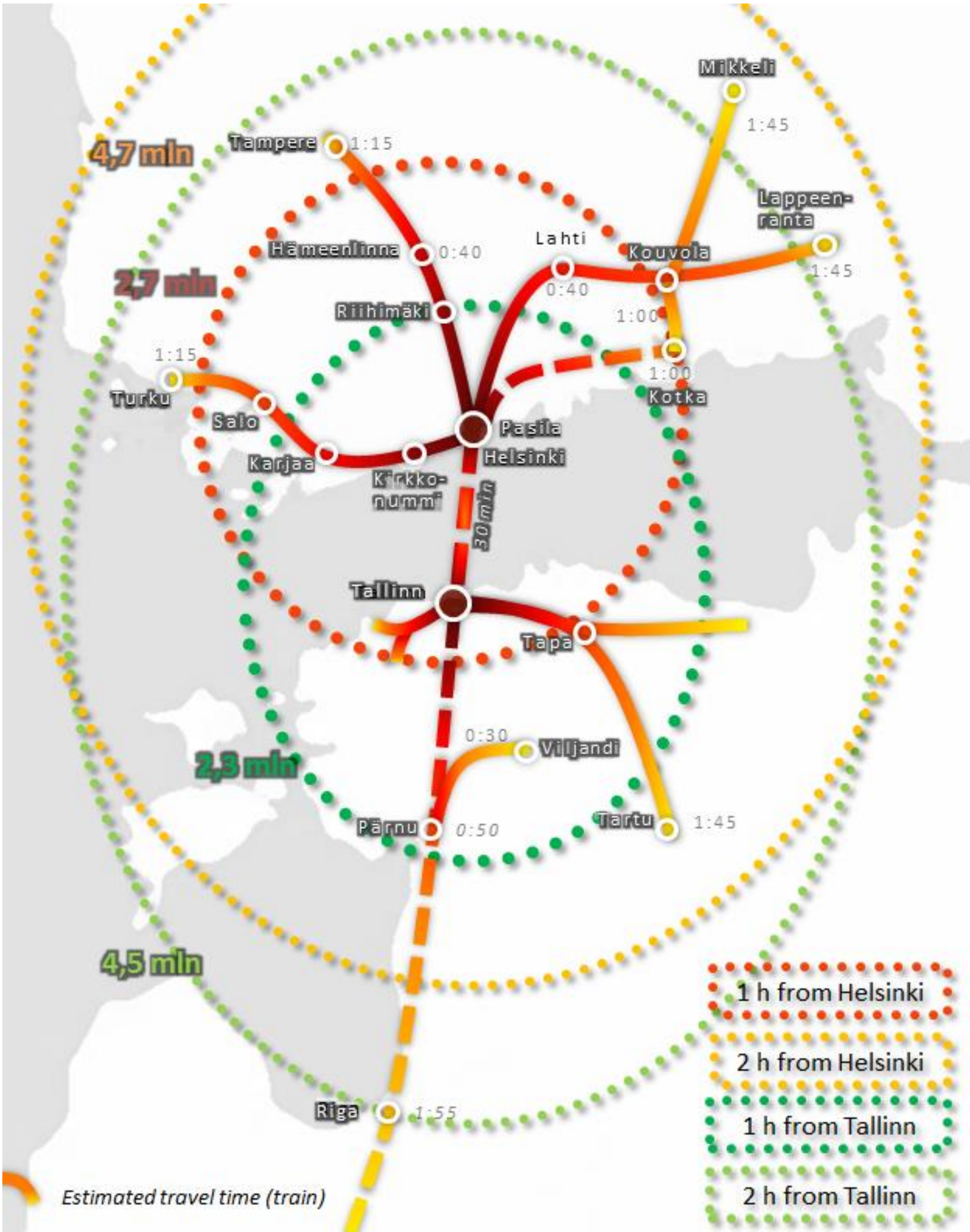
A short 30-minute travel time between Helsinki and Tallinn is about the same as the present travel time from Hyvinkää or Järvenpää to Helsinki by train. More than 30% of the work force in those regions has a job in the Helsinki Metropolitan Area. A transportation model and travel time in Southern Finland and Estonia for the current situation is presented in Figure 10.

Figure 10 Current travel time zones from Helsinki and from Tallinn, year 2014



The possible future transport model and travel times in Southern Finland and Estonia are presented in Figure 11.

Figure 11 Travel time zones from Helsinki and from Tallinn in the future with fix link



Based on: Ratahallintokeskus Strategioita ja selvityksiä 1/2009 Tulevaisuuden henkilöliikenneselvitys Rail Baltica

5.2 Transport scenarios

Passenger transport

The traffic prognosis for the tunnel is made on the basis of current traffic between Helsinki and Tallinn. Estimations are based on changes in passenger volumes in the past ten years. The increase in passenger volumes is assumed to continue until 2030 at the same level as in 2000–2013.

After the tunnel is built (presumably in 2030) the target travel time will be 30 minutes by train or shuttle. It is assumed, that daily commuting – as a new segment in Tallinn-Helsinki traffic – is going to face strong growth in the first ten years after the opening of the tunnel. This has been the case of Øresund fixed link (see section 6.2).

Table 7 Tallinn–Helsinki passenger traffic growth rates

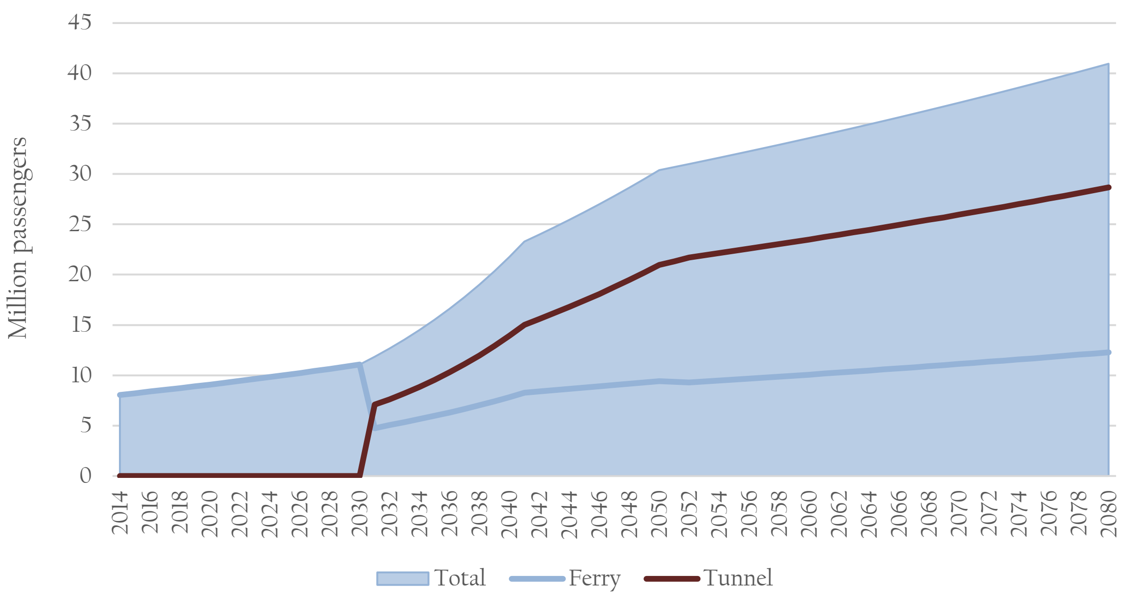
From	To	% a year
2003	2013	2.2
2014	2030	2.0
2031	2040	7.0
2041	2050	3.0
2051	2080	1.0

The growth is continuing due to the population and tourism overall growth and migration combined with commuting between Helsinki and Tallinn regions.

The total volume of passengers between Helsinki and Tallinn is estimated to grow from about 8 million passengers in 2013 to 41 million by 2080. Ultimately, about 10 trips a year per inhabitant will be made in the influence area of the tunnel. That is the same level as today in the impact area of the Øresund Bridge.

Commuting will have a substantive effect on the passenger forecast. Today, 60,000 Estonian are working in Finland (see section 3.1.). If this amount of people would daily commute (i.e. 40 trips a month, 11 months), more than 25 million trips a year would be made between Tallinn and Helsinki. The calculations include the assumption that 40,000 people are commuting in 2080. This is about 20% of the work force in the Tallinn area. Today, 20–60% of people in Harju County (from local authorities except Tallinn) work in the city of Tallinn. With the tunnel it is expected that Finns will also move to Tallinn and work in Helsinki – the pattern observed in the Øresund area.

Figure 12 Passenger traffic across the Gulf of Finland



The new short travel time offered by the tunnel will generate more than 50% of the estimated total passenger traffic. In the year 2030 there will be shortage of 400,000 employees in Finland (Source: Boston Consulting Group, 20.11.2014) and around half of this in the Helsinki region. It is possible that the commuting traffic will be much greater or increase faster than estimated. The crucial aspects are how fast and convenient access to the Helsinki region is, and what the fare is.

Cargo transport – unitised cargo

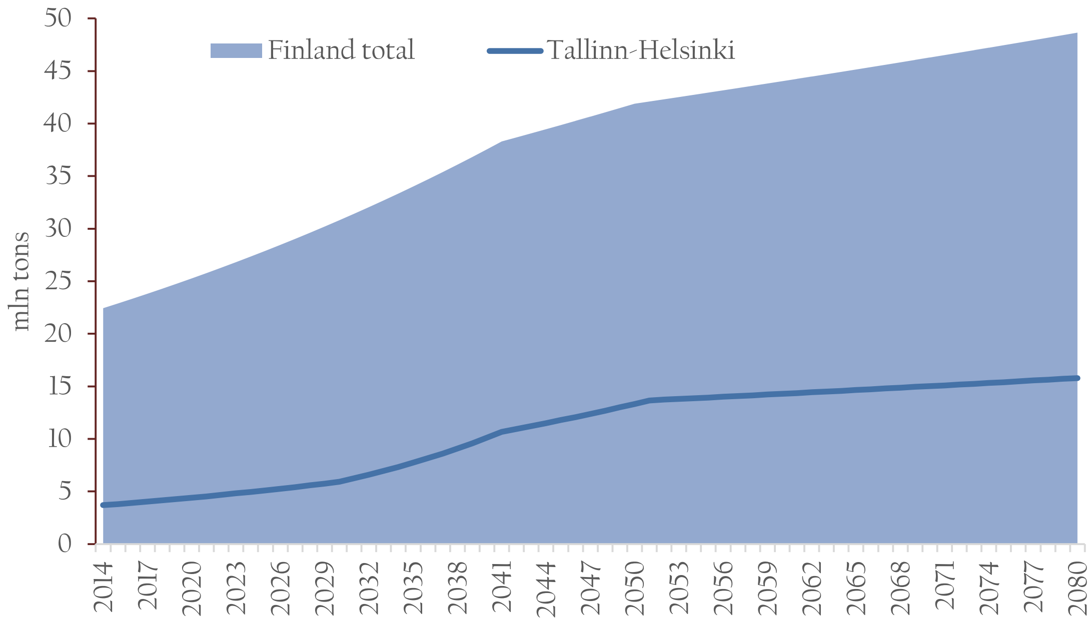
This forecast concerns unitised cargo transported to and from Finland using ferries today. The estimated increase in cargo transport between Tallinn and Helsinki is based on the historic growth seen in 2000–2014 and the expected growth of Finland's GDP and trade. The changes in sea transport on the Baltic Sea are considered in the growth potential. The Sulphur Directive and changes in Finnish production might change and redistribute transport flows.

A major change in sea and road transport in Central Europe in the unitised cargo segment is increasing the share of rail transport. It has been assumed that thanks to the improved rail link (Rail Baltic) the share of Helsinki–Tallinn route will increase from 12% in 2012 to 33% in 2050 (see Figure 13).

Table 8 Tallinn–Helsinki cargo traffic growth rates

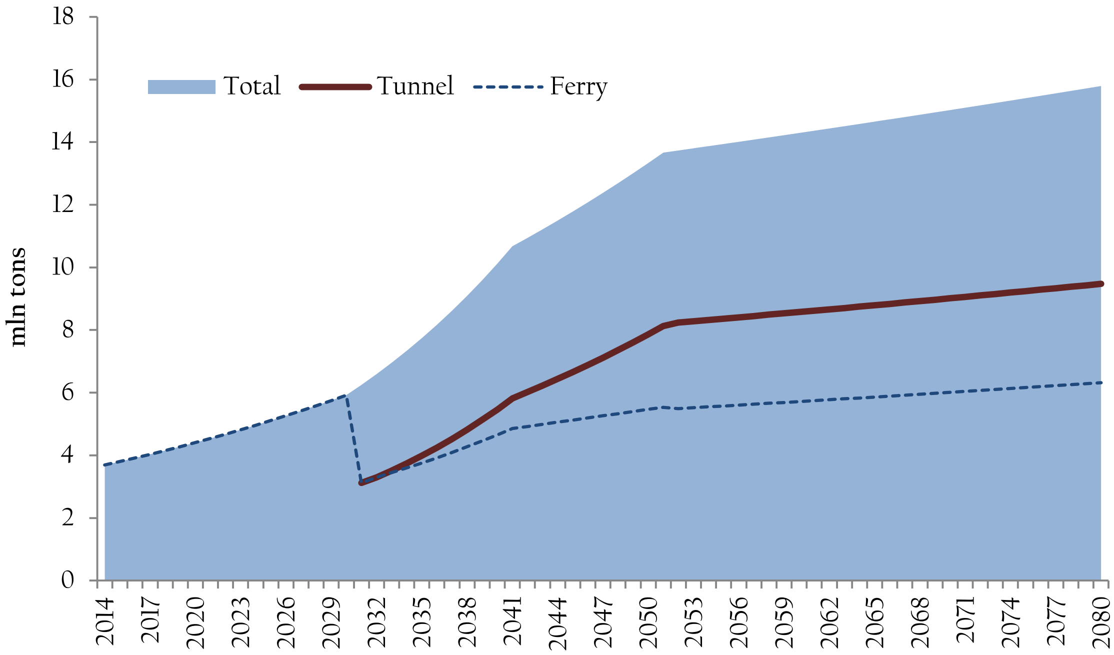
From	To	% a year
2003	2013	4.5
2014	2030	3
2031	2040	5.5
2041	2050	2.5
2051	2080	0.5

Figure 13 Finnish trade of unitised cargo and transportation via Tallinn–Helsinki route



Unitised cargo flows between Tallinn and Helsinki are expected to experience a strong growth in the first ten years after the opening of the tunnel (Table 8 Tallinn–Helsinki cargo traffic growth rates). The tunnel's expected gross market share of the gulf cargo traffic is assumed to be 60% by the 22th year after opening.

Figure 14 Cargo transport on Tallinn–Helsinki route by transportation mode

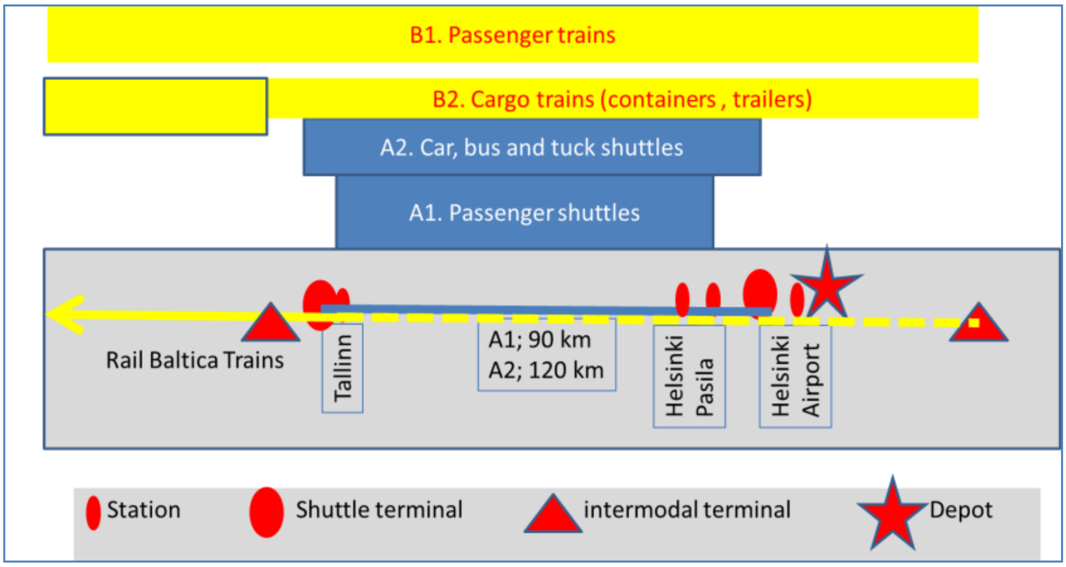


The estimated cargo transportation is mainly generated by the fast train transport offered by the tunnel. The volume of unitised cargo on ferries will increase by about 50%. It seems that all the additional increase will be thanks to the tunnel.

5.3 Technical goals

The rolling stock of tunnel transportation will be of speed shuttle type. The basic unit will comprise 2 locomotives and 8 carriages (plus possible loading and unloading carriages).

Figure 15 Tunnel length and shuttles types



The rails using the standard gauge in Finland have to run up to Riihimäki which will have an intermodal terminal for cargo transferred between euro-trains and Finnish trains or trucks. In Finland the terminals of passenger trains will be in the first phase: Helsinki city, Pasila, Helsinki-Vantaa Airport and Riihimäki.

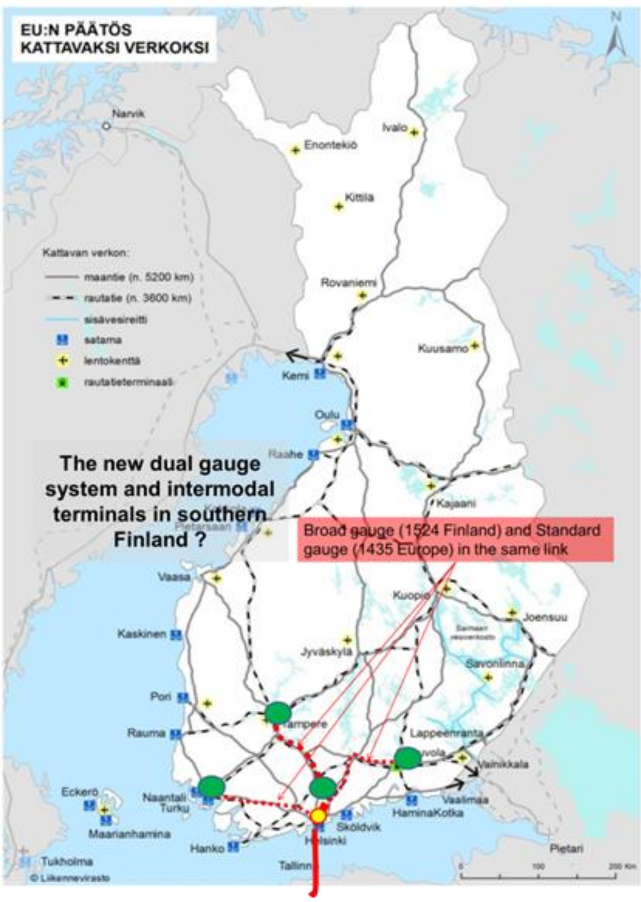
5.4 Integration to existing transport system

Commuters from Estonia to the Helsinki region seem to be the most important group of passengers. They will travel without a car and the most important reason for selecting the tunnel train is the short total travelling time. Interconnections from the tunnel to public transport services should be at the same level of quality on both sides in order to realize commuting and labor mobility potentials. Stations must be the best interchange stations in Helsinki and Tallinn.

Commuter shuttles will run from Tallinn Ülemiste station to Helsinki Pasila station. Pasila station has very good rail connections to locations all over the Helsinki region. If there will be another station under the Helsinki Railway Station, there would be useful connections to metro, trams and buses. In Ülemiste the new tram line will connect passengers to the city centre and Lennart Meri airport. Rail Baltic passenger terminal is located in Ülemiste and also local railway (to east and south directions) has a station there. Regional, long distance and international bus terminal is located less than 1 kilometre from Ülemiste and is easily reachable by tram.

Vehicle shuttles (car, bus and truck) are loaded and unloaded only at terminals located at Muuga in Estonia and around Ring III in Finland. Terminals are connected by main roads. Muuga terminal is close to Muuga Harbour (biggest cargo port in Estonia) and there will also be the Rail Baltic cargo terminal, where the cargo can be directed to the marine port, railway passing towards Russia or for local distribution.

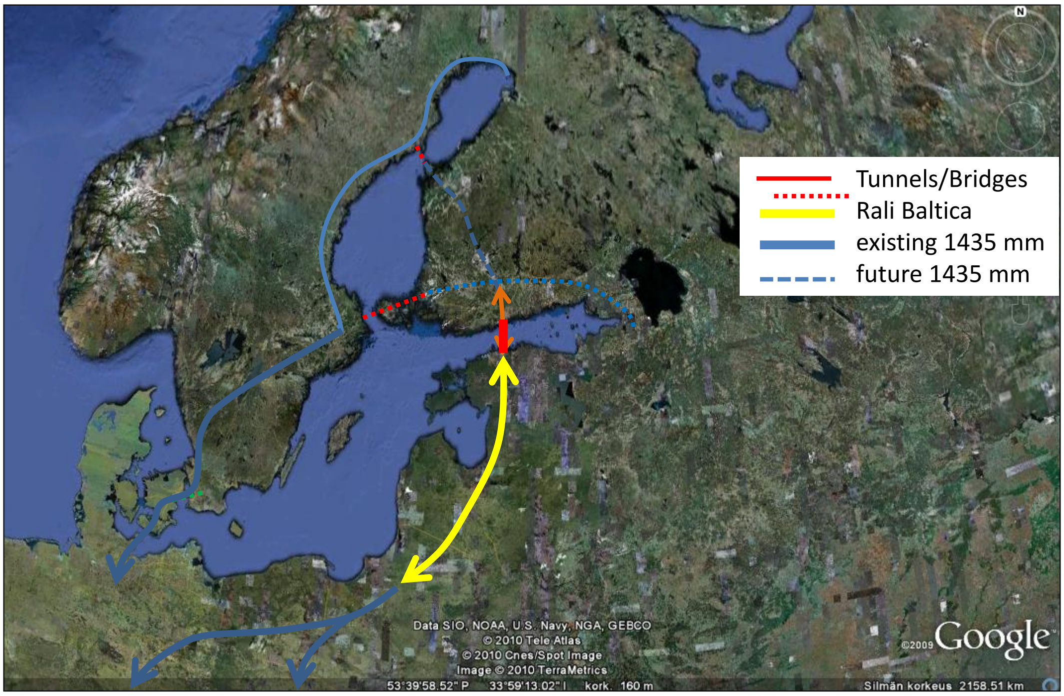
Figure 16 Possible new dual gauge systems in southern Finland



Passenger and cargo trains using the tunnel have access to the European rail network via Rail Baltica. In Finland the stations and connections to Finnish railways of passenger trains are in Helsinki main station, and at Pasila and Riihimäki. If good technical solutions are found, connections using the European gauge of 1435 mm will be continued to Tampere and maybe also to Turku and Kouvola.

In the future, it may be possible to connect the European standard rails through Finland to Sweden via Vaasa–Uumaja or Tornio–Haaparanta.

Figure 17 Railroad types and European gauge 1435 mm



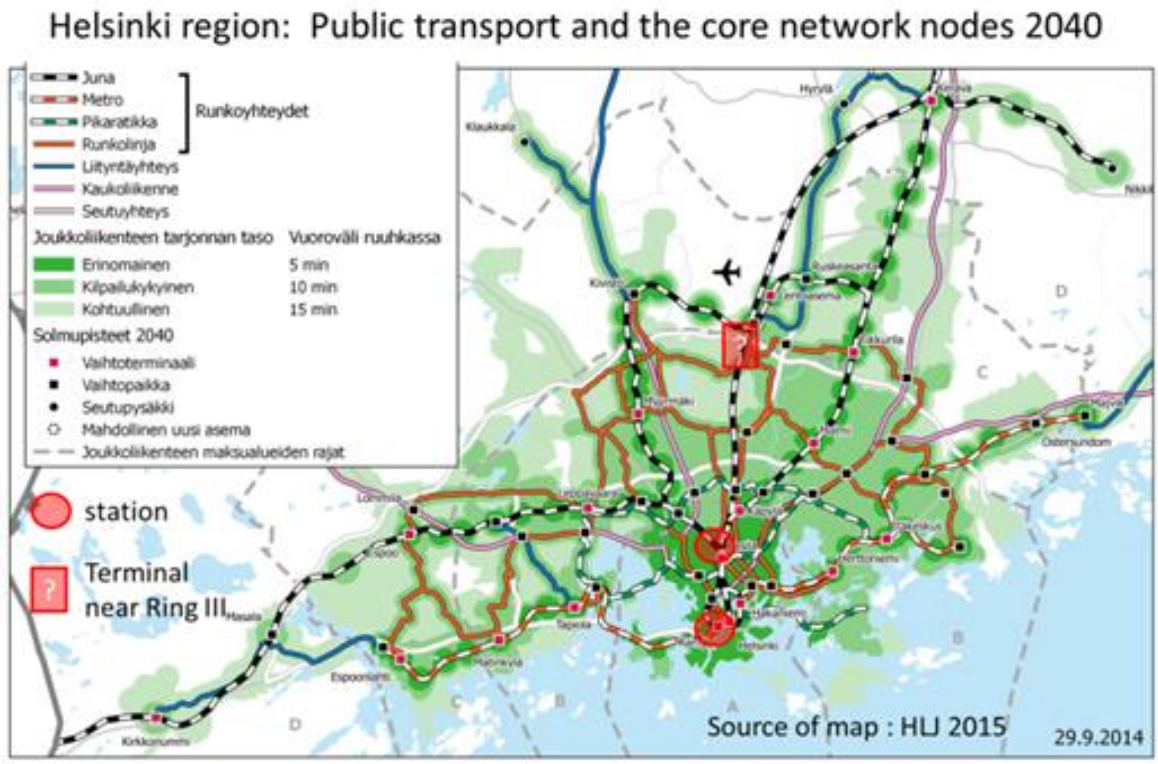
5.5 Stations, terminals, depots

Stations, terminals and depots for operation and connections to existing networks are:

- Passenger terminals (passenger shuttles):
  - In Tallinn: Ülemiste station
  - In Helsinki: Pasila Station, Main Railway Station
- Vehicle terminals (loading/unloading car, coach and truck shuttles):
  - In Tallinn, Muuga
  - In Helsinki, location between Pasila and Airport near Ring III (maybe Ring IV)
  - Terminal locations need further studies in the feasibility study phase
- Cargo: terminals:
  - In Estonia: Muuga Port,
  - In Finland: New logistic hub in Riihimäki or Hyvinkää.
  - Terminal location needs further studies in the feasibility study phase.

- Depots
    - In Estonia: Muuga
    - possible in Finland: Riihimäki
- On the Finnish side, the railway is connected to Lentoraide (Helsinki–Vantaa airport fast train connection) and to the main railway up to Riihimäki and possibly to Tampere or even Turku and Kouvola if technical solutions are found. Detailed technical solutions need further investigation in the feasibility study phase.

Figure 18 Possible stations, terminals (car, truck and buses) and depot locations in Finland



5.6 Project influence

Besides the direct effect of the improved transport connection – expressed mainly in reduced travel time, frequency of public transportation and costs – there are wider economic and social impacts which can be realised thanks due to the transportation links.

The need for and the impact of the TALSINKIFIX Tunnel can be determined on different regional levels:
- European (Core networks and Fenno-Baltic corridor)
- National (Finland, Estonia)
- Regional (Helsinki-Uusimaa, Harju county)
- Twin-City (Helsinki + Tallinn = Talsinki)

The following section is an elaboration of the potential benefits which may be created on different levels.

EU level

General need for transport connections

The EU New Transportation Infrastructure Policy states that *(41)*:

- Transport is fundamental to an efficient European economy.

- Growth needs trade. And trade needs transport. Areas of Europe without good connections are not going to prosper.
- Freight transport is expected to grow by 80% by 2050, and passenger transport by more than 50%.

Specific problems with transport network

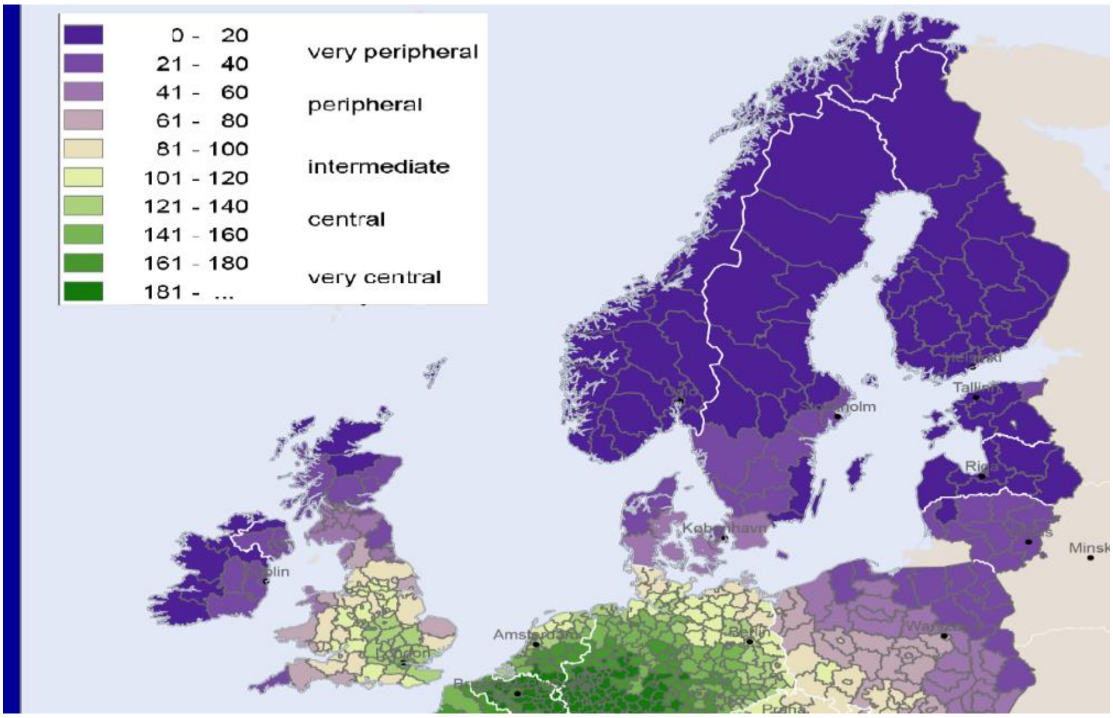
The EU New Transportation Infrastructure Policy states that *(41)*:

- Missing links, in particular at cross-border sections, are the major obstacle to the free movement of goods and passengers within and between the Member States and with its neighbours.
- There is a considerable disparity in quality and availability of infrastructure between and within the Member States (bottlenecks).
- Transport infrastructure between the transport modes is fragmented.
- Investments in transport infrastructure should contribute to achieve the goals of reduction of greenhouse gas emissions in transport by 60% by 2050.

Specific to TALSINKIFIX project

- Not only Estonia and Finland will benefit from the connection. There are also the countries in Central Europe (Germany, Poland, Czech Republic, Slovakia etc.), which can increase their competitiveness on the Finnish market and benefit from it.

Figure 19 Accessibility of regions by road, 2011



Source: ESPON(2011);

National level

Finland

- Poor accessibility to Central Europe (see Figure 19 and Figure 20) is obstructing the economic growth. Tunnel to Tallinn and Rail-Baltic will improve the situation.
- Spiekermann&Wegener (40) estimate a 1–3% increase of Finnish GDP, dependent on the region, thanks to the Tunnel by 2051[6]. Based on the level of

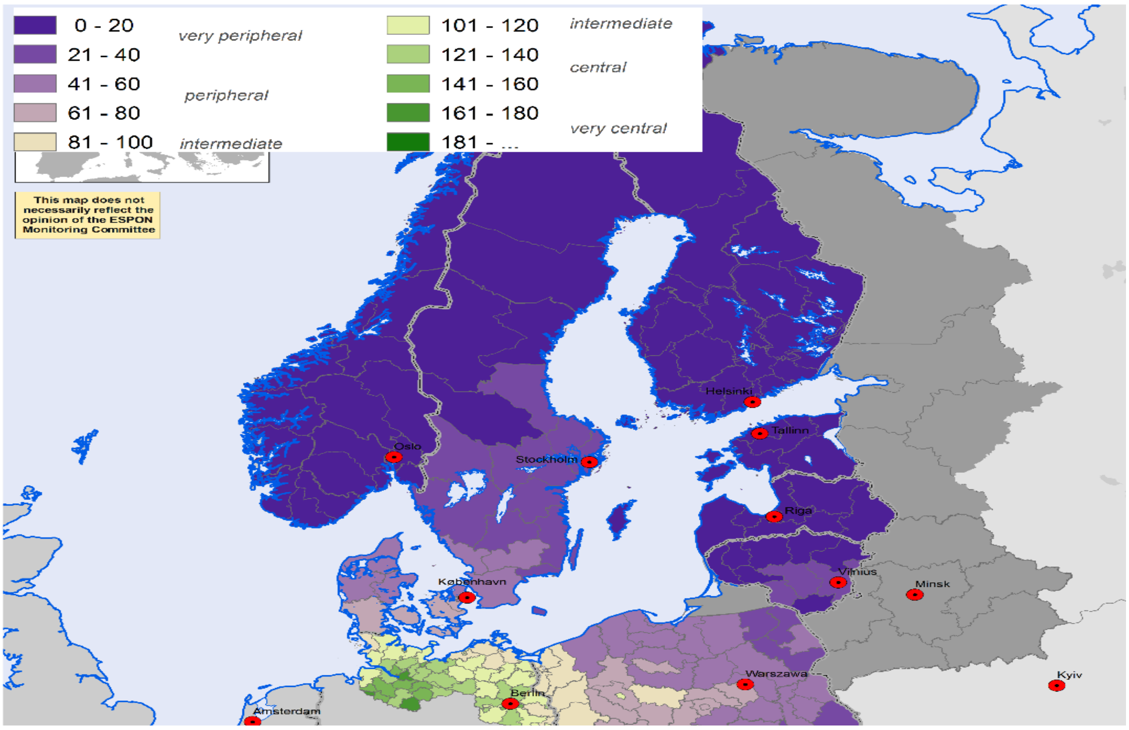
[6] Please refer also to chapter 9.2.

2013 (EUR 193 billion) this means approximately EUR 2–6 billion of additional GDP. This will generate substantial revenues for the public sector budget. In 2013, the general government revenues in Finland made up 55% of country's GDP (*source: Eurostat*).

Estonia

- Finland is the second biggest trade partner for Estonia today. Faster access will remove another barrier for trade and support the generation of additional volumes, diversification of the trade and the general economic integration, to use the strengths of both side (e.g. educated workforce).
- The Estonian business environment has an urgent need for improved air connectivity. This can be solved with Tunnel projects, supplemented by a fast link to Vantaa Airport.
- The Rail Baltic project was considered as a precondition for the Tunnel project in this analysis. However, it is not only that the Tunnel will benefit from Rail Baltic, but also *vice versa*. According to the estimate the share of Tallinn–Helsinki route in total Finnish external unitised cargo trade will increase from 20% before the opening of the Tunnel to 32% within 20 years after the opening of the Tunnel. Diverted (from ships) cargo volumes are about 5 million ton by that year (2053). According to AECOM's study[7] the access charge of Rail Baltic for freight trains is assumed to be EUR 5.9 per train kilometre. When assuming 600 tons cargo per train and a 700-kilometre distance, it can be estimated that every million ton of cargo generates EUR 7.5 million additional revenues for Rail Baltic in values of 2014[8]. **Thus the Tunnel project will potentially generate substantial additional revenues to Rail Baltic**, given that annual revenues from freight traffic were estimated at EUR 183 million (nominal 30 year average).

Figure 20 Accessibility by rail, 2011



Source: ESPON(2011);

[7] AECOM, page 254;
[8] It should be considered that part of the cargo will be taken by trucks;

Regional level

Together

- Improved opportunities for cooperation and sharing of resources especially in the areas of research and development. This is supported by the excellent education level of the countries: Estonia and Finland are at the top of the EU level when considering the share of people with higher education (Table 9). For example, after the fixed link to Copenhagen, the attractiveness of Malmö as a destination of life science, clean-tech, mobile media etc. investments have increased[9].
- Infrastructure development in the metropolitan areas of both cities can potentially get a boost and improve the business and living environment of the region. It is likely to boost the development of new business and residential areas. Malmo is a good example in this regard as well.
- Marine ports and airports in Copenhagen and Malmö also benefited from the cooperation after the opening of the fixed link. Ports and airports in Tallinn and Helsinki (Vantaa) could follow these success stories.

Specific to Helsinki-Uusimaa

- According to the studies, the Finnish labour market will have a labour shortage of approximately 400,000 by 2030. With a tunnel, the companies in the Helsinki area can get improved access to new, well educated work force.

Specific to Tallinn metropolitan area

- According to a study by the Confederation of Finnish Industries, many small and medium-sized Finnish companies are considering moving to Estonia[10]. With a faster access the attractiveness of Estonia as a business location will increase, generating new investments and jobs.
- Establishing logistic/distribution centres close to the Tunnel's truck shuttle terminal could serve as a basis for providing goods to the South-Finnish market. Preconditions would be good: cheaper land and labour, a fast connection.
- The real estate market and spatial development are expected to get a boost from the fixed link. Transportation connections have a positive impact on the number of inhabitants. According to Eurostat's projections, the population of Estonian will shrink to nearly 1 million by 2080. The example of Malmö shows that improved connectivity can help increase the population.
- Congestion in the city centre of Tallinn will be reduced; today, most trucks use passenger ferries to travel to and from Helsinki and depart from the Old City Harbour. Trucks will also have a faster access to the terminal when it is located at Muuga Port instead of the Old City Harbour.

Table 9 Population aged 25-64 with tertiary education in 2013

Country/Region	% of total
European Union (28 countries)	28.5
European Union (15 countries)	30.0
Estonia	38.4
Finland	40.5
Denmark	35.4
Sweden	37.0

Source: Eurostat

[9] See http://www.malmobusiness.com/sites/default/files/filearchive/trade_industry.pdf
[10] A study conducted in September 2012 revealed that 18% of Finnish SMEs consider it possible to move to Estonia.

It is also important to note that the improved connection will only create preconditions for development and integration. It will largely depend on policy makers at both local (cities) and central level how well the potential of the connection will be realised. There is a good example from Øresund and a slightly more mediocre one from the English Channel (see conclusions in sections 6.1. and 6.2.).

6. Benchmarking

6.1 Channel tunnel

The tunnel over the English Channel – **the Eurotunnel** or **the Channel Tunnel** – would be the best benchmarking example for a tunnel only with railway functionality, including a shuttle service for cars and trucks.

Channel Tunnel in short

Opening for traffic	**June 1994 – freight train** **July 1994 – truck shuttle** **Nov 1994 – Eurostar service** **Dec 1994 – car shuttle**
Investment cost	ca 15 billion euros
Length: coast to coast Length: terminal to terminal	37.9 km 50.5 km
Functionality	1+1 rail + service tunnel
Intermediate impact regions	Kent (UK) Pas-de-Calais (FR)
"Actual" impact areas	**London, Lille, Brussels, Paris**

Concession agreement

The Treaty of Canterbury, signed by British Prime Minister Margaret Thatcher and French President François Mitterrand on 12 February 1986, prepared the Concession for the construction and operation of the Fixed Link by privately owned companies. The Intergovernmental Commission was set up for monitoring the construction and operation of the Tunnel on behalf of both governments.

The signing of the Concession Agreement followed on 14 March 1986. The governments entrusted the consortia of France-Manche and the Channel Tunnel Group (jointly established Eurotunnel Group SA) with the construction, financing and operation of the Channel Tunnel for a period of 55 years. As a consequence of the first financial restructuring, the Concession was extended to 2086 in December 1997.

Services

The construction of the tunnel began in December 1987 and operation started in the middle of 1994.

Traffic through the Channel Tunnel falls into three distinct categories:

- The shuttle service (le Shuttle) between Folkestone and Calais.
- Passengers without vehicles use the Eurostar service.
- Train freight service provided by independent operators.

Eurotunnel Group SA, a company listed on the stock exchanges of Paris and London, is responsible for the infrastructure management and operation of the shuttle services.

Eurostar provides daily connections between London, Paris and Brussels with intermediate stops at stations such as Stratford, Ebbsfleet, Ashford, Calais and Lille. London and Paris have a direct rail connection of just 2 hours 15 minutes and London-Brussels 2 hours.

Traffic

There are about 20 **passenger train** calls a day between London and Paris and 10 calls a day between London and Brussels in each direction. The passenger number of Eurostar exceeded 10 million first time in 2013 (see Table 10).

The passenger **car shuttle**, with up to 4 departures (each direction) an hour, has a travel time of 35 minutes between Folkestone (UK) and Coquelles (FR) terminals. The shuttles travel at a speed of 140 km/h (nearly 90 mph) and are capable of transporting 120 cars and 12 coaches each.

The market share of the tunnel in passenger traffic has grown from 47% in 2005 to 57% in 2013. The total passenger traffic across the English Channel has increased only by 8.5% in 2005–2013, to **36.1 million**, whereas the Tunnel traffic increased by 30.5% (see Table 10) and ferry traffic decreased by 11.1%. This is still well below the historical high with close to 40 million passengers in 1998. (5) In 1994, the year the tunnel was opened[11], passenger flow across the Channel was 24 million people.

Table 10 Eurotunnel traffic in 2005–2013

	Truck shuttle		Passenger shuttle		Train services			
Position	Trucks	Freight	Cars	Passengers	Eurostar passengers	Train freight	Total passengers	Total freight
Unit	*mill*	*mill tons*	*mill*	*mill*	*mill*	*mill tons*	*mill*	*mill tons*
2005	1.31	17.0	2.05	8.2	7.5	1.60	**15.7**	**18.6**
2007	1.41	18.4	2.14	7.9	8.3	1.21	**16.2**	**19.6**
2010	1.09	14.2	2.13	7.5	9.5	1.13	**17.0**	**15.3**
2013	1.36	17.7	2.48	10.3	10.1	1.36	**20.4**	**19.1**
2013/2005	4.1%	4.1%	21.2%	25.6%	35.9%	–15.0%	30.5%	2.5%

Source: Eurotunnel Group;

The **truck shuttle** service is open 24 hours a day, 365 days a year. A shuttle train, capable of transporting up to 32 trucks, leaves every 10–15 minutes, depending on the volume of traffic, with no need to book. The market share of the Eurotunnel in truck traffic was 37% in the first 9 months of 2014. (10)

2,547 **freight trains** crossed the Channel Tunnel in 2013 (with 1.4 million tonnes of freight on board), which is a 10% increase compared to 2012. Rail freight service is provided by rail operators DB Schenker on behalf of BRB, the SNCF and its subsidiaries and Europorte (owned by Eurotunnel Group). As can be seen in Table 10, over 90% of the freight is carried by trucks (and truck shuttle).

Regional impact

In 2012, Canterbury Christ Church University analysed the impact of the Channel Tunnel on the immediate regions: the Kent County in UK (1.7 million inhabitants in 2011) and Nord-Pas-de-Calais in France (4.1 million inhabitants in 2010).

Hopes: Both regions have shown relatively poor socio-economic performance in the EU within UK and France respectively (see also Table 11) and in the early 1990s there were high hopes that the construction of the Channel Tunnel and its associated rail infrastructure would become a catalyst for regional economic growth.

[11] Passenger service was launched at the end of 1994;

Table 11 Regional GDP per capita relative to the average for the EU 15

In percentage of EU15	1986	1996	2008
France	109.8	103.9	96.0
Île-de-France (the Paris Region)	162.4	159.9	151.1
Nord-Pas-de-Calais	**88.2**	**85.4**	**78.1**
UK	98.6	99.8	103.2
South-eastern England	116.1	117.8	134.4
Greater London	147.5	140.4	177.0
Kent	**86.4**	**91.8**	**83.5**

Source: Canterbury Christ Church University, 2012

The conclusions from the study performed by the scientists of the Canterbury University in 2012 (4) regarding the impact of the Channel Tunnel specifically from the regional perspective were as follows:

- Being one of the largest engineering projects of the twentieth century, the Channel Tunnel also became a powerful symbol of integration and a pointer towards a European future without borders.
- The Channel Tunnel is only one of the means by which the Channel can be crossed and its overall impacts have been both more limited and less universally positive than had been anticipated.
- For a variety of reasons, the Channel Tunnel has not displaced the ferries but instead operates alongside them, as one element in a mixed system of cross-Channel provision.
- The English Channel still represents a significant physical and cultural and psychological barrier.
- The overall impact of the Channel Tunnel on the regional economies of Kent and Nord-Pas-de-Calais has been quite limited (see also Table 12).
- Spatial inequalities seem to have been reinforced by the high-speed rail system, as indeed was predicted in the academic literature.
- While the Channel Tunnel terminals are located in Eastern Kent and in the coastal zone of Nord-Pas-de-Calais, these immediate areas appear to have gained relatively little. One exception appears to be the Ashford district, which has benefited from faster connection to London.

Table 12 Selected growth indicators for selected regions in England

	Total population			Number of business enterprises		
	1995	2010	*change*	2004	2009	*change*
England	48,384	52,234	8.0%	1,885,265	2,040,150	8.2%
South-East	7,763	8,523	9.8%	353,770	375,595	6.2%
Kent and Medway	1,535	1,684	9.7%	59,755	63,420	6.1%
Ashford	**95**	**116**	***21.5%***	**4,875**	**5,400**	***10.8%***

Source: Canterbury Christs Church University, 2012

- The Channel Tunnel system has undoubtedly had a significant impact on Western Europe's changing geography, though evidence of its impact can be found just as much in locations such as the Olympic Park in East London or in Lille as in Kent or Nord-Pas-de-Calais.

Financial performance

“Not a public penny”: that was the imperative condition set by Margaret Thatcher when she approved the re-launch of the Channel Tunnel project in 1986. The cross-Channel Fixed Link was therefore entirely built with private funds. (6)

The Tunnel project exceeded the planned investment cost by 2 times and strongly underperformed the traffic forecasts:

- **Investment costs** (in 1994 values): Forecast costs of the tunnel – 7.5 billion euros, actual costs – 15 billion euros.
- **Passenger traffic** in 2008: projected in 1994 – 40 million passengers, actual – 16.1 million passengers.
- **Freight traffic** in 2008: projected in 1994 – 40 million tons, actual – 15.5 million tons (5)

One of the reasons for the underperformance of traffic is unexpectedly strong competition from ferries.

Since it won the bid to operate and build the tunnel in 1986, Eurotunnel has had several debt restructurings. The ultimate debt restructuring, which more than halved its £6.2bn (EUR 9.3bn) in borrowings, was sealed by a Paris court on 15 January 2007. (9) At the end of 2013, Eurotunnel Group’s debt burden was ca 3.9 billion euros.

Starting from 2009, i.e. 15 years after opening the Tunnel, Eurotunnel Group has been in a position to pay dividends to its shareholders. Today the company’s performance is rather good. In the first 9 months of 2014 the cross-Channel market increased by 7%. In 2015 the Tunnel will further benefit from environmental regulations imposed on ferries.

Table 13 Eurotunnel Group: Fixed Link Concession segment

€ million	2012	2013	*Change*
Shuttle Services	470	477	1.5%
Railway Network	280	289	3.2%
Other revenue	13	13	0.0%
Revenue	**763**	**779**	2.1%
External operating costs	−184	−182	−1.1%
Employee benefits expense	−149	−145	−2.7%
Operating costs	**−333**	**−327**	−1.8%
Operating margin (EBITDA)	**430**	**452**	5.1%
EBITDA(*)/revenue	56.2%	58.0%	

Source: Group Eurotunnel SA (8)

In 2013, the total revenue of Eurotunnel Group was EUR 1.1 billion, 71% of which was attributed to the fixed link segment. Eurotunnel Group’s direct employment effect was 3,744 jobs in 2013, of which 2,324 were attributed to the fixed link operations.

Overall conclusions

Besides the conclusions described in the study of the Canterbury University, the following can be derived from the Channel Tunnel project:

- For the TALSINKIFIX project, the Channel Tunnel project is a good example of a railway tunnel with shuttle services.
- The ‘build, finance and operate’ public private partnership (PPP) model was used for the project. No public funding was spent on construction. The Tunnel operator – Eurotunnel Group SA – is also responsible for the shuttle services (both trucks and cars). Passenger trains (between London and

Paris/Brussels) are operated by Eurostar. Several companies operate freight trains, including Eurporte, a subsidiary of Eurotunnel Group.

- Unlikely the Øresund region in Denmark and Sweden (see the next chapter), the Channel fixed link had a marginal impact on the integration of the regions in the immediate vicinity of the link – Kent in the UK and Nord-Pas-de-Calais in France. It is said that the "real" Tunnel entry is 100 or 150 km farther from its physical entry. It is said that one of the reasons was poor cooperation between regional authorities and the Project Company in the planning phase.
- The regional winner in France is Lille, regional capital (1.2 million inhabitants), which became a strategic location at the middle of the London-Brussels-Paris triangle. The City of Ashford has benefited the most in the UK, as the project has made it possible to commute from there to London.
- Political reasoning: the European Parliament saw the Tunnel as an instrument that would lead to greater unification between Europe and the United Kingdom. Reality: many British citizens still remain far from enthusiastic supporters towards the ideas that underpin the European Union, e.g. attitude towards the single European currency; discussions about the UK leaving the EU are getting more heated.(10)
- Considerable forecasting errors – both investment costs and traffic projections – indicate the importance of the planning process. "The political process was too long and the technical one was too short". This would be an important learning point for the TALSINKIFIX project as well.
- Given the technical challenges and the size of the investments some argue that funding from public sources would have been a better solution for the Tunnel. Several financial restructurings have also had an impact on the possible socio-economic outcomes of the fixed link.

6.2 Øresund Bridge

For benchmarking purposes the Øresund fixed link **(the Bridge)** connecting Copenhagen and Malmö is the best example when having in mind a connection between two major cities and a twin-city concept.

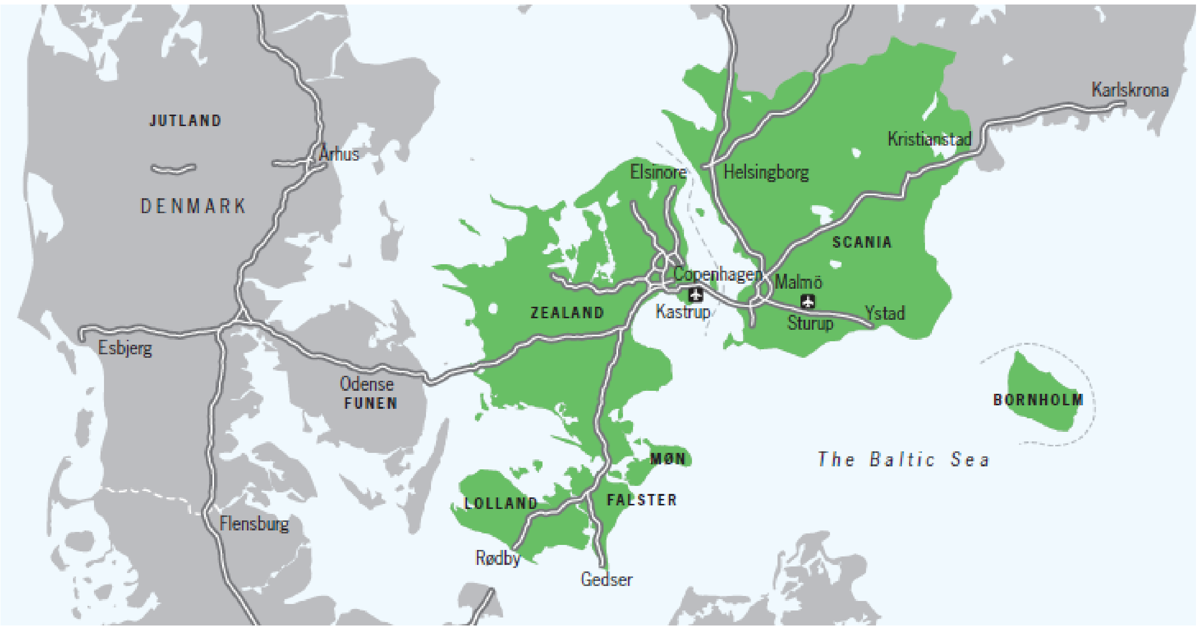
Øresund Bridge in short

Opening	**July 2000**
Investment cost	**ca 4.0 billion euros (in 2000 prices)**
Length	**ca 16 km**
Functionality	**2+2 road 1+1 rail**
Local catchment area	**Copenhagen city (710,000 inhabitants) Malmö (303,000 inhabitants)**
Regional catchment area	**Øresund region (3.9 million inhabitants)**

Since the passenger traffic of the Bridge is largely made up of inhabitants of the immediate regions, the link is also considered as a regional connection between Zealand in Denmark and Skane in Sweden, together forming the so-called Øresund region of today.

"At the beginning, the bridge was a politically-driven vision which didn't mean much to the average person. But gradually, people began to see the new opportunities that the region could offer in terms of study programmes, jobs, housing, business and much more." Ilmar Reepalu, Mayor of Malmö City in 1994–2013 (11, p 14)

Figure 21 Øresund region



The regional catchment area – the Øresund region – has about 4 million inhabitants, 1.4 million in Sweden and 2.6 million in Denmark. The region consists of 8 counties on NUTS3 level, 6 on the side of Denmark and 2 in Sweden (see Table 14).

Table 14 Population of Øresund region in 2012

Region NUTS2	Population (th)	Region NUTS3	Population (th)
Sweden: South-Sweden (Sydsverige)	1,410.7	– Skåne County	1,258.0
		– Blekinge County	152.5
Denmark: Hovedstaden Region	1,723.3	– City of Copenhagen	710.3
		– Copenhagen region	523.1
		– Nordsjælland	448.6
		– Bornholm	41.1
Denmark: Zealand (Sjælland)	817.1	– Ostsjælland	236.9
		– Western and Southern Zealand	580.2
TOTAL			**3,951.1**

Source: Eurostat

"68 percent of Zealanders and 44 percent of Scanians have family, friends or colleagues across the waterway. In other words, the Øresund Region has become part of daily life for many as Danes and Swedes become ever closer." (11)

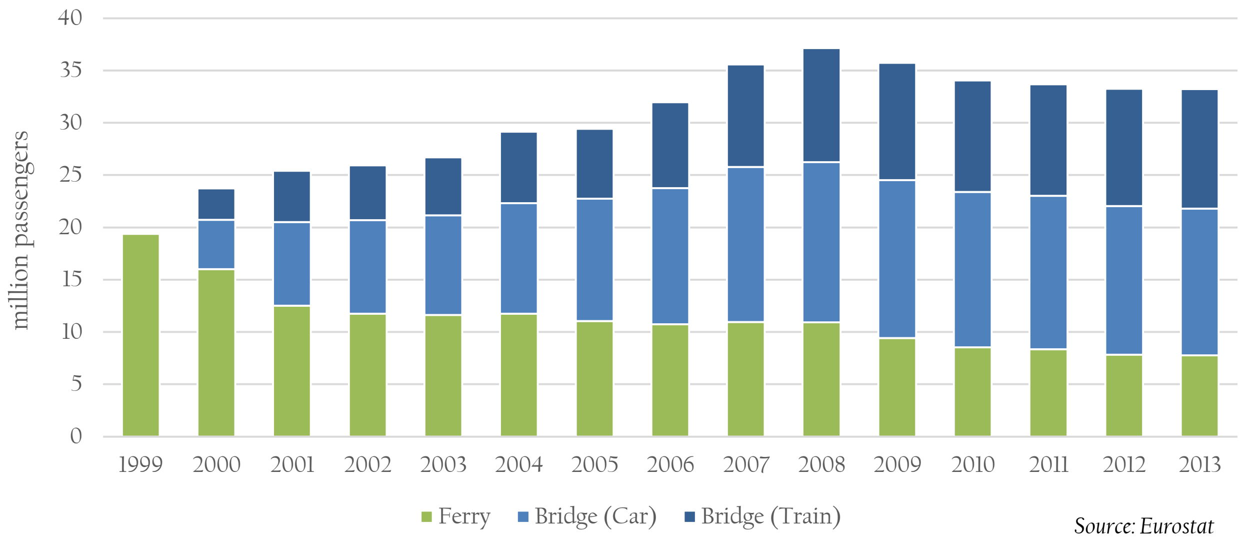
Traffic

Passenger traffic over the Øresund Strait, when considering all modes of transportation (fixed link and ferry), grew to 37.1 million people by 2009, i.e. by 92% when compared to 1999. However, due to the economic slowdown, the traffic decreased thereafter and in 2013 the number of passengers passing the Strait was 33.2 million (see Figure 22).

The market share of the fixed link in passenger traffic has increased from 51% in 2001 to 77% in 2013. The highest level of passenger flow over the fixed link was achieved in 2009 with 26.9 million people crossing the Strait. In 2013 the flow was 26.6 million people. By 2013, the traffic, both in terms of people and vehicles, had not fully recovered from the economic downturn.

About 60% of the passengers use cars (incl. also coaches, motorcycles, vans, trucks) for crossing and 40% use the train. The proportion was relatively stable until 2011, after which the share of trains jumped to 44% in two years (40.8% in 2011).

Figure 22 Passenger traffic of the Øresund Bridge in 1999–2013



Source: Eurostat

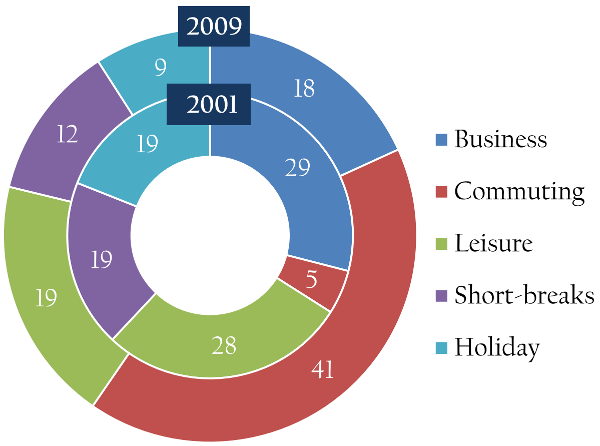
About 90% of the passenger train journeys are regional and 80% of the passengers are residents of Sweden. (11) The majority (60%) of the train passengers are commuters and 95% of them live in Sweden. This structure of traffic also causes higher loads of rush-hour traffic in the morning towards Copenhagen and in the evening when moving back to Malmö.

Until 2010, the commuters drove the traffic growth (see Figure 23). The highest estimated number of everyday commuters was 20,400 people in 2010 (2,800 in 1999). More than half of the commuters are Danes who have chosen to live on the Swedish side and who have kept their jobs on the Danish side. (13) However, in 2010–2013 commuting by car fell by 21% as a result of increased unemployment in Denmark, weaker Danish krona and fallen Danish house prices.

Commuting has been driven by differences in property prices and salaries between the Danish and the Swedish side. In 2007, nearly 80% of the commuters were in the 25–44 age group. Two thirds of the commuters mentioned higher salary as their reason for commuting. Better job opportunities within the commuters' professional area was the second most frequently cited reason. (11, p 21).

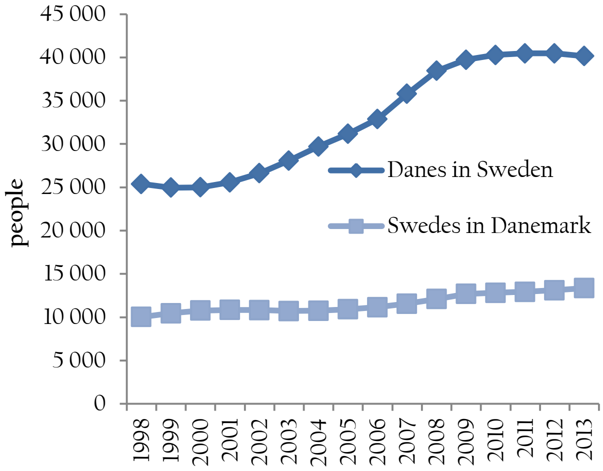
Approximately 25,000 Danes currently live in Skane. According to Eurostat, the number of Danes living in Sweden increased by 15,200 in 1999–2013, from 25,000 to 40,200 (see Figure 24). The increase stopped in 2009 – the same year in which the fixed link traffic stopped to increase. In the same period the number of Swedes in Denmark increased only by 2,900 people, to 13,360.

Figure 23 Structure of the car passenger traffic of the Öresund fixed link in 2001 and 2009



Source: Öresundsbron

Figure 24 Number of Swedes and Danes living in neighbouring country

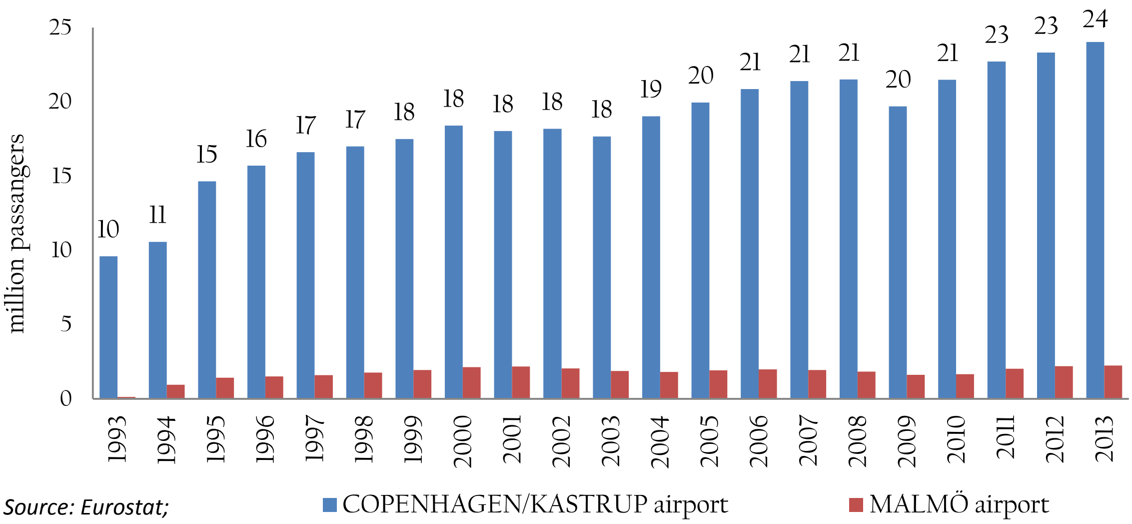


Source: Eurostat;

Copenhagen's Kastrup Airport is today considered as Sweden's second largest departure airport. In 2011, a total of 3.8 million Swedes used Kastrup Airport as departure airport (1.0 million in 1998).This corresponds to a total of 17 percent of all passengers departing from Kastrup (13). According to the pessimistic scenario the Kastrup Airport would have lost its status as a Nordic hub without Øresund Bridge.

The traffic of the Malmö Airport has remained relatively stable in the period after the bridge was opened - around 2 million passengers annually in 2000-2013 (see Figure 25).

Figure 25 Passenger figures of Copenhagen and Malmö airports in 1993–2013



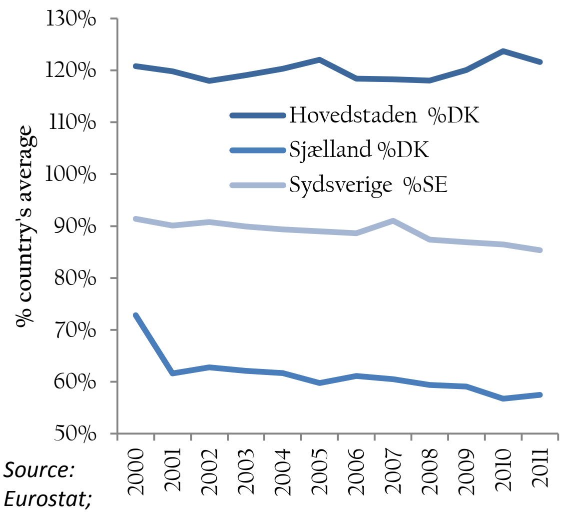
Source: Eurostat;

Economy

The estimated impact of the Øresund fixed link through commuting and reduced travel costs was **EUR 7.7 billion** from 2000 to 2012. Of this, EUR 5.8 billion accounts for Swedes working in Denmark; 8,800 Swedes commuted to work in Zealand in 2010. The average added value per employee on the Danish labour market was EUR 80,605 a year. The total value of the saved travel time and lower monetary travel costs for all travellers amounted to EUR 1.9 billion in the period 2000–2012. (13)

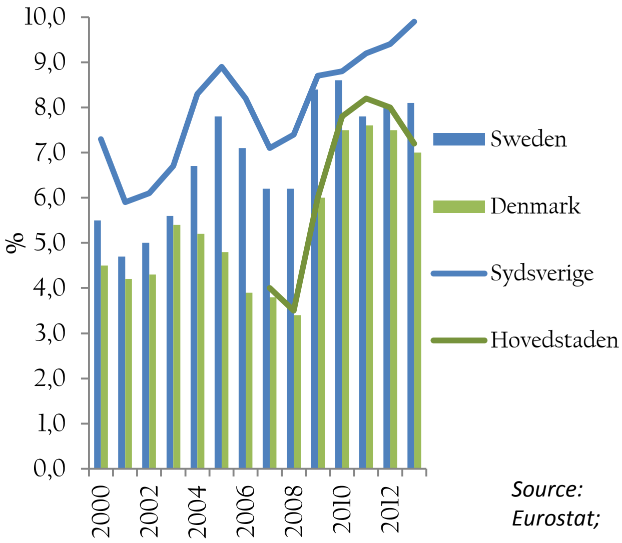
However, on a larger scale the economic impact of the fixed link is not that visible. When comparing the regional gross domestic product (**GDP**) per capita with the national average (see Figure 26) the ratios of Sydsverige and Zealand have decreased in the period of 2000–2011, from 91.4% to 85.4% and from 61.6% (2001) to 57.4% respectively. The ratio of GDP per inhabitant of the Copenhagen metropolitan area (Hovedstaden) to the average of Denmark has remained on the same level (around 120% of the Danish average).

Figure 26 Regional GPD per inhabitant as % of respective country's average in 2000–2011



Source: Eurostat;

Figure 27 Unemployment rates in Sweden, Denmark and Øresund region



Source: Eurostat;

A similar pattern can be noticed with regard to the labour market. Although in the decade following the opening of the Øresund fixed link, 76,000 jobs were created in the Øresund Region (13), the relative unemployment, when compared with the countries' average, has not changed at the end of the day (see Figure 27). Unemployment in Sydswerige and the Malmö metropolitan area has remained higher than Sweden's average. The cap was 1.8% in both 2000 and 2013.

The Copenhagen-Malmö Port

The estimated loss of turnover of the ports of Copenhagen and Malmö as a result of the opening of the Øresund Bridge was expected to be 15–20%. Instead the opening of the bridge brought opportunities for new collaborations. For example, the unloading of cargo at the port in one country and easily distributing it in the other country. As a result, the two port companies decided to merge in 2001.

The Copenhagen–Malmö Port is currently Scandinavia's largest port for the import of cars and Europe's leading port for cruise ships. Turnover has increased 57 percent since 2001 and profit has improved from EUR 1 million to EUR 12.2 million. (13)

Organisation and financial performance

The owner and operator of the Øresund Bridge is ØresundsbroKonsortiet.

ØresundsbroKonsortiet is a Danish-Swedish company, jointly owned by A/S Øresund (50%) and SVEDAB AB (50%). A/S Øresund is owned by Sund&Bælt Holding A/S, which is owned by the Danish state. SVEDAB AB is owned by the Swedish state. The owners are jointly and severally liable for ØresundsbroKonsortiet's liabilities, i.e. creditors are given state guarantees.

The construction of the Øresund Bridge, which was undertaken by a joint venture of Hochtief, Skanska, Højgaard& Schultz and Monberg&Thorsen, began in 1995, and was completed on 14 August 1999. The bridge-tunnel was finished three months ahead of schedule. The bridge-tunnel was opened for public on 2 July 2000.

Table 15 Investment cost of the Oresund Bridge, in billion euros

Position	1990 prices*	2000 prices
The Øresund Bridge (ØresundsbroKonsortiet)	1.97	2.32
Danish land-works (A/S Øresund)	0.71	NA
Swedish land-works (SVEDAB AB)	0.26	NA
Total	**2.94**	**4.04****

Source: 10 YEARS. The Oresund Bridge and its regions; 2010; ** OECD*

The Øresund Bridge must be self-financing, which means that the charges paid by users for using the link must cover all construction and operating costs, including maintenance, reinvestments and new investments. (11)

Loans for the link and the land-works will be repaid from the revenue of the Øresund Bridge, primarily from road traffic. Revenues from rail operations are not influenced by traffic volume, but are regulated annually in accordance with the rate of inflation.

Table 16 Results of the Øresundsbro Konsortiet in 2009–2013

In mill euros	2009	2010	2011	2012	2013
Net turnover	**194**	**204**	**207**	**214**	**223**
Operating expenses (excl. depreciation)	36	38	39	39	39
incl. employees' benefits				16	15
EBITDA	**158**	**166**	**169**	**176**	**184**
EBITDA margin (% of net turnover)	*81.5*	*81.4*	*81.4*	*82.0*	*82.5*
Depreciation	46	41	35	35	36
Operating profit/loss (EBIT)	**112**	**125**	**134**	**140**	**148**
EBIT margin (% of net turnover)	*57.7*	*61.4*	*64.7*	*65.5*	*66.2*
Number of employees	178	178	181	180	180

Source: Øresundsbro Konsortiet annual report 2013

Annual recurrent investments in property, plant and equipment have been in the range of 7–11 million euros. In 2012 and 2013 another 5–6 million euros were invested into working capital.

Road link

Income from the railway link makes up about 69% of the revenue, i.e. 153 million euros in 2013. Income from the road links comprises passenger fees paid when crossing the bridge and income from the sale of prepaid trips.

With regard to traffic growth, leisure traffic and the BroPas have played a key role with an increase of 6.0 per cent in 2013. During 2013, the number of BroPas customers increased from 272,000 to 303,155.

Railway link

Income from the railway link makes up about 30% of the revenue, i.e. 66 million euros in 2013. Income from the rail link comprises payments from Banedanmark/Trafikverket for using the rail links. Fees have been determined in accordance with the inter-government agreement between Denmark and Sweden of 23 March 1991.

The rail link is operated jointly by the Swedish SJ and Danish railways via DSBFirst. Trains operate every 20 minutes, once an hour during the night, in both directions. An additional couple of Øresundstrains are operated at rush hour, and 1–2 SJ trains and DSB trains per hour and direction every other hour. Freight trains also use the crossing. The rail section is a double track 1,435 mm standard gauge and capable of speeds of up to 200 km/h, slower in Denmark, especially in the tunnel section.

Operating costs

The total operating expenses – excluding depreciation – of Konsortiet were EUR 39 million both in 2012 and 2013. Staff related costs, which comprise direct payroll costs, pension contributions, training expenses and other direct staff costs, accounted for 40% of the operating expenses and the number of employees was 180 in both years. Salary expenses per employee were around 5,200 euros per month.

Funding

The link will be entirely user-financed. Øresundsbro Konsortiet has taken loans guaranteed by the governments. At the time of opening the bridge, the loan burden of the group was around EUR 4 billion, i.e. the fixed link was 100% loan-financed.

After the increase in traffic, the user fees are enough to pay the interest and begin paying back the loans, which is expected to take about **30 years**.

Table 17 Net debt and financial expenses of the Øresundsbro Konsortiet

In mill euros	2009	2010	2011	2012	2013
Interest bearing net debt	2,484	2,424	2,387	2,342	2,228
Net financing (interest) expenses	–102	–99	–97	–91	–67
Estimated interest rate	4.1%	4.0%	4.0%	3.8%	2.9%

Source: Øresundsbro Konsortiet annual report 2013

With 184 million euros EBITDA, 67 million euros financial expenses and 15 million euros investments (both fixed assets and working capital), ca 100 million euros could have been spent on debt repayment in 2013.

Problems

Some disparities in regulations have been identified, which do not allow the use of the full potential of the fixed link or a fair sharing of its benefits:

- Lack of a single currency, as both Sweden and Denmark maintain their own currencies.
- Lack of transparency of the rules for taxes, social security and pension and unemployment benefits. While specific tax treaties exist for the region, there are still problems with administrating them. People commuting to work over the border sometimes risked paying double taxes. They also risked losing the right to unemployment benefits because foreign employment did not contribute to entitlements in their home state, losing the right to kindergarten for their small children for the same reason etc.
- An imbalance in the municipal budgets, since the flow of commuters move in one direction: from Sweden to Denmark. Rules of taxation have left the Skane municipalities with increased costs not

covered by increased tax revenues from the growing commuter population mainly taxed in the country of employment.

- Voting privileges: the Danes living on the Swedish side of the Øresund Region, but working on the Danish side lose their right to vote in general elections in Denmark as long as they work in Denmark.

Overall conclusions

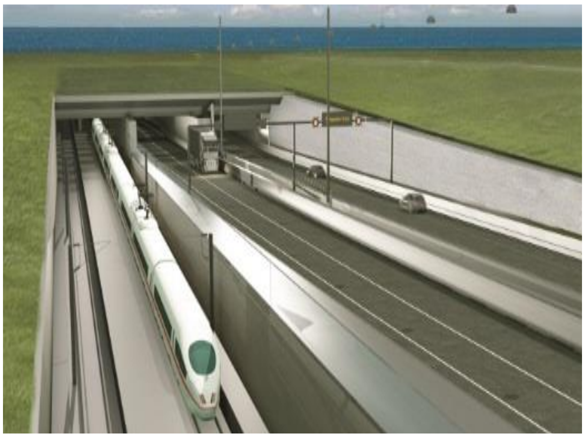
- Although especially in the first years after the opening of the fixed link traffic has underperformed the forecasts, the figures have improved and by now the project seems to be financially sound. There are still risks related to the future economic developments, e.g. the commuter traffic has shown a strong dependence on the general economic situation.
- Unlikely the Channel Tunnel project, the Øresund Bridge has contributed to the integration of the regions – by today, there is a relatively big share of people on both sides who identify themselves as people from Øresund.
- Commuters are the driver of traffic growth. The direction of commuting is from Sweden to Denmark (95%). However, commuting is highly sensitive to economic downturns and commuting traffic has seen a strong decrease since 2009.
- Although the fixed link has affected economies – commuting, Copenhagen airport, the cities' marine harbours, spatial development etc. – the project has not changed the relative wealth (GDP per capita) of the regions and the employment situation in comparison to respective country's average.
- In terms of population growth, the city of Malmö – with higher than Sweden's average growth in population – seems to benefit the most from the Project. Malmö has outperformed Stockholm and Göteborg by growth in population in 1990–2012.
- The selected operating model – state-owned Project Company – seems to be successful. It is considered that a state-owned company pays more attention to making full use of the project's socio-economic potential, which is where the Channel Tunnel project has had less success.

6.3 Fehmarn-Belt

Femern Belt fixed link (**Femern Tunnel**) project between Rodby in Denmark and Puttgarden in Germany is in development phase and therefore a good example for the development of an infrastructure project in the current economic environment.

Femern Tunnel in short

Expected opening	**2020**
Investment cost (2008 prices)	**EUR 5.5 billion***
Length	**ca 18 km**
Functionality	**2+2 road 1+1 rail**
Connecting	**Rodby, Lolland (DK) – Puttgarden, Fehmarn (DE)**
Regional hinterland	**Hamburg (DE), Copenhagen (DE)**



** Project company's costs only, does not include hinterland access connections*

Organisation

The Fehmarn Belt link treaty was signed by Ministers of Transport of Denmark and Germany in early September 2008.

Femern A/S, the project company, is a Danish legal entity engaged in the development of the fixed link. It is a 100% subsidiary of Danish government owned Sun &Bælt Holding A/S, i.e. belongs to the same group as Øresundbro Konsortiet.

The tunnel project, i.e. the coast-to-coast section, will be wholly financed and operated by Denmark. Connecting the tunnel to the hinterland rail and road network will be performed and financed by the respective country. This means that the coast-to-coast section and the land-works are considered separate projects. (16)

Expected benefits

The opening of the Fehmarn belt link will cut the travel time from the Danish to the German coast from the current 45 minutes to 12 minutes. Journey times by rail between Copenhagen and Hamburg will be shortened from the current four hours and 31 minutes to three hours and 30 minutes. Future high-speed trains in Denmark and Northern Germany would further reduce journey times to two hours and 15 minutes.

The link will replace energy-consuming ferries. The rail sector is to save 50 million euros per year as the Fehmarn belt link is 160 km shorter than the present route via Jutland, Funen and Storebælt.

Investment costs and construction

The immersed tunnel solution was selected as the preferred solution for the link. Investment costs include items presented in Table 18.

Table 18 Breakdown of investment costs in 2008 prices

Position	Cost (in billion EUR)	Comments
Planning and tender preparation	0.31	Conceptual design, environmental investigations, geotechnical studies etc
Construction works	3.84	Coast-to-coast construction costs of the immersed tunnel
Other works	0.26	Navigation systems, land purchase, all-risk insurance, toll station and payment system, customs and border control facilities etc
Project management in construction phase and operational preparations	0.42	Client consultancy, supervision and environmental monitoring
Reserves	0.64	Planning phase reserve, contractor's risks, client's risks, free reserve
TOTAL	**5.47**	

The estimated construction period will be 6.5 years. The hinterland infrastructure costs – German and Danish sides together – will be EUR 1.1 billion and the total cost of the project is thus **EUR 6.6 billion**.

The bored tunnel solution appeared to be more expensive (EUR 6.8 billion) compared to the immersed tunnel option, and would also take longer to construct (8 years).

The Fehmarnbelt project is expected to be executed by a system of contracts under which the contractors will carry out the detailed planning and design and are responsible for the construction works (Design & Build Methodology). This approach needs a clear allocation of tasks, responsibilities and risks between project company (Femern A/S) and the contractors.

So far Femern A/S has prequalified nine contractor consortia to submit tenders for the four major construction contracts for the fixed link across the Fehmarnbelt. The four contracts are: 1) tunnel north, 2) tunnel south, 3) portals and ramps, and 4) excavation and land reclamation. The procurement process will end in 2015, when the contracts will be ready to be signed.

The competitive bidding process is not only aiming to ensure the best price, but also inspire the construction industry to think creatively and perhaps come up with proposals for new and better methods than seen previously.

Funding and operating costs

The Danish government will guarantee the project loans that are to be repaid within 32 years using the revenue received from the users. (17)

EU subsidies are expected to cover 50% of the costs of feasibility studies, 10–20% of the construction costs and 7% of the indirect expenses. (16) In total, the expected EU subsidy will be in the range of EUR 0.65–1.18 billion, depending on the support rate in the construction phase.

The estimated operating, maintenance and reinvestment costs are EUR 73.7 million a year (in 2008 prices).

Traffic

The fixed link is expected to carry 8,000 vehicles and 3,800 train passengers per day, compared to ferries which carried 5,450 vehicles per day in 2001. (17)

The first-year traffic jump is estimated to be 40 per cent on Fehmarnbelt. In long-term forecasts, Femern A/S has assumed that the average traffic growth over the first 25 years of the link's lifetime will be 1.7 per cent a year. This corresponds to around half of the actual average growth over the past 40 years, which was 3.4 per cent per year. After the first 25 years, traffic growth is expected to be zero. (17)

Conclusions

- Similarly to the Øresund Bridge project, the Femern Belt project also uses the state-owned Project Company structure. While in Øresund the Swedish and Danish states shared the ownership and responsibilities (e.g. financial guarantees), the sole owner and driver of the Fehmarn Belt project is Denmark. This can be explained by the link's bigger impact on the Danish economy.
- The primary impact area of the tunnel is the region between Hamburg and Copenhagen. The fixed link closes a gap in the rail network between Scandinavia and Central Europe and is supported by the EU as part of the community's priority rail corridors – thanks to the tunnel freight trains the 160-kilometer detour via the Great Belt could be avoided.
- The design&build methodology is applied in the construction of the tunnel, with 4 main contractors to be selected in 2015. The Danish government is expected to have adopted the construction decisions by that time and the authorities of Schleswig-Holstein are expected to have given all the necessary approvals. This would allow the completion of the investment phase by 2021.
- The project is planned to be financed mainly with loans – excluding 20% of the investment costs which is to be financed from the EU budget. The loans will be repaid from the fares collected from the users of the tunnel within 32 years from opening the link.

7. Technical Opportunities

7.1 Topographical and geological analyses

Previous studies

Topographical, bathymetric, geological, geotechnical and geophysical and ecological studies related to the tunnel corridor area are described below. The Geological Survey of Estonia has collected data on soil and bedrock construction conditions and on the compilation of a geological database for the possible Tallinn–Helsinki tunnel area in their report from 2012. It concentrates and analyses most of the data on the tunnel region. A 3D model of the Estonian part of the tunnel was compiled and physical-mechanical properties of the rocks were characterized. (29)

Marine geological mapping of the tunnel area was carried out in 1989–1994. As a result, a geological map of the shelf area of the Baltic Sea on a scale of 1:200 000 (30) was produced. Geophysical mapping was carried out in the course of deep geological mapping of the Tallinn–Loksa area on a scale of 1:200 000 in the mainland part of the tunnel area (18) and some deep wells reaching to crystalline basement rocks were drilled. (22)

Physical-mechanical and hydro-geological properties of the crystalline basement, as well as the covering sedimentary rocks were studied in the "Report on granite prospecting in the Maardu region". Altogether 46 wells were drilled in the course of granite prospecting in the Maardu region, to the east of the expected tunnel area (23).

A set of digitized geological-geophysical-hydro-geological maps and explanatory letters of the Tallinn (6334), Rohuneeme (7312) and Maardu (6343) sheets were compiled in the course of a large-scale (1:50 000) geological mapping (28). The map and the explanatory letter of the 1:1 000 000 Precambrian basement map (Koistinen, 1996) give an overview of the geological structure of the seabed of the Gulf of Finland and its surroundings. The crystalline basement map of North-Estonia on a scale of 1:200 000 (21) provides data on the geological structure of the crystalline basement of the mainland part of the tunnel area.

Additional geological and hydro-geological surveys of the Maardu granite massif area were carried out by the Geological Survey of Estonia in 2010 (26). Geological-geotechnical-hydro-geological studies of Suur-Pakri Island and the surroundings were compiled in the "Report on geological-geotechnical-hydro-geological studies of Suur-Pakri Island and the surrounding seabed" (25).

The soil and bedrock construction conditions of the possible Tallinn–Helsinki tunnel area and the geological data are presented in the Geological Survey of Estonia's report "Tallinn–Helsinki tunnel soil and bedrock construction conditions. Compilation of a geological database for the possible Tallinn–Helsinki tunnel area" (29).

In the course of an environmental impact assessment, Maves Ltd assessed the impact on groundwater in the case of the possible underground mining of the Maardu Rapakivi granite (31).

Analysis on the basis of relevant previous studies

The main data for the geological setting of the Gulf of Finland region are based on marine geological mapping data from 1989–1994 (30). Numerous seismo-acoustic profiles, ca 25 km long in the north-south direction, were compiled in the Estonian territorial waters using a seismic profiler system. The surfaces of crystalline basement rocks and covering sedimentary rocks were explored in these studies.

Some deep wells reaching down to the crystalline basement rocks were drilled in the course of the deep geophysical (18) and geological (22) mapping of the Tallinn-Loksa area on a scale of 1:200 000 in the mainland part of the tunnel area. An overview of the deep geological structure of the possible tunnel area was obtained.

Geophysical (gravimetric and magneto metric) mapping was carried out in the course of the granite prospecting of the Maardu region immediately to the east of the expected tunnel area (23). Through the 46 deep wells the physical-mechanical and hydro-geological properties of the Rapakivi granites and the covering sedimentary rocks were studied.

A set of digitized geological–geophysical–hydro-geological maps and explanatory letters of the Tallinn (6334), Rohuneeme (7312) and Maardu (6343) sheets were compiled in the course of large scale (1:50 000) geological mapping (27; 28). This set of maps gives a detailed overview of the geological and geophysical structure of the tunnel area.

The Precambrian basement map of the Gulf of Finland and the surrounding area on a scale of 1:1 000 000 and its explanatory letter (20) give a good overview of the geological structure of the Precambrian basement of the tunnel corridor. The crystalline basement map of North-Estonia on a scale of 1:200 000 (21) gives an overview of the geological structure of the crystalline basement in the possible tunnel area.

Data on tectonic conditions at the Neeme (Maardu) Rapakivi Massif boundary and the Maardu Fault area are provided by additional geological and hydro-geological surveys of the Maardu granite massif area (26). The physical-mechanical and hydro-geological properties of the Ediacaran and Lower-Cambrian weakly lithified and water-saturated sandstones have been studied.

For a possible nuclear plant site, geological, geotechnical, hydro-geological studies were conducted on Suur-Pakri Island and its surroundings (25). These explorations provide data on the physical-mechanical properties of the numerous sedimentary rocks. Because of analogical geological sequence, these results are applicable also for the geological sequence of the tunnel area.

The Geological Survey of Estonia's report from 2012 is devoted to soil and bedrock construction conditions and to the compilation of a geological database for the possible Tallinn–Helsinki tunnel area. It concentrates and analyses most of the data on the tunnel region. A 3D model of the Estonian part of the tunnel was compiled and physical-mechanical properties of the rocks were characterized (29).

An environmental impact assessment report compiled by Maves Ltd gives an estimate of the possible impact on groundwater in the case of mining the Maardu granite (31).

Selection of optimal routes for the fixed link

The geological characterization of alternative tunnel corridors is based only on the geological conditions of the Gulf of Finland region. The list of the route alternatives corresponds to the route map in Appendix 2.

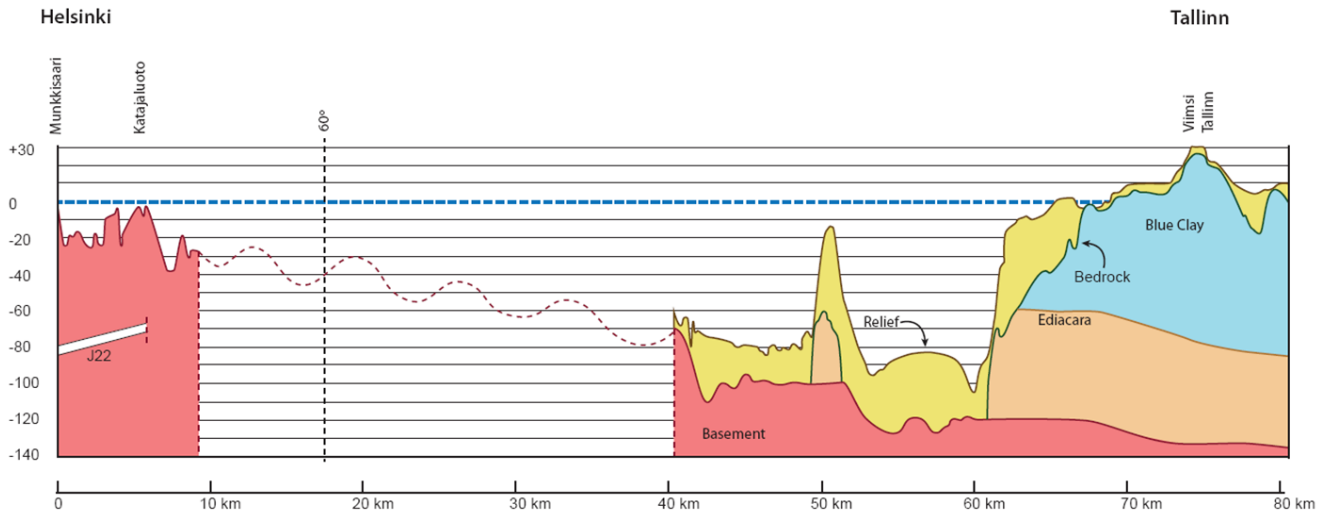
Table 19 Best route alternatives based on geological conditions A ... E

Line options	Conclusions
A. Pasila–Muuga–Ülemiste	The tunnel goes through the bedrock in the blue clay bed in Viimsi area and dives into crystalline basement rocks under the Aegna Island. This route would be suitable for a tunnel corridor.
B. Pasila–Naissaar–Paljasaare–Ülemiste	In the entrance region between Paljassaar and Aegna, the tunnel should penetrate a buried valley filled with weakly lithified and water-saturated Quaternary deposits (gravel, sand, silt). These deposits are very unsuitable for tunnel constructions.
C. Pasila–Porkkala–Muuga–Ülemiste	This is comparable with alternative A, but the tunnel area would be shorter. This route would be suitable for a tunnel corridor.
D. Vuosaari–Aegna–Muuga–Ülemiste	This is comparable with alternative A, but the tunnel area would be longer. This route would be suitable for a tunnel corridor.

E. Vuosaari–Maardu–Muuga–Ülemiste	This is a longer and geologically unsuitable alternative for the tunnel. The tunnel would enter into the crystalline basement at the boundary of the Maardu Rapakivi Massif trough the Maardu tectonic fault zone (25).

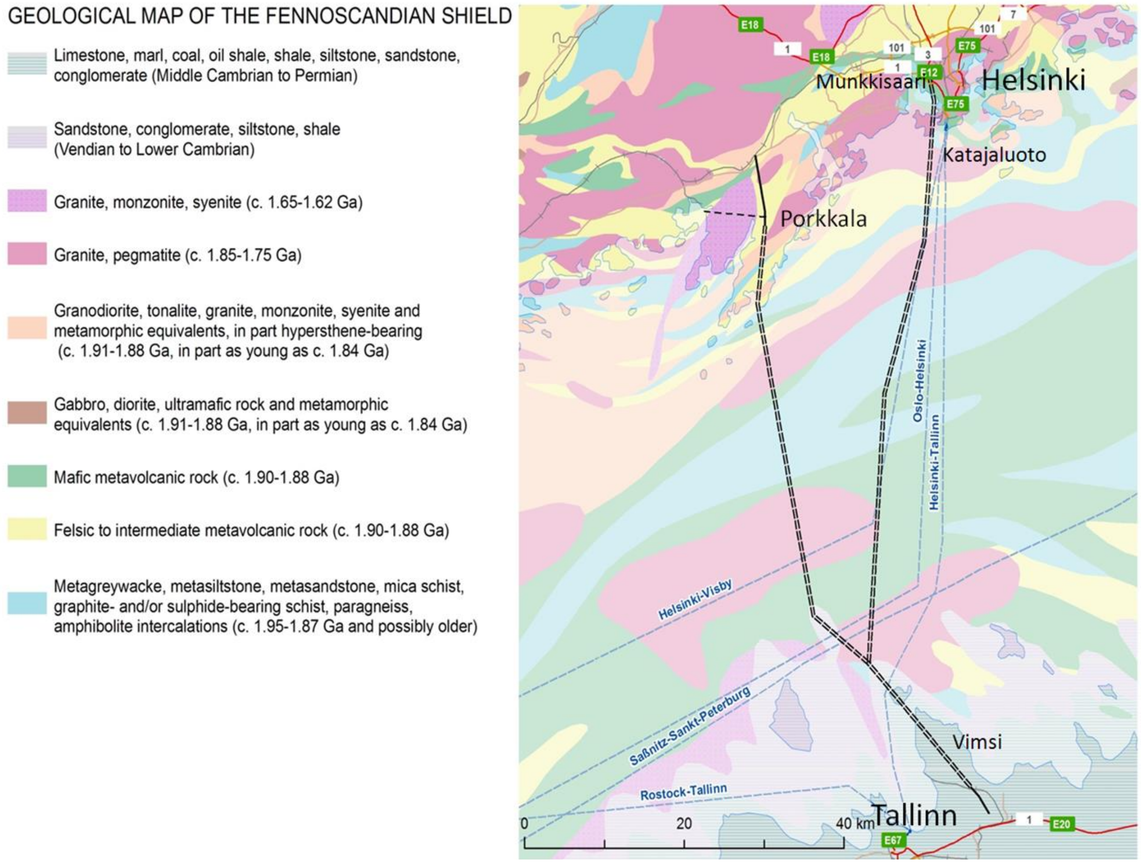
The Precambrian crystalline basement in the tunnel area, except for the Paljassaar–Naissaar–Tallinnamadal–Pasila route, is a representative complex of the Paleoproterozoic migmatizedmicca and quartz-feldspar gneisses and amphibolites. The complex contains smaller bodies of migmatite granites. By mechanical properties, these are very hard or up to extremely hard rocks (compressive strength 100–260 MPa). In the Paljassaar–Naissaar–Tallinnamadal–Pasila direction, the tunnel would penetrate the Naissaar Rapakivi Massif. By mechanical properties, the Rapakivi granites of the Naissaar Massif are very hard (compressive strength 100–250 MPa) up to extremely hard (<250 MPa, aplite veins) rocks (25). These are very suitable rocks for tunnel construction.

Figure 28 Principal cross-section of tunnel area (Ikävalko et al. 2013)



In the areas where the basement is covered by sedimentary rocks (Ediacaran sandstones or gravelites) the crystalline basement rocks are within 1–20 m weathered (weathering crust) and the strength of these rocks is accordingly lower. In the zones of tectonic disturbances the thickness of the weathered rocks may extend up to some tens of meters.

Figure 29 Proposed tunnel alternatives (Ikävalko, 2013) on the geological map of Fennoscandian shield (Koistinen, 1996)



Further Investigation

The main problems associated with the tunnel are connected with geology at the exit locations on the Estonian side. The problems are associated with mainly weakly consolidated and water-saturated Ediacara – Lower Cambrian layers (the groundwater reservoir of Tallinn and its surroundings). A 75–80 m thick complex of weakly lithified and water-saturated silt- and sandstones of the Kroodi Formation (Ediacaran – ca 55 m thick) and Sämi Member (Lower Cambrian – ca 25 m thick) covers the crystalline basement in the optional tunnel entrance area in Viimsi. This complex is an important source of water supply for the Tallinn city area and one of main challenges for tunnel penetration.

The existing full-coverage (at the scale of 1:200 000) geophysical marine geological data for the Gulf of Finland area is available mainly for the Estonian EEZ (exclusive economic zone). This research was carried out during a national marine geological mapping programme by the Geological Survey of Estonia in 1984–1989 for the purpose of achieving a general overview of the geological setting.

Mainland geological data on the Estonian end was compiled on the basis of small- and medium-scale geological maps of the crystalline basement. Data on the sedimentary rock cover was obtained mostly from medium- and large-scale (1:50,000) geological mapping and natural resource exploration projects. Data obtained from numerous boreholes drilled in the course of geological mapping and various exploration projects on mineral resources or groundwater were used for compiling 3D models.

A number of studies need to be carried out for determining the geological setting of the seabed in the area of the Gulf of Finland between Tallinn and Helsinki along the possible tunnel alignment alternative A (Pasila–Muuga–Ülemiste). The relevant objects of study include: the morphology of the crystalline basement surface, the thickness of the overlaying sedimentary cover rocks, the thickness of the Quaternary sediments, and outlining the existence of buried valleys and tectonic fault zones.

The programme for further investigation is described below.

a) The seabed data gathering methodology will be profiling along the whole route with continuous seismo-acoustic reflections in low (0–250 Hz) (e.g. with Airgun) and middle (Chirp/Boomer profiling, 4 kHZ) frequency ranges, together with other types of geophysical investigation (side-scan sonar, magnetometry, and bottom gravimetry). The distance between profiles will be 1 km in the 4 km wide investigation area. It is necessary to also profile across the route.

b) Seismic risk in the Gulf of Finland region has to be estimated. For getting a proper overview of possible major crystalline basement fault lineaments along the sea bottom, it may turn out to be necessary to conduct seismic structural profiles reaching to greater depths than is feasible with the seismo-acoustic methods.

c) All available geological data will be collected for the pre-determined route A area.

d) A GIS-based geological database will be compiled including more detailed digitized geological maps and cross-sections for the route A area.

e) The boreholes with core extraction and full complex of logging will be drilled for gathering direct information on geology.

   i. With regard to the optional tunnel entrance area in the Rohuneeme area (Longitude: 24,798603 / Latitude: 59,564639) a well of ca 200 m will be drilled on the Viimsi Penisula. The aim is to investigate the geotechnical, hydro-geological and structural properties of the ca 60 m thick complex of weakly lithified and water-saturated silt- and sandstones of the Kroodi Formation (Ediacaran).

   ii. This complex, which is an important source of water supply for the Tallinn city and its surroundings, will be one of the main challenges for tunnel penetration. reliable data on the geotechnical and hydro-geological properties of rocks in this complex are practically non-existent, because the drill core output from this interval was minimal in the existing holes (less than 10%, and only beds with stronger mechanical properties were represented). A special drilling method (e.g. double tube system) has to be used.

   iii. On Aegna Island (Longitude: 24,766463 / Latitude: 59,588466) a well of 200 m will be drilled for studying sedimentary rocks (Ediacara sandstones, blue clays), crystalline basement rocks and weathered crust. The geological, geotechnical, geophysical and hydro-geological properties of the rocks will be studied.

   iv. On the northern part of route A, around the shallow of Helsinginmatala (Latitude: 59.950556 / Longitude: 24.901667) a well of 100 m is recommended to be drilled for studying crystalline basement rocks. The geological, geotechnical, geophysical and hydro-geological properties of rocks will be studied.

7.2 Alternative tunnel alignments and tunnel types

Several options for the tunnel corridor between Tallinn and Helsinki have been discussed in different studies over the years. Appendix 2 provides an overview of five tunnel corridor alternatives (A...E). In this study, potential options have been reviewed on a rough level from different perspectives. Geological exclusions have been described in the previous chapter. The most important perspective has been the connection to the entire transport systems in both counties.

A comparison of alternative tunnel alignments is shown in Table 20.

Table 20 Route options A … E

Line options	Length, km		Cost estimate, EUR	Conclusions
	Tunnel	Surface		
A. Pasila–Muuga–Ülemiste	85	20	7,000–8,800	The quickest alternative for passenger traffic between the city centres of Helsinki and Tallinn. Connections to the existing traffic system are most optimal.
B. Pasila–Naissaar–Paljasaare–Ülemiste	77	25	not done in this study	Connection to the existing track network on Estonia's side is challenging. At Paljassaare the track would go through the existing town structure and settlement.
C. Pasila–Porkkala–Muuga–Ülemiste	65	65	not done in this study	The shortest tunnel. Possibly the cheapest. Connections to traffic systems are weak. For passenger traffic, this is a slow connection to Helsinki. Environmental impact in the area of the cape of Porkkala. Geologically complicated.
D. Vuosaari–Aegna–Muuga–Ülemiste	92	20	not done in this study	Several disadvantages for passenger traffic, because it requires a change to subway when travelling from the city centre of Helsinki, which lengthens the travel time. At Vuosaari there is less space for the tunnel exit and a railway station. For cargo traffic, there are good connections to the main track through the tunnel of Savio.
E. Vuosaari–Maardu–Muuga–Ülemiste	82	17	not done in this study	Several disadvantages for passenger traffic, because it requires a change to subway when travelling from the city centre of Helsinki, which lengthens the travel time. At Vuosaari there is less space for the tunnel output and a station. For cargo traffic, there are good connections from Muuga to the main track through the tunnel of Savio.

Taking into account the technical results and geological properties as well as the results presented in table above, tunnel alternative A fulfils the most criteria for a suitable route.

Tunnel types

In the pre-feasibility study, connections to the current transport systems in both countries have been an important aspect of the functional study of different tunnel types and cross-sections. Previous studies have discussed the idea of a road tunnel or a combined road and railway tunnel. Due to general safety risk and emergency related reasons, it would be very difficult to allow passenger car traffic in such a long underwater tunnel. The (EU) regulations concerning safety systems, tunnel operation and rescue facilities will raise investment and operating costs to an extremely high level and could lead to infeasible solutions. For that reason, this study mainly focuses on railway tunnel solutions.

Table 21 Tunnel Types by construction method

	Tunnel type	Construction method	Conclusions
1.	Rock tunnel	by drill and blast or partly TBM	Challenges in weak soil layers on the Estonian coastline. The most feasible route is found. Excavation method and construction time have to be studied more carefully in the next planning. D&B rock material could be used as construction material in this project and for other purposes. Minor environmental impacts (whole tunnel section under seabed).
2.	Rock tunnel , partly bridge	by drill and blast or partly TBM, bridge constructed in traditional way	Tunnel section as in whole rock tunnel type. Naissaar Bridge section does not enable fast train connections (over 250 km/h). Connection to the existing transport system is difficult (Rail Baltica and railway corridor through the city of Tallinn). D&B rock material could be used as construction material in this project and for other purposes. Minor environmental impact on underground sections, major environmental impacts on bridge section.
3.	Immersed tunnel	Immersed concrete elements	Slow and expensive construction: time, excavation on seabed, immersing and connecting elements, system installations. Solution will need landmasses outside of the project. Major environmental impacts. Risks: Underwater construction works Intersecting cable and pipelines, environmental permissions, crossing vessel traffic.

Table 22 Types by Cross-section

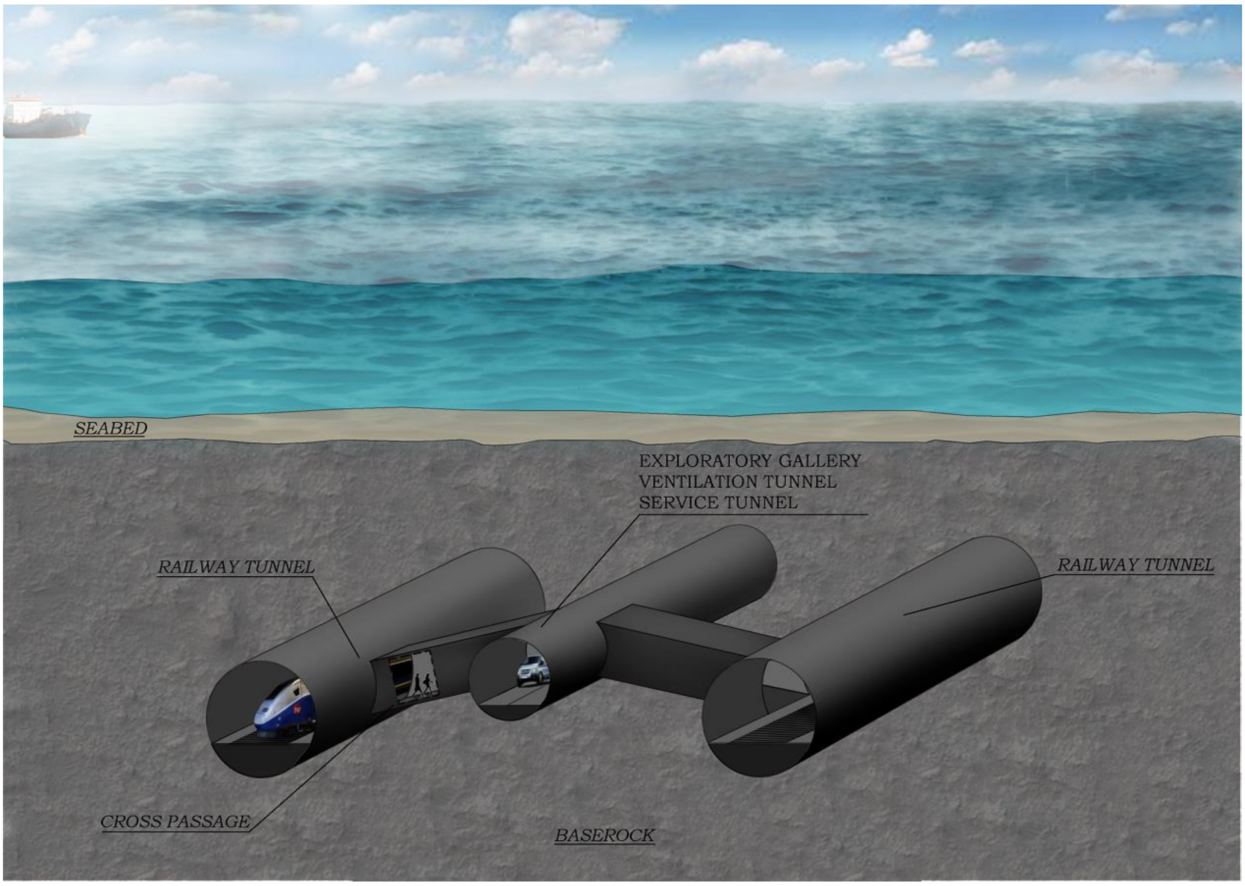
Tunnel type	Cross section	Conclusions
A	Train tunnel (2 rails) + Ventilation tunnel + Service & emergency tunnel + Cross passages approximately 400 m	In train operations a possibility to change rails in the tunnel (in case of passing slower traffic or breakdown). Disadvantage: hard to achieve 250 km/h target speed level.
B	Two separate train tunnels + Combined service and ventilation tunnel in the middle Cross passages approximately 400 m	Enables the speed level of trains 250 km/h = 30 minutes travel time. No possibility to change rails in the tunnel.

The most important criteria for achieving the objectives:

- to connect to the existing transport systems in both cities;
- to achieve a 30-minute travel time between cities;
- to achieve the most feasible combination from the technical perspective (investment costs, safety and rescue, maintenance and operation).

Tunnel Option 1.B – a Rock Tunnel with two separate train tunnels is recommended for development as a primary solution in further studies.

Figure 30 Option 1.B – a Rock Tunnel with two separate train tunnels



7.3 Cost estimates

7.3.1 Investments

The cost estimate is based on the unit costs for similar train tunnel projects that are currently being planned or have already been executed in Finland and elsewhere in Europe. The cost estimate includes a risk reserve and costs such as planning and the contracting authority's tasks. The cost estimate shown in Table 23 consists of two prices – the low price and the high price. The cost estimate is for tunnel alternative 1.B for route A.

Table 23 Technical cost estimate for tunnel 1.B for route A

Cost types	Low price, MEUR	High price, MEUR
Tunnel with railways, 85 km	3,600	4,100
Surface track sections	700	1,000
All technical systems, maintenance canals, security	2,500	3,300
Finnish cargo terminal and passenger station	200	400
Estonian cargo terminal and extension of passenger station	70	150
Rolling Stock	1,000	1,000
Risk reserves	1,000	3,000
TOTAL COST	**9–13 billion euros**	

The different works included in the cost estimate are as follows:

- 2 separate railway tunnels, maintenance and escape tunnel and ventilation tunnel all made by drill/blast method in hard rock areas and TBM method on the Estonian side. The total length of tunnels and track will be 85 km;
- Surface track from Viimsi (Äigrumäe) to Maardu cargo terminal and to Ülemiste will be 20 km in total. Surface track from Pasila, Helsinki to Riihimäki cargo terminal will be 70 km in total;
- All technical ventilation, electricity, drainage and safety systems in tunnels and surface track. Vertical ventilation shafts, fill islands (Ulkomatala and Tallinnamatala) works and connections from tunnel;
- Finnish cargo terminal at Riihimäki and underground passenger station at Pasila;
- Estonian cargo terminal at Muuga and extension of passenger station at Ülemiste;
- Risk reserves for unexpected matters and conditions.

7.3.2 Rolling stock

The shuttles used in the tunnel are running at maximum speed 250 km/h. Normally, these will be operated in short units. It is possible to also use a combination of two units. There will be three different main train operation types in the tunnel:

- Passenger shuttle, consisting of locomotives and drivers one on each end, with eight carriages in the basic unit. If all carriages are only for passengers, the shuttle can operate between Pasila and Tallinn (800 passengers/train, speed 250 km/h, A.1. route; distance 90 km).

- If there are car, bus or truck carriages in the shuttle there are eight vehicle carriages and loading/unloading carriages, operating route A.2 links loading terminals (operating like the terminals of the Euro Tunnel) in Tallinn and Helsinki (length of A.2 route is 120 km).
- Normal trains using the standard gauge can operate in the tunnel. The trains can be high-speed passenger trains (800 passengers/train, speed 250 km/h) or cargo trains (total capacity 96 units/TEU, speed 120...200 km/h), which normally operate by night. There are various routes to Europe via Rail Baltica.

7.3.3 Operating

The operating cost will be calculated on the basis of Finnish train cost model. The model is prepared for the purpose of model construction. The operating costs of passenger and freight trains have been categorised as costs dependent on travel time and journey length, as well as overhead costs. In the Finnish model, the costs dependent on travel time include the capital costs related to rolling stock, the labour costs of train personnel and, in passenger traffic, train maintenance costs. The costs dependent on journey length include energy costs and costs incurred in the maintenance and repair of rolling stock. Overhead costs comprise the costs of administration, planning, ticket sales, etc (7).

Three basic cost models have been calculated:

- shuttle (passenger, car or truck), investment EUR 20...25 million per shuttle;
- cargo train;
- high-speed train.

The total costs will be calculated using the total time (driving hours) and driving (driving kilometres) performance and costs per hour and costs per kilometre. Unit costs are estimated in two versions:

1. total operating cost, including rolling stock investments;
2. without rolling stock investments and taxes.

Table 24 Estimated operating cost model for total cost calculation

Type	Total, incl. investments		Without investments	
	€/h	€/km	€/h	€/km
Shuttle (passenger, car or truck)	1,030	7.00	442	7.00
High speed train	1,000	6.20	341	6.20
Cargo train	716	5.19	503	5.19

Table 25 Cost per transport unit calculated on the basis of operation model and basic cost model

Type	Cost per passenger, €/passenger	Cost per unit, €/unit (using double unit)	Link
Passenger shuttle High-speed train	6.40 7.33	– –	Tallinn–Pasila Tallinn – Airport (Hki)
Car shuttle bus shuttle		58.48 (30) 350.74 (176)	Terminal Hki – Tallinn Terminal Hki – Tallinn
Truck, shuttle truck, cargo train		467.55 (234) 181.48	Terminal Hki – Tallinn Riihimäki–Tallinn
Containers, cargo train		83.18	Riihimäki–Tallinn

Table 26 Cost per transport unit (without investments, estimated loading factor 85%) calculated on the basis of operation model and basic cost model

Type	Cost per passenger, €/passenger	Cost per unit, €/unit (using double unit)	Link
Passenger shuttle high speed train	3.80 4.42	–	Tallinn–Pasila Tallinn – Airport (Hki)
Car shuttle bus shuttle		36.84 221.03	Terminal Helsinki – Tallinn; Terminal Helsinki – Tallinn
Truck, shuttle truck, cargo train		294.71 147.80	Terminal Helsinki – Tallinn; Riihimäki–Tallinn
Containers, cargo train		33.76	Riihimäki–Tallinn

In the case of only one shuttle unit running, the operating cost per train kilometre (without investments) is:

- passenger shuttle: 11.91 €/km (route 90 km, Pasila–Tallinn)
- passenger train: 9.80 €/km (route 120 km, Tallinn–Airport)
- car, bus and truck shuttle: 12.50 €/km (longer terminal times, route 120 km)
- cargo train: 11.48 €/km (containers, route 160 km from Riihimäki)

If is recommended to study tunnel-related operation models and operating costs in more detail in the next planning phase.

7.3.4 Maintenance

Maintenance is essential for operating the tunnel system efficiently and safely. From the operational point of view (to get full benefits from the tunnel), the tunnel should be available for traffic fur as many hours as possible throughout the whole year. Train traffic interval is dense and time schedule critical during daytime for fast passenger traffic. At night-time there is more capacity, and moving trains are more likely not to be as time sensitive as passenger trains. This allows for short maintenance break intervals mainly at night-time for minor maintenance operations. Larger maintenance operations (physical construction on railway tunnels) affect the railway capacity of the tunnel for longer periods, and certain solutions (like railway turnouts between tunnels) are needed for maintenance purposes.

Maintenance operations can be divided into three sections:

- for physical structures
    - rock tunnels and cladding
    - concrete structures
    - railways
- for tunnel systems
    - rail operating systems
    - HVAC
    - electrical systems
    - safety and emergency

    - ICT and operating systems
- rough tunnel operating model during maintenance works
    - for different kinds of maintenance works

In order to find the needed solutions for maintenance and an optimized balance of maintenance operations (time tunnel is closed) and costs (investment, operating) in the tunnel, we recommend that life-cycle analysis of different maintenance operations be performed in the next planning phase.

7.3.5 Safety

The tunnel between Helsinki and Tallinn would be one of the longest underwater railway tunnels ever constructed, which will demand specific requirements from the safety and rescue perspective. From the technical and operational point of view this tunnel has similarities with the Channel Tunnel and the Gotthard tunnel in Switzerland. Safety regulations and requirements have been tightened since the Channel Tunnel was designed, constructed and commissioned. The basic principles of safety solutions could be benchmarked from the Gotthard Base tunnel experience and matched to these project characteristics in cooperation with relevant authorities in the next planning phase.

Traffic projections lead to an operation model where the planned train interval in the tunnel is quite short. It means that large numbers of passengers are simultaneously moving in the tunnel tubes. Passenger safety issues are essential in further studies (how to rescue and exit a large number of passengers from long tunnel sections and guarantee safety operations in case of an emergency).

It is recommended that the following be created in next planning phase:

- a safety concept for the tunnel – benchmark, regulations and general acceptance from the relevant authorities and parties;
- a risk analysis (including safety risks) for the construction period and the operating period;

8. Cost-benefit Analysis

The EU methodology for the evaluation of projects in a cost-benefit analysis has been applied in the analysis. *(35)* The evaluation of the Project in a cost-benefit analysis is divided into two steps:

Financial analysis:		Economic analysis
- Investment cost - Operating costs and revenues - Financial return on investment - Sources of financing - Financial sustainability	›››››	- From market to accounting prices - Monetisation of non-market impacts - Inclusion of additional indirect effects - Social discounting - Economic performance indicators
Performance indicators:		*Performance indicators:*
Financial net present value (**FNPV**)		Economic net present value (**ENPV**)
Internal rate of return (**IRR**)		Economic rate of return (**ERR**)

Decision criteria: if the **FNPV < 0** => the project requires financial support. If the **ENPV < 0** => the society is better off without the project, unless the project has significant non-monetary benefits.

Financial and economic analyses largely rely on the results of the technical feasibility and option analyses.

8.1 Components of financial analysis

The following section describes the key parameters and assumptions of the financial analysis.

Taxation

For reasons of simplicity, the Estonian tax regulations are used in the taxation of sales and corporate income.

According to the Estonian Value Added Tax Act (**VATA**), international passenger and cargo (all, import, export and transit) traffic service has a zero percent tax rate[12]. The Project Company can refund input VAT whether it has been paid to an Estonian company or companies from other EU countries.

It is assumed that all imported goods and services are purchased from EU countries.

According to the Estonian corporate income tax regulation only dividends are subject to income tax. Starting from 2015, the rate is 20%. However, corporate income tax is ignored in the model, i.e. the model provides pre-tax results.

Pricing

Like in the case of the Øresund Bridge, the pricing strategy of TALSINKIFIX should aim at securing financial stability of the Project Company and ensuring customer benefits at the lowest prices. (11)

The following general customer segments are distinguished in pricing the services:

- Train passengers (shuttle train);
- Passengers in cars and coaches, i.e. customers of the car shuttle;

[12] Estonian VAT Act, clauses 15 (4) 2) and 9)

- Trucks, i.e. customers of the truck shuttle;
- Cargo trains.

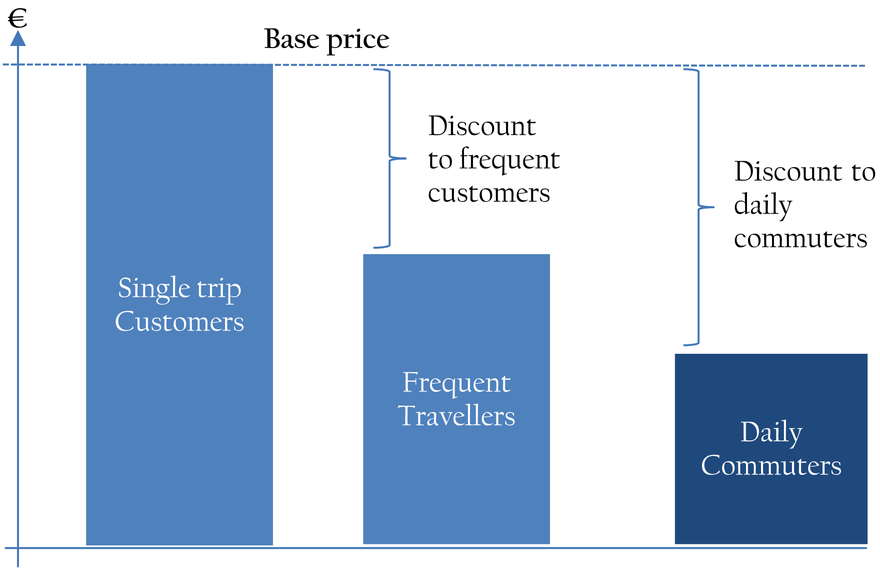
Prices for all the segments, except for cargo trains, have to the greatest extent possible been benchmarked to the current ferry prices of the Tallinn–Helsinki lines.

The pricing structure for passengers – both by train and by car – has a base price, to which specific customer group discounts are applied. In the model, the customers are divided into three categories:

Single trip customers	will pay the highest price per trip (base price);
Frequent travellers	will pay annual charge and receive a certain discount from every trip;
Daily commuters	will purchase a 30-day card.

For reasons of simplicity, no other discount categories were distinguished in the financial model, i.e. the base price is considered as the weighted average for all age and other categories (children, adults, elderly, students, disabled etc.).

Figure 31 Passenger pricing categories



Train passengers

Today faster ferries (Linda Line Express) spend 1h40 minutes on a trip. There are no considerable discounts to customers. According to the 2013 annual report, Linda Line's average revenue per passenger was **EUR 30** in both 2012 and 2013. The estimated annual average ticket revenue per passenger of Tallink on the Tallinn–Helsinki line was around EUR 21–22 (in 2012 and 2013). However, in 2015 the prices – dependent on the day and time – vary between 29–54 euros per one-way trip. This is also taking into consideration the impact of the new sulphur requirements. (32)

The price level of EUR 36 per trip has been taken as a basis for train passengers in TALSINKIFIX tunnel, which according to our assessment is competitive, compared to the ferry prices.

The discount for frequent travellers is estimated to be **20%**, i.e. they pay the average of **EUR 29** per one-way trip.

The estimated affordable 30-day card price level could be **EUR 300–400**. When considering 40 trips (both ways) within 30 days, the price per trip would be **EUR 9**, i.e. a 75% discount from the Base Price.

Passenger cars

Standard car (less than 6 m) ticket today with Tallink costs ca EUR 120 for one person in the car and ca EUR 160 for two and more persons. For the purposes of TALSINKIFIX project those prices have been taken as benchmarks.

The average price per car on a ferry is assumed to be EUR 140 per return trip and **EUR 70** per one-way trip. For comparison, a one-way ticket for a standard car in the Eurotunnel was EUR 69 (excluding VAT) at the beginning of November 2014.

On the Øresund Bridge, frequent travellers can buy a 10-time card, which gives a discount of about 25% compared to the standard ticket (EUR 46 and EUR 33.7 respectively). However, the pricing used for the Øresund Bridge is not directly transferable to TALSINKIFIX, because in the latter case the shuttle trains will provide the service, which means cost savings for travellers (fuel) on the one hand, but cause considerably higher operating costs for the Project Company in providing the service on the other hand. The Eurotunnel for example does not offer any discounts to recurrent customers.

We assume a **15% discount** for frequent travellers using a 10-time card, i.e. EUR 59.5 per trip and a **50% discount** for commuters using a 30-day card, i.e. EUR 35 per trip. This makes EUR 630 for a 10-time card and EUR 1,400 for a 30-day card.

Trucks

The truck rates are not publicly available for the Tallinn–Helsinki ferry lines. Based on annual reports the estimated revenue level for Tallink's truck and trailer service was around EUR 250–300 per cargo unit (truck/trailer). *(32)* The best benchmarking possibility is offered by the Eurotunnel truck shuttle service. The price level of the Eurotunnel freight service is provided in Table 27.

Table 27 Eurotunnel freight rates in euros (excluding VAT)

Vehicle	Rate per single trip
Truck <7.5 m	204
Truck 7.5–13 m	267
Truck > 13 m	349

Source: http://www.eurotunnelfreight.com/uk/bookings/fares/

The MyFerryLink, a subsidiary of Eurotunnel Group, offers EUR 145 per one-way trip across the Channel for trucks over 13 metres. When comparing the tunnel and ferry rates, it appears that customers are willing to pay about twice the price for a faster service.

The Øresund Bridge can offer considerably lower fares: EUR 130 for non-contractual customers and EUR 55–62, depending on the number of trips, for contractual corporate customers.

According to information received from Tallink, the truck prices for 17-metre trucks are between EUR 478–805 per one-way trip in 2015. Prices for 12-metre trucks are EUR 322–553 per one-way trip. These prices are only slight higher than in 2014.

Based on Tallink's price level, we assumed a **EUR 450** average ticket price for a single trip for average trucks on the TALSINKIFIX truck shuttle service.

Pricing of cargo trains

The Øresund Bridge and the Eurotunnel use a different price structure in charging for railway network usage. In the case of the Øresund Bridge, the national railway agencies (both Denmark and Sweden) pay a fixed index-linked amouns for the right to use the railway of the Øresund fixed link. This has been set at DKK 300 million (in 1991 prices) and was indexed to DKK 495 million (EUR 66 million) in 2013. The average increase of the revenue was 2.2% per year. The national railway agencies sell this capacity to rail operators. (11)

Eurotunnel Group signed a contract with the UK and France state railways in 1987. The document establishes a detailed charging framework on the basis of long-term costs, covering all operating costs and allowing for construction investment recovery. The usage charge comprises a fixed element ("Fixed Annual Usage Charge") and a variable cost ("Toll"). The variable charges are based on passenger numbers and cargo tons. (33)

Those charging systems – of the Øresund fixed link and the Eurotunnel – result in more than a 5-fold difference in train rates, per train and when estimated per train kilometre (see Table 28).

Table 28 Rail infrastructure revenues and number of trains of Øresund Bridge and Channel Tunnel

	Øresund (2012)	Eurotunnel (2013)
Income from railway link (MEUR)	65	287*
Number of trains	55,560	20,067*
Revenue per train (EUR)	1,166	14,302
Revenue per train km (EUR)	73	377

*Source: annual reports; * does not include shuttle trains*

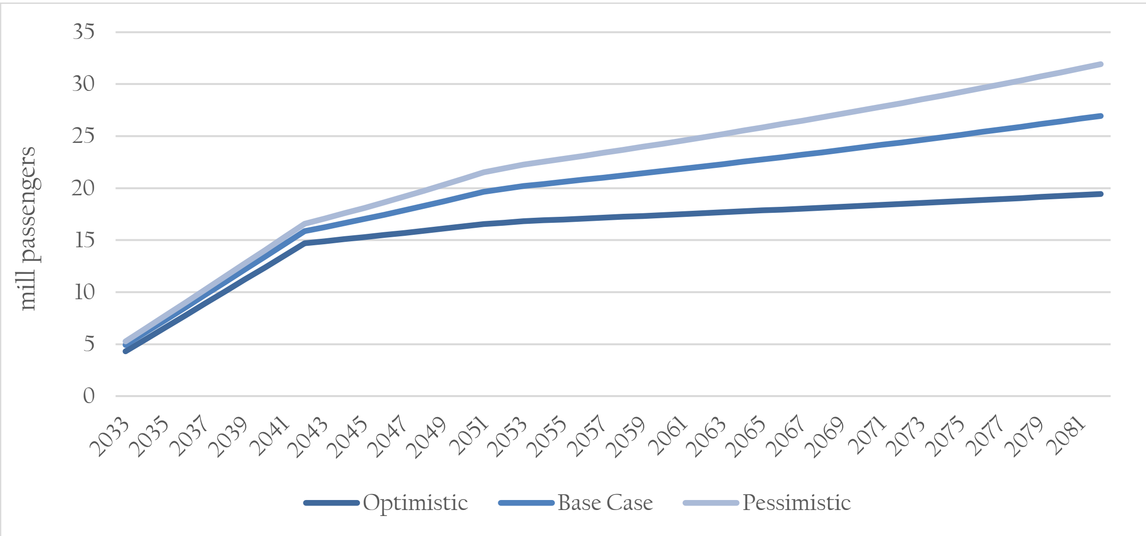
An average freight train crossing the Øresund Bridge had 600–700 tons of cargo in 2010–2012 and in the Eurotunnel 500–550 tons in 2010–2013.

In a final Rail Baltic report, the AECOM has assumed a EUR 0.86 infrastructure charge per container kilometre in the medium scenario, i.e. a train kilometre for a train with 40 rail cars would cost EUR 34. For TALSINKIFIX, **EUR 150 per train kilometre** is assumed for the modelling purposes.

Passenger traffic

Traffic projections are described in more detail in section 5.1. Figure 32 summarises the tunnel passenger traffic starting from the opening year (2033) of the tunnel.

Figure 32 Tunnel passenger traffic projections by scenario



The majority of the customer trips are made by daily commuters, partly also because it is expected that many of the single-trip customers and frequent travellers – especially for leisure purposes – use the ferries. The split between passenger types and mode of travel is provided in Table 29.

Table 29 Share of passengers by type and mode of trip

	2033	2043	2053	2063	2073
Passenger train					
Single trip	29%	13%	14%	14%	14%
Frequent travellers	25%	10%	11%	11%	11%
Daily commuters	21%	55%	53%	53%	53%
Car shuttle passengers					
Single trip	8%	4%	4%	4%	4%
Frequent car travellers	7%	3%	3%	3%	3%
Daily commuters	5%	14%	13%	13%	13%
Coach	4%	2%	2%	2%	2%
TOTAL	100%	100%	100%	100%	100%

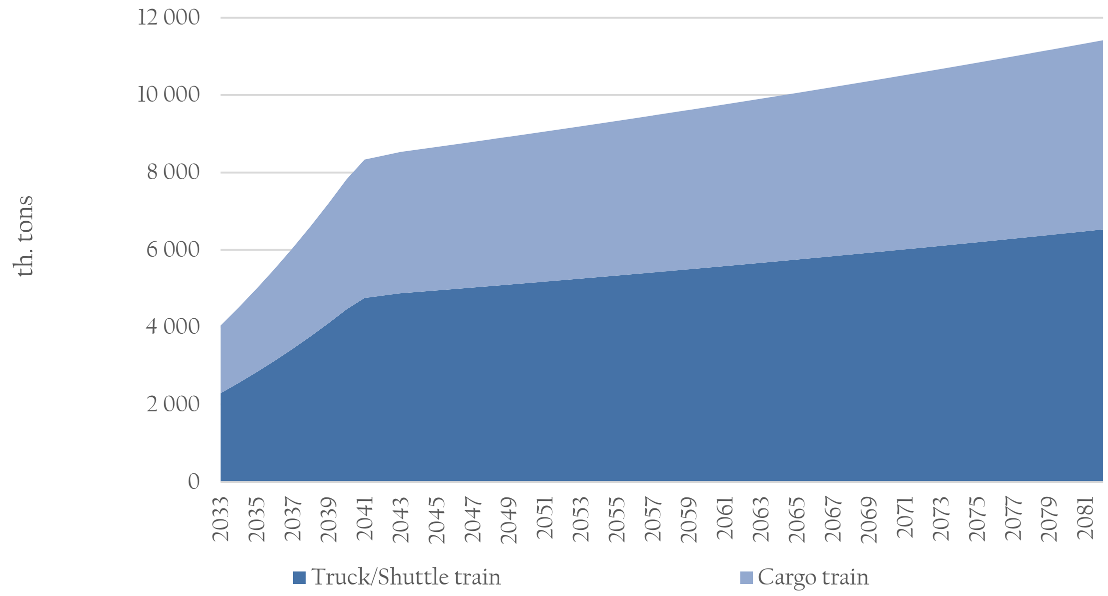
Although daily commuters make up the largest number of the passengers, they also generate the lowest financial revenue as per trip for the Project Company.

Freight traffic

Freight traffic projections are described in more detail in section 5.1. Traffic is almost equally divided between trucks (shuttle train) and cargo trains, whereby the Ro-Ro is 100% allocated to trucks, containers equally (50/50) to trucks and cargo train and bulk cargo 100% to cargo train.

An overview of the cargo volumes is provided in Figure 33.

Figure 33 Development of fixed link cargo volumes by mode of transport



The number of trucks and cargo trains passing through the fixed link is based on 13 tons of cargo per truck and 600 tons per train. These figures are derived from the Eurotunnel and Øresund statistics.

Operating expenses and reinvestments

Costs arising during the operating period are divided into two:

1. Infrastructure management expenses;
2. Shuttle and passenger train operating expenses.

Infrastructure management and operating expenses

The cost estimate is based on benchmarking with the Øresund and Femern Belt projects. Tunnel infrastructure operating expenses are assumed to be mainly of fixed nature. Costs are divided into personnel expenses and other operating costs.

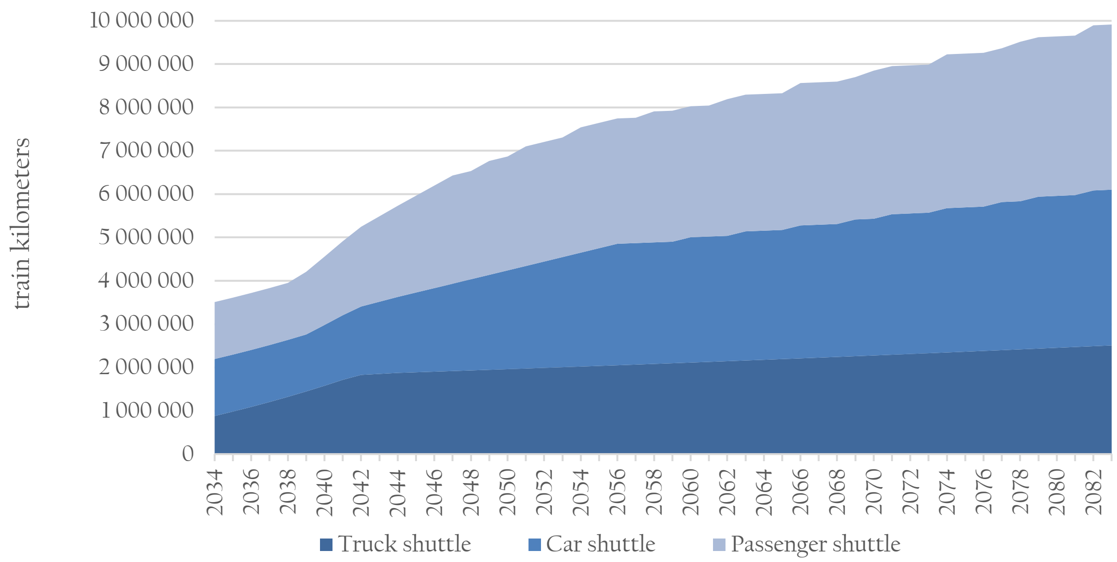
In total, 200 employees are estimated to provide the services, compared to 180 on the Øresund fixed link. The estimated gross salary level is EUR 2,200 a month (in 2014 prices), which combines the Finnish and Estonian labour costs. Additional staff-related costs make up 40% of the gross salary expenses. The cost of personnel is indexed to a combination of expected Estonian and Finland salary growth rates (4–5% a year).

Other operating expenses are estimated to amount to EUR 30 million a year (in 2014 prices).

Shuttle and passenger train operating expenses

The Eurotunnel project and the Finnish railway cost model have been the main benchmarking sources in projecting the operating costs of the shuttle train service. The driver of the costs is the service volume, expressed in travel distance (see Figure 34) and travel time.

Figure 34 Train kilometres of car/coach, truck and passenger shuttle services



The cargo and passenger railway companies in Estonia were also used for benchmarking purposes.

Assumptions of the operating costs are described in section 7.1.2 of this report. Adjustments have been made to personnel expenses, in order to take into account the salary level in Estonia. By combining the Finnish and Estonian salary levels, considerable cost savings have been achieved. Those savings will be partly traded off with a higher salary increase in Estonia over time.

Reinvestments

Annual reinvestments amount to EUR 20 million on infrastructure and EUR 30 million on shuttle/train segments (in 2014 prices). This level of reinvestments will be achieved within 11 operating years.

This reinvestment level is in the same range with the Øresund fixed link and the Eurotunnel.

The replacement costs of amortised rolling stock (trains) have been calculated separately, on the assumption that the useful life of trains is 25 years.

Financing

Three financing sources have been taken into account in the financial model:

- grant from the EU;
- support and equity from governments;
- debt.

The EU grant and the governments' financing is assumed to cover **40%** of investment costs in the base case.

An overview of EU funding opportunities, given the current knowledge, is provided in section 2.2 of this report. For example, the Femern Belt project is expecting less than 20% of investment costs to be covered from EU funds.

Government support will help cover a part of the funding gap not financed from the EU budget.

Remaining part of the funding is expected to come from banks and bond issue. Debt interest rate assumed in the model is 4% a year. Debt principal repayments depend on the cash flows of the Project.

Financial discount rate

The discount rate expresses the time value of money and the risks related to specific investments. The first component is expressed at a risk-free rate and the second one with a risk premium. The most common methodology for estimating the discount rate is the weighted average cost of capital (WACC) approach, which is also used by the Estonian Competition Authority in regulating the utility sector and the Estonian Technical Regulatory Authority in regulating the railway sector.

The Estonian Competition Authority suggested 5.3–6.6% discount rates for the Estonian electricity (distribution), gas, water and heating sectors for the year 2014. The median of the proposed WACC is 5.7%. (39) This relatively low level of WACC is due to the current low global interest rates – in 2013 the suggested WACC was more than 1% higher.

The EU guide to cost-benefit analysis recommends a real interest rate of 3.5% for countries not eligible for Cohesion Fund support (incl. Finland) and 5.5% to eligible countries (incl. Estonia) (33). The average of the two is 4.5%. It can be assumed that Estonia has by the beginning of the Project investments considerably reduced the risks related to its economy and that a 4% real discount rate for the Project would be a justified assumption. By assuming a 2.0% long-term annual inflation, the respective nominal discount rate would be 6%.

Given the information above, the discount rate applied in the evaluation of the Project was therefore 6.0%.

However, we assume that there would be some extra risks related to the TALSINKIFIX project when compared to utility sector companies or average projects supported from the Cohesion Fund. These are most likely related to competition from ferry companies and to the big size and unique technical nature of this Greenfield investment. Therefore a higher discount rate would also be justified.

8.2 Financial Projections

This section provides a summary of the results of the financial projections based on the assumptions discussed in the previous sections.

The project is assumed to start – with the launch of the construction works – in 2025. The operating period is assumed to start in 2033, i.e. after the 8-year investment period. The monetary values are indexed to the respective year and the model thus provides the nominal values of investments, revenues and operating costs.

As can be seen from Table 30, the nominal investment costs have been indexed from the EUR 9.3 billion in the 2014 prices to EUR 12.2 billion in the actual investment period.

Table 30 Investment projections according to the base case investment cost scenario

in million euros	TOTAL	2025	2026	2027	2028	2029	2030	2031	2032
Initial investments, tunnel	13 054	1 548	1 571	1 595	1 619	1 643	1 668	1 693	1 718
Initial investments, trains	1 309	0	0	0	0	320	325	330	334
TOTAL INVESTMENTS	**14 363**	**1 548**	**1 571**	**1 595**	**1 619**	**1 963**	**1 992**	**2 022**	**2 053**

The revenues of the Project are expected to increase faster in the first years of the operating period, in line with achieving the expected maximum market share in the gulf traffic. In 2047 the revenues are expected to exceed the EUR 1 billion mark, supported by the traffic and price increase.

A summary of the projected revenues is provided in the table below.

Table 31 Project revenues of the selected years according to the medium passenger number scenario

in million euros	TOTAL	2033	2043	2053	2063	2073	2083
Train passengers							
Single trip	11 367	62	109	183	246	331	433
Frequent travellers	7 128	44	71	113	153	206	269
Daily commuters	10 769	12	120	174	235	316	413
Total train passengers	**29 263**	**117**	**300**	**470**	**633**	**853**	**1115**
Car shuttle							
Single trip cars	3 721	20	36	60	81	108	142
Frequent car travellers	2 295	14	23	37	49	66	87
Daily commuters	5 340	6	59	86	116	157	205
Coach	580	3	5	9	13	17	22
Total car shuttle	**11 937**	**43**	**123**	**192**	**259**	**348**	**455**
Truck shuttle							
Total truck shuttle	16 220	77	200	263	345	453	579
Freight trains							
Total freight trains	9 664	51	127	161	206	263	327
TOTAL REVENUES	67 084	289	749	1 086	1 443	1 917	2 476

All the operating expenses related to the tunnel infrastructure are categorised into fixed costs and are projected to grow in accordance with the respective inflation rates. The shuttle service costs are mainly of variable nature and are based on traffic volumes (see the assumptions section).

Table 32 Projections of operating expenses for selected years

in million euros	TOTAL 2033–2083	2033	2043	2053	2063	2073	2083
TOTAL REVENUES	81 337	352	912	1 316	1 748	2 322	2 999
OPERATING EXPENSES							
Tunnel infrastructure							
Operating and maintenance	3 017	40	46	54	62	72	84
Personnel expenses	2 515	17	25	37	52	73	103
Total tunnel infrastructure	**5 532**	**57**	**72**	**90**	**114**	**146**	**187**
Shuttle services							
Time driven cost - personnel (drivers)	13 800	40	96	183	285	446	676
Distance driven - fuel, materials etc	6 378	38	71	109	139	180	224
Distance driven - personnel	3 699	11	26	49	76	120	181
Total shuttle service expenses	**23 877**	**88**	**193**	**341**	**501**	**745**	**1 082**
TOTAL OPERATING EXPENSES	29 408	145	265	432	615	891	1 269
OPERATING PROFIT	51 928	207	647	884	1 133	1 431	1 730
	Operating margin	58.9%	71.0%	67.2%	64.8%	61.6%	57.7%

As can be seen from the table above, the operating margin – before depreciation – is expected to increase until the 2040s, starting to decrease thereafter. This is due to a slower growth in traffic volumes and a relatively higher increase in personnel costs.

Table 33 presents a comparison with the Eurotunnel and Øresund fixed link projects. The revenues of TALSINKIFIX are discounted to 2013 to make the figures comparable.

Table 33 Comparison of results with Eurotunnel and Øresund fixed links

	TALSINKIFIX 2034	TALSINKIFIX 2050	EUROTUNNEL 2013	ØRESUND 2013
Revenues (MEUR)	232*	571*	779	223
EBITDA[13] margin	58.9%	68.0%	56.2%	82.5%
Passenger (mill)	4.9	19.2	20.4	25.5
Freight (mill tons)	4.0	9.0	19.1	11.0

** indexed back to year 2013 by applying a 2% annual inflation rate;*

The higher profitability, i.e. the higher EBITDA margin of Øresund can be explained by its different business model – the Project Company there does not provide shuttle services and therefore has lower operating costs. It can be seen from the table above that passenger flows of TALSINKIFIX are on a comparable level with the benchmark projects by 2050. Even by 2050 the cargo flows of TALSINKIFIX are projected not to exceed the volumes of the Øresund Bridge today.

8.3 Results of the Financial Analysis

The outcome of the financial analysis is expressed in internal rate of return (IRR) and net present value (NPV) figures. In addition, the year by which the Project debt is fully repaid was calculated.

The results are expressed under the assumption that **40%** of construction (not rolling stock) costs are financed from the EU and state budgets.

A 6.0% discount rate was applied in calculating the net present value (NPV)[14]. Results of the calculations are presented in Table 34.

Table 34 Results of the financial analysis

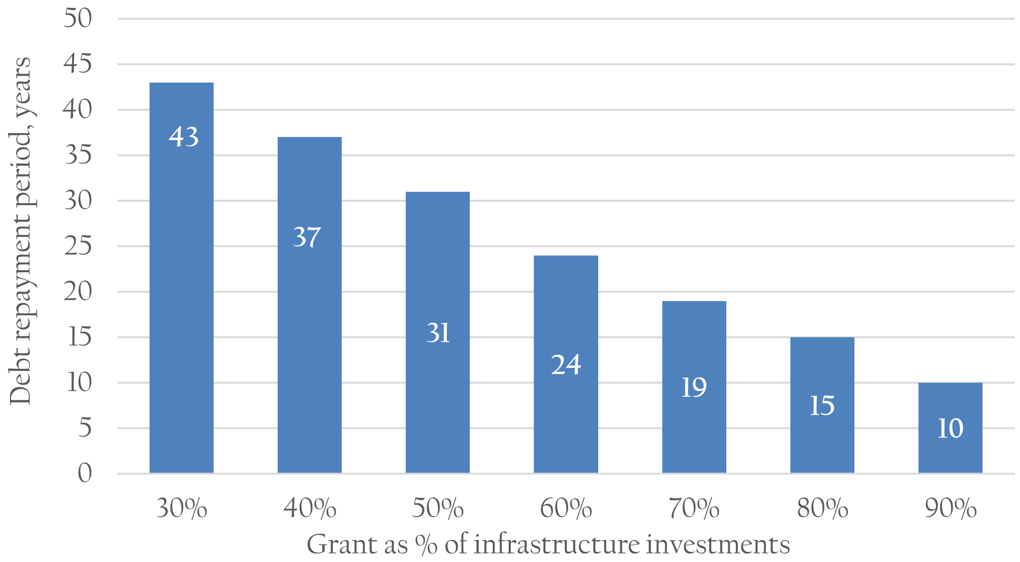
	IRR	NPV (MEUR)
Pessimistic scenario	1.5%	−8,982
Base Case scenario	3.4%	−5,319
Optimistic scenario	5.1%	−1,722

As can be seen from the table above, the Project needs considerable financial support from public sector as the IRR is lower than the reference rate (6.0%) and the NPV of the project cash flows is negative.

The following chart indicates that the project debt can be repaid within less than 50 years when support to the Project exceeds 20% of construction costs (EUR 11 billion in current values). The rolling stock was considered as not eligible for the support.

[13] EBITDA – earnings before interests, taxes, depreciation and amortisation
[14] Net present value is equal to discounted revenues, less discounted expenses and including initial investments

Figure 35 Project debt repayment period by different grant sizes, Base Case



For comparison, the expected debt repayment period of the Øresund fixed link is 34 years, but that project did not received grants from the EU or governments. The financial analysis of Femern Belt project foresees a 32-year debt repayment period, given that the EU support is about 20%.

The following conclusions can be drawn from the financial analysis:

- This preliminary financial analysis indicates that the Project will not be sustainable without considerable support from the public sector (EU, governments). However, it is assumed that with a support of 30% of construction costs or more, the Project could be feasible – also considering the state guarantees – as has been proven in the Øresund project and is also the case in the Femern Belt project.
- This preliminary feasibility study is based on examinations of studies conducted with regard to projects carried out until today as well as on benchmarking to comparable undertakings. Since the Project development today is at a very early stage, no in-depth analyses have yet been conducted. Therefore the outcomes of the current analysis are highly indicative and it is suggested that further analyses be performed in order to base decision-making on more solid ground.

9. Socio-Economic Analysis

9.1 Components of the Economic Analysis

The starting point of the economic analysis is the financial analysis. The methodology for the economic analysis can be summarised as follows:

- Converting market prices to accounting prices
- Monetisation of non-market impacts
- Social discounting
- Economic performance indicators.

From market prices to accounting prices

The reason for conversion is that prices set by markets or by governments sometimes do not provide a good measure of the social opportunity cost of inputs and outputs.

In the current analysis, specific conversion factors were applied to labour and energy costs, and a standard conversion factor to other costs, except for imports.

Labour cost

The difference between the market wage and the social opportunity cost of labour lies in the specificity of the labour market that may overrate (less frequently underrate) the opportunity cost of labour due to specific market features.

Regional unemployment and social tax contribution are elements of a simplified formula which is used to determine the conversion factor for labour cost: (35) p306

$$SW = W\,(1-u)(1-t)$$

where SW is the social wage, W is the market wage, u is the regional unemployment rate, and t is the rate of social security payments and relevant taxes. The factor t was used only for unskilled labour (see below).

Seasonally adjusted unemployment was 7.6% in Estonia and 8.7% in Finland in August and September 2014 respectively[15]. By the end of 2019 the International Monetary Fund forecasts 6.5% and 7.4% for Estonia and Finland respectively. In the model, a 7% long-term unemployment rate was used.

Separate conversion factors for skilled and unskilled labour were estimated. There are two reasons for this:

1) Unemployment of skilled labour has historically been lower compared to that of unskilled labour, i.e. respective adjustment factors have been applied to long-term unemployment rates[16]; (36)
2) Unskilled labour is more open to informal/black market; therefore a 35% social tax discount was applied to the cost of unskilled labour.

Estimations of the conversion factors for labour are provided in Table 35.

Table 35 Conversion factors for labour cost

	Skilled	Unskilled
Coefficient (applied to 7.0%)	0.73	1.37
Long-term unemployment (u)	5.1%	9.6%
Conversion factor (1-u)	***0.95***	***0.90***

[15] Eurostat
[16] From K.Philips, M.Loova (2005)

Tax component (t)	0.0%	35.0%
Tax conversion factor (1-t)	*1.00*	*0.65*
Total conversion factor	***0.95***	***0.59***

Source: Philips et'al; IMF

The conversion factors are applied to labour cost in both the investment and operating costs.

A three-step approach has been used to estimate the proportion of the labour costs and unskilled/skilled labour costs in the tunnel investments:

1) Allocation of the investments to geographical source: imported from other EU countries, from Estonia and from Finland. This was based on the expert opinion of the project team members, as it was not possible to rely on empirical evidence.
2) Share of labour costs in standard investment costs in Estonia and Finland. Based on statistics of civil engineering (Eurostat) and manufacturing of electric machinery (statistical offices) industries.
3) Share of unskilled labour in total labour. Based on Statistics Estonia data for the construction industry. For technical systems, a 20% share was assumed for maintenance canals.

Overview of the above assumptions is provided in Table 36.

Table 36 Proportion of labour costs in tunnel investments

	Contracted from			Labour cost share		Share of unskilled labour
	Other EU	Estonia	Finland	Estonia	Finland	
Tunnels + track, 85 km	30%	40%	30%	15%	25%	28%
Surface track, 90 km	30%	40%	30%	15%	25%	28%
All technical systems, maintenance canals etc.	50%	10%	40%	14%	20%	20%
Finnish cargo terminal and passenger station	30%	40%	30%	15%	25%	28%
Estonian cargo terminal and passenger station	30%	40%	30%	15%	25%	28%

Source: Statistics Estonia, Statistics Finland, Eurostat

In the operating part, the labour costs were estimated directly and the allocation as described above was not needed. The respective share was determined using the average share of unskilled labour in the transportation and logistics industry (22%), based on Statistics Estonia data.

Energy costs

Although the energy market can be considered perfect, the energy (liquid fuels, natural gas, electricity) consumption is subject of excise tax, i.e. indirect taxes, which are part of fiscal correction.

The only considerable energy consumption item among the Project cost positions – both investments and operating – is electricity expenses of the train traffic. It is assumed that the tunnel will be electrified and the trains will run on electricity.

In 2013, the estimated share of excise tax (today 4.5 EUR/MWh) in the final price of electricity in Estonia was 5.6%. It was assumed that the rate will remain same also in the future and therefore the conversion factor of 0.944 was applied to electricity expenses.

Standard conversion factor

The standard conversion factor of 0.95 was applied to other cost items, given the proportion of labour and energy (also liquid fuels, which have a relatively higher excise tax level) among other expenses. The conversion factor of 1.0 was applied to imported goods, as those are assumed to be sourced from EU countries. The duty on imported goods is generally very low in Estonia and can therefore be ignored.

Monetization of non-market impacts

The second step of the economic analysis is the inclusion of the appraisal of the project effects which are relevant for the society, but for which a market value is not available. The value of time and impact on climate changes were quantified and monetized in the economic evaluation.

Value of time

Time benefits often represent the most relevant part of a transport project's benefits. Also, the main purpose of the Project is to make the crossing of the Gulf of Finland faster.

The passengers' value of time generally varies according to the purposes of travel and is largely dependent on income. According to a EU guideline, the value of non-working travel time (including homework commuting) vary in most countries, from 10% to 42% of the working time value. (35)

The value of working time is usually derived using the resource cost principle, i.e. the marginal value of production lost to the economy per travel hour, predominantly measured by the **average wage cost per hour**. (37)

When analysing the Fehmarn Belt traffic, COWI arrived at the result that the average household income of the Fehmarn Belt business travellers is about 80% higher and the average household income of leisure travellers about 70% higher than the average income of German households. (37, p 2–8) Considering this, we increased the incomes – compared to the country's average hourly earnings – of TALSINKIFIX travellers by 50%.

The following table provides the values used in the current analysis:

Country's median hourly earnings (euros), in 2013	
Estonia	8.6
Finland	37.5
Value of time as % of average hourly earnings	
Business	90%
Holiday, leisure, commuting	30%

Source: Eurostat

The earnings are indexed with the nominal salary growth rate.

For **cargo** traffic, time savings per trip from Tallinn to Helsinki can be higher compared to a passenger trip. Firstly, trucks use slower ferries and secondly, the lead time (i.e. time for waiting for the start of the trip) is longer for trucks but gets considerably shorter due to the round- the-clock service and thirdly, there will be no change-over loading from train/truck to ferry for bulk and container cargo.

In the model, the average time saving of 3 hours was applied for cargo, which can be considered as conservative.

The cost of time for cargo is less analysed in the literature, although there is considerable advantages to consider:

1. The rolling stock – trains, trucks – and the drivers' time can be used more efficiently;
2. The cargo owners have a faster working capital turnover.

The value estimate was based on road freight costs assumed in the AECOM's study and was EUR 0.9–1.15 per km (in 2010 prices)[17]. The obtained value was transferred to the per hour/ton basis, using the assumed average speed (60 km/h) and cargo volume (13 tons) of trucks. An additional coefficient was applied for also considering the lower cost of train transportation compared to trucks.

The values of EUR 2.3 and EUR 1.2 per ton and hour were used for unitised and bulk cargo volumes respectively. Those values from 2010 were transferred to the Project period with 2% annual growth assumptions. Induced traffic was not included in the time saving calculation.

Climate change

The climate change or global warming impacts of transport are mainly caused by emissions of greenhouse gases, i.e. carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH4).

According to the methodology, the various greenhouse gas emissions will be added to the total CO_2 equivalent greenhouse gas emission, using the Global Warming Potentials[18]. (38) The total tonnes of CO_2 equivalent greenhouse gas emission will be multiplied by an external cost factor expressed in €/tonne to estimate the total external costs related to global warming.

The central values recommended in the CE Deft study[19], based on damage avoidance and damage value approaches, were used in the modelling.

Table 37 Recommended values for the external costs of climate change (in €/tonne CO_2), expressed as single values for a central estimate and lower and upper values

Year of application	Lower value	Central value	Upper value
2020	17	40	70
2030	22	55	100
2040	22	70	135
2050	20	85	180

Source: CE Delft

Emission figures of ferries and passenger trains per passenger and cargo trains were applied to determine the emission quantities. Values used in the analysis are provided in Table 38.

Table 38 Air emissions per ship, train ton and train passenger kilometre

Mode	Value
Tallinn–Helsinki ferry emissions (g per ship km)	499,983
Train emissions – passenger (g per passenger km)	53.4
Train emissions – cargo (g per cargo ton km)	56.8

Source: European Environment Agency; VTT Lipasto[20]

Train emissions in the table above express the emissions of electric trains and are related to the emissions of electricity production. In the calculation, the share of green electricity, which produces zero emissions, was assumed to be 50%.

[17] See AECOM page 89
[18] For CH4 the Global Warming Potential (GWP) = 23, for N_2O GWP = 296
[19] The study was commissioned by the European Commission DG TREN
[20] http://lipasto.vtt.fi/yksikkopaastot/henkiloliikenne/vesiliikenne/autolautta.htm

Social discount rate

Although some literature sources suggest using a lower discount rate for economic costs and benefits compared to the financial analysis, convincing arguments to decrease the discount rate are few, given that the project risks remain unchanged.

The nominal discount rate applied in the economic cost-benefit evaluation was therefore also **6.0%**.

9.2 Socio-economic estimates

Besides striving to improve travel conditions for passengers and goods, transport infrastructure projects with a wider public interest also aim to have a positive impact on the general economy. General economic objectives are usually expressed in increased employment, GDP and government budget figures.

Impact on GDP

Spiekermann & Wegener have used the regional economic simulation model SASI[21] to forecast the socioeconomic impacts of the Tallinn–Helsinki tunnel[22]. (40)

The analysis assumes that the rail tunnel link between Helsinki and Tallinn will be completed by 2036 and the rail travel time between Helsinki and Tallinn will be 30 minutes. In addition, the scenarios analysed also assume the completion of Rail Baltica. The impact is measured in 2051, i.e. 15 years after the completion of the tunnel.

The model estimates isolated the GDP effects of both Rail Baltica and the Tallinn–Helsinki tunnel.

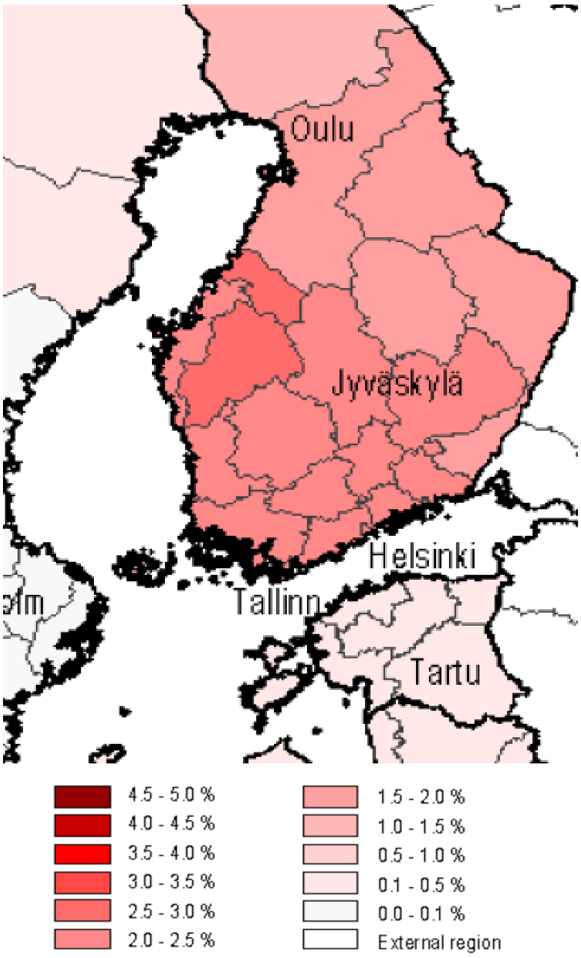
The impact of Rail Baltica in terms of GDP per capita is bigger in the western part of Estonia, where GDP per capital is expected to be 4–5% higher compared to the situation without Rail Baltica by 2051. In other parts of Estonia the impact is in the range of 0.1–2.5%.

The Helsinki–Tallinn tunnel will almost exclusively have an impact on Finland (see Figure 36) as it is now better connected to the central, eastern and southern Europe, whereas Estonia, Latvia and Lithuania do not benefit much (up to 0.5% of GDP). The impact, measured by a 1–3% increase in GDP per capita, spreads relatively evenly around the country, also reaching the far north areas.

[21] SASI is recursive-dynamic simulation model of socio-economic development of NUTS-3 regions in Europe, subject to exogenous assumptions about the economic development of the European Union as a whole due to transport systems improvements. It measures the impacts of transport on regional development by modelling GDP per capita based on six economic sectors.

[22] www link: http://www.spiekermann-wegener.de/pro/pdf/HTTPS_SuW_FinalReport.pdf

Figure 36 Isolated spatial impact of the Helsinki–Tallinn rail tunnel: GDP per capita in 2051



Although it appears that the improvements in accessibility translate into rather small gains in economic activity, it has to be considered that these additional revenues accrue to every citizen every year.

Spiekermann (et al) also pointed out that the relative accessibility changes through the rail tunnel look different if the destinations of interest are limited to the Helsinki–Tallinn macro-region. In that perspective, Tallinn and other regions of Estonia would benefit from the fast rail connection with the larger Helsinki metropolitan area.

Spiekermann (et al) concluded that the rail tunnel between Helsinki and Tallinn would be successful in bringing Finland closer to the European mainland and linking Helsinki and Tallinn into one integrated metropolitan region.

Impact on employment

The direct employment impact of the Project is manifested in the employment rate related to the construction works, employment of the Project Company in the operating phase and a reduced employment rate in ferry services.

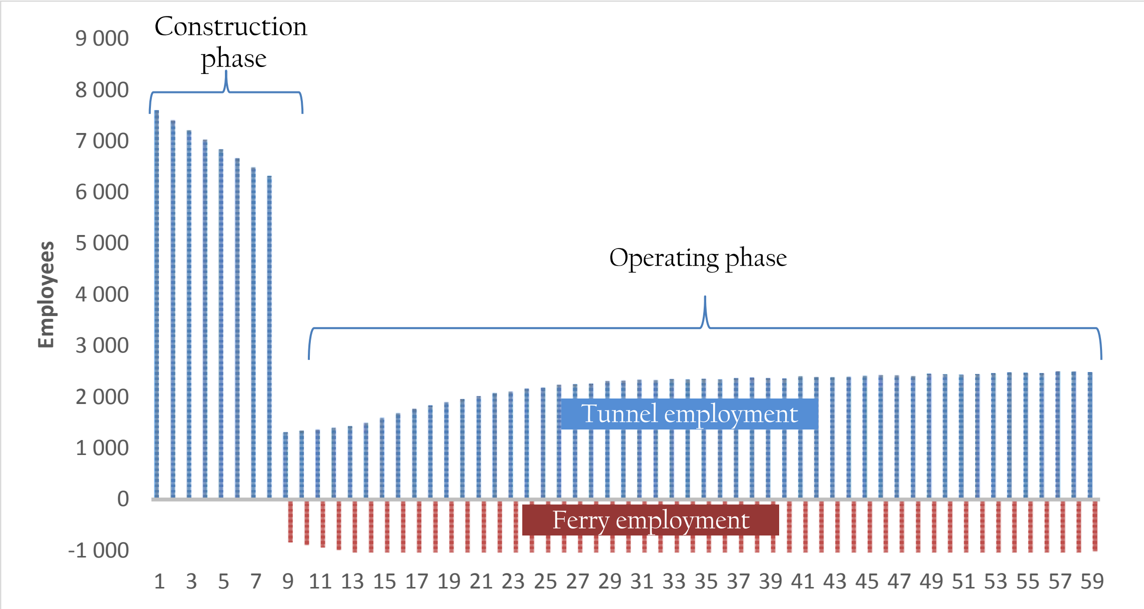
Estimations were based on the following approach and assumptions:

- The share of contracting from Estonia and Finland was considered in the construction phase. The share of labour costs in construction activities was considered and the industry average salary level was applied to derive the employment numbers.

- The number of employees in the operating phase was determined in the financial analysis, based on the cost of personnel of the Project Company and the weighted average salary level of Finland and Estonia.
- The water transport sector is going to lose revenues and jobs. The loss of revenues of ferry companies is conditioned by lost traffic and the average price level. Induced traffic (commuters etc) was not included in the calculation.

The results of the estimation of direct employment impact are presented in Figure 37.

Figure 37 Direct impact of the Project on employment and on the water transport sector



It can be seen from the table above that in the operating phase the new employment considerably exceeds the decrease of employment in the ferry sector, which is largely due to the induced traffic in the tunnel.

In addition to direct employment, the employment is influenced by intermediate consumption in the investment phase (e.g. construction materials, energy etc) and intermediate consumption of the Project Company (goods and services).

Based on a macroeconomic input-output framework, coefficients were calculated to estimate employment in the sectors which deliver goods and services to construction companies and the Project Company. It appeared that on top of one direct job the construction works generate 1.6 indirect jobs. In the transport sector the respective coefficient is 0.8.

Based on this, the estimated total employment in the investment phase is 2.6 times and in the operating phase 1.6 times the direct employment. This means about 12,000–13,000 full-time jobs (human years) per year in the investment phase and 3,000–4,000 in the operating phase.

The induced impact of the fixed link will also have a positive effect on employment. The magnitude of this can be indicated from the expected GDP increase. According to Spiekermann & Wegener, the Tallinn–Helsinki tunnel will enhance GDP per capita by 1–3%, depending on the region. Assuming that productivity in generating this additional GDP equals the countries' average productivity, employment will increase at the same pace with the GDP increase.

9.3 Economic Cost-Benefit Projections

Conversion from market prices to accounting prices has reduced the investment costs by 1.6% and operating costs by 8.6%, to 10.4%, depending on operating year.

The economic value of investment costs – the higher end of the estimated range – is provided in Table 39.

Table 39 Conversion of investment costs

	FACTOR	SUM	2025	2026	2027	2028	2029	2030	2031	2032
Import of goods and services	1.00	3,999	570	468	475	482	490	497	504	512
Skilled labour	0.95	909	131	106	108	109	111	113	114	116
Unskilled labour	0.59	196	29	23	23	23	24	24	25	25
Other costs	1.00	7 765	791	952	967	981	996	1 011	1 026	1 041
Total tunnel infrastructure investment		12 868	1 521	1 550	1 573	1 596	1 620	1 645	1 669	1 694
Investments, trains	1.00	1 309	0	0	0	0	320	325	330	334
TOTAL INVESTMENTS		14 176	1 521	1 550	1 573	1 596	1 940	1 969	1 999	2 029
% to financial value			98.2%	98.6%	98.6%	98.6%	98.8%	98.8%	98.8%	98.8%

A considerable economic benefit of the Project results, as expected, from the value of time for passengers. Smaller benefits result from time savings in cargo traffic, while the effect of the emissions of greenhouse gases is estimated to be marginal. The impact of the Project on climate change is likely to be negative.

Projections of the economic benefits are provided in Table 40.

Table 40 Estimation of the Project net benefits for selected years

in million euros	2033	2043	2053	2063	2073	2083
OPERATING REVENUES						
TOTAL REVENUES	352	912	1 316	1 748	2 322	2 999
OPERATING EXPENSES						
Total tunnel infrastructure	53	66	83	104	132	169
Total shuttle service expenses	79	173	304	444	659	953
TOTAL OPERATING EXPENSES	132	239	387	548	791	1 122
OPERATING PROFIT	221	673	930	1 200	1 531	1 877
TOTAL REPLACEMENT INVESTMENTS	7	68	88	102	118	137
TOTAL OPERATING CASH FLOWS	214	606	842	1 098	1 413	1 740
VALUE OF TIME SAVINGS						
Total value of time – passenger traffic	158	341	707	1 166	1 933	3 188
Total value of time – cargo traffic	13	33	44	58	76	99
EMISSION COST						
Total emissions costs (–)	0	0	1	1	1	1
NET BENEFITS OF THE PROJECT	385	980	1 592	2 321	3 421	5 026

The table above only measures the monetised economic revenues and costs of the fixed link, and does not therefore express the wider economic impact of the Project, like GDP growth and employment. According to the methodology, the general growth of GDP is connected to the usage of resources (e.g. labour, capital), which are accounted as costs and cannot therefore be considered as benefits of the project. However, employment, income, tax revenues etc can be considered as wider positive impacts of the Project and can be taken into account in the decision-making process.

9.4 Results and Conclusions

The outcome of the economic analysis is expressed in terms of economic rate of return (ERR) and economic net present value (ENPV). The results of the calculations are provided in the table below.

Table 41 Results of the economic analysis

	ERR	ENPV (MEUR)
Pessimistic scenario	4.6%	–3,742
Base Case scenario	6.7%	2,018
Optimistic scenario	8.5%	7,093

Conclusions of the economic analysis are as follows:

- Positive economic impact – especially the passenger time savings – is estimated to cover the bigger part of the financial deficit of the Project. Economic outcome, expressed in ERR and ENPV, is positive in the Optimistic scenario as well as in the Base Case scenario.
- The outcome likely to derive from positive indirect – wider economic – effects of the increased efficiency of the transport link. Those likely effects are described in section 5.7. The possible impact on GDP and population has also been calculated in the analysis by Spiekermann & Wegener, a German research institution. The results of the latter are presented in section 9.2 of the report. (40)
- It should be noted that according to the methodology, indirect effects occurring in efficient markets should not be included in the evaluation of the project costs and benefits. The main reason for not including indirect effects is the fact that they are irrelevant in a general equilibrium setting, as they are already captured by shadow prices. (35)

9.5 Sensitivity

In order to assess the project's economic resilience to changes in key parameters, a number of sensitivity tests have been performed. The following section describes the individual sensitivity ability calculations and the results are expressed in terms of changes in the expected debt repayment period, IRR and ERR.

Investment costs

The investment cost estimate is based on benchmarking to similar works and projects. However, a 90-kilometre rail tunnel is unique not only in terms of length but also by its geological and other conditions. The Channel Tunnel project has shown that underestimating investment costs by 50% or more can be a real possibility.

The sensitivity of the Project outcome has been tested to ± 20% change in total investment costs, i.e. including all of its elements. An analysis shows that a 20% decrease in costs will result in a 9-year decrease in the debt repayment period:

Scenario	Tested value	Change from Base Scenario	Effect on the repayment period	IRR	ERR
Base Case	**EUR 11b**	**0.0%**	**37 years**	**3.4%**	**6.7%**
Higher cost	EUR 13.7b	20.0%	+11 years	2.7%	5.8%
Lower cost	EUR 8.5b	−20.0%	−9 years	4.4%	7.8%

Operating and maintenance costs

The Øresund and the Eurotunnel benchmark projects and the operating cost model based on Finnish railways have been the main sources in estimating the operating costs of the TALSINKIFIX project. The costs have been partly adjusted to the Estonian labour costs level, which allowed considerable savings when compared to the benchmarks.

The operating model, based on different types of shuttle trains, is unique and therefore exposed to high uncertainties.

Sensitivity calculations tested a 20% change in the operating cost level, compared to the Base Case. As it can be seen from the table below, a lower cost level results in a 4-year decrease in the debt repayment period:

Scenario	Change from Base Scenario	Debt repayment period / Change	IRR	ERR
Base	**0.0%**	**37 years**	**3.4%**	**6.7%**
Higher cost	20.0%	+6 years	2.9%	6.5%
Lower cost	−20.0%	−4 years	3.9%	6.9%

Service prices

The prices of the services – passenger, car and truck fares, infrastructure charges for cargo trains – are, where possible, benchmarked to the current ferry prices. Due to the lack of information in public sources, comparable information for some services – truck rates and train infrastructure fees – is very scarce and indirect. Commuting traffic will be a new traffic segment on the Gulf of Finland and the sensitivity of commuters to the price level is unknown. Therefore, an important task in the next stage of the Project preparation would be to conduct a deeper analysis of suitable price levels, also taking into account the elasticity of potential demand.

The table below provides information about the sensitivity of the main outcome indicators to the price level. The higher price scenario means, for example, that the base price for passengers is increased from EUR 36 per one-way trip to EUR 43 and all the discounted prices (for frequent passengers and commuters) are changed respectively.

This estimate does not consider the elasticity of demand with regard to the prices. The latter will reduce the direct impact of the price change, e.g. when the price is increased the traffic will shrink and reduce the expected positive impact on the revenues:

Scenario	Change from Base Scenario	Debt repayment period / Change	IRR	ERR
Base	**0.0%**	**37 years**	**3.4%**	**6.7%**
Higher price	20.0%	−10 years	4.6%	7.3%
Lower price	−20.0%	+15 years	1.8%	6.0%

Traffic forecast

The traffic forecast is linked to a wide variety of underlying assumptions, especially to general economic growth. The (daily) communing, as mentioned in the previous section, will be an entirely new segment and therefore entails extra uncertainties. The forecast incorporates a ramp-up period for commuter traffic, which represents a staged or adjustment period before the traffic across the fixed link reaches the full forecast level.

Cargo traffic is very much dependent on the success of the Rail Baltica project. There are also some regulatory issues – carbon regulation, road charges – to consider, which also increase the uncertainty.

The sensitivity test has been performed with ± 20% difference in the level of traffic when compared to the base scenario:

Scenario	Change from Base Scenario	Debt repayment period	IRR	ERR
Base	**0.0%**	**37 years**	**3.4%**	**6.7%**
Higher traffic	20.0%	−8 years	4.3%	7.5%
Lower traffic	−20.0%	+15 years	2.5%	5.7%

Interest rate

Interest expenses do not influence the operating performance (measured by IRR and ERR) as those are calculated before financial expenses, but they do influence the financial sustainability of the Project.

Given the low interest rate level of today, the nominal interest rate on the Project debt was set at 4%. For example, the 30-year Euribor swap rate was 1.68% at the end of November 2014. It is assumed in the analysis that governments will provide a guarantee to the Project Company, which will also reduce the interest rate.

By the start of the Project investments, the economic situation can change and interest rates may change as well, especially upwards:

Scenario	Interest rate	Debt repayment period / Change
Base Case	**4.0%**	**37 years**
Lower rate	3.0%	30 years

The above sensitivity test does not indicate the likelihood that actual developments would differ from the central business case, but serves as an illustration of the different risk characteristics of the Project.

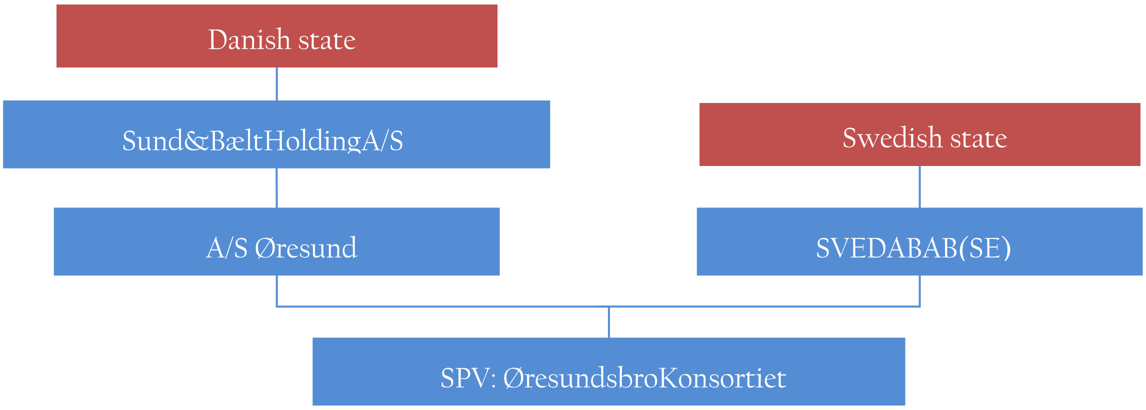
10. Organization and Funding

10.1 Organisation

It is common to establish a special purpose entity for bigger standalone projects, thereby shielding the project sponsors' other assets from the detrimental effects of a project failure. As a special purpose vehicle (the **SPV**), the project company has no assets other than the project.

The SPV based structure is common also in the case of public sector owned revenue-generating projects. The Øresund fixed link would be the good example of a publicly owned SPV, and the Channel Tunnel the example of privately owned SPV.

Figure 38 Øresund structure

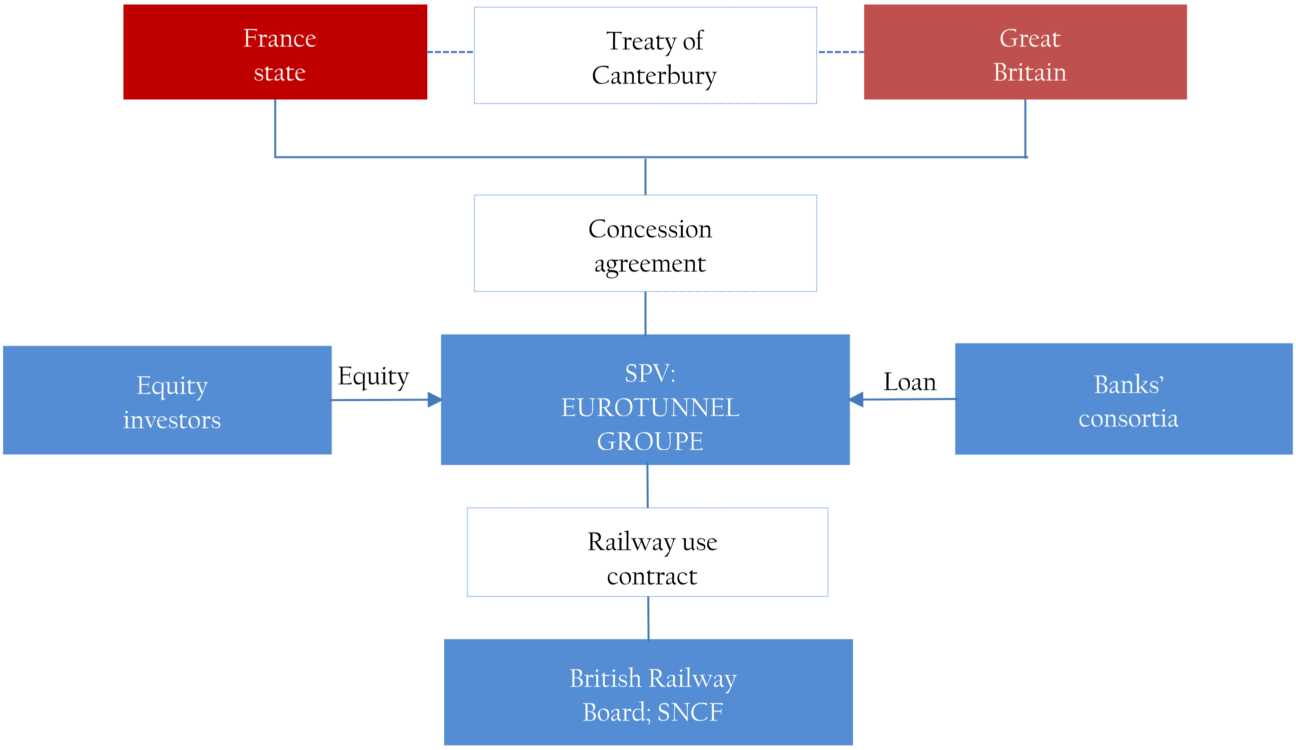


- ØresundsbroKonsortiet's ownership and objectives are set out in the Danish-Swedish Government agreement of 1991 and in the Consortium Agreement between SVEDABAB and A/S Øresund, which has been approved by both countries.
- ØresundsbroKonsortiet's responsibility is to own and operate the Øresund Bridge. Loans for the link and the land-works will be repaid from the revenue from the Øresund Bridge, primarily from road traffic.
- The owners are jointly and severally liable for ØresundsbroKonsortiet's liabilities.

Eurotunnel example

The structure and organisation chart of the Eurotunnel presented below is a classic example of public private partnership **(PPP),** where the private party takes responsibility for the financing, construction and operating of the infrastructure assets and related services.

Figure 39 Eurotunnel structure



Source: Eurotunnel Group; Annual review 2013

- **Canterbury treatment**: ratified in 1987 by the parliaments of both countries, it authorises the construction of the cross-Channel Fixed Link and its operation by private concessionaires with no public funding or guarantee.
- **Concession agreement**: defines Eurotunnel's rights and obligations for the design, construction, financing and operation of a rolling motorway throughout the duration of the Concession, namely until 2086.
- The Eurotunnel Group, a company listed on the Paris and London stock exchanges, is active in the fields of infrastructure management and transport operations.
- The Eurotunnel Group's core business is the operation of the cross-Channel Fixed Link, for which it is the concessionaire until 2086.
- The **Railway Usage Contract**: defines the conditions for Access to the infrastructure and the charging framework based on long-term costs that allow Eurotunnel to cover all operating costs and recover the initial investment. It guarantees non-discriminatory access to all accredited railway operators.
- The Shuttle services – both passenger cars and trucks – are provided by the Eurotunnel Group and are entirely free to set their prices.

In both examples presented above, the project SPV was responsible for the construction of the fixed link and the financing of the investments, and is responsible for the operation and maintenance of the project assets. SPV is free to decide which services they will provide themselves and which will be outsourced.

PPP

Using the public private partnership (**PPP**) model is justified if the private party is in a better position to control and bear the risks of the project and a reasonable portion of the risks can be transferred to the private party. Only when this is the case, it is possible that the benefits resulting from the expertise and efficiencies that the private sector can bring to the delivery of certain facilities and services will outweigh the higher cost of invested capital, complicated procurement process and also somewhat lower flexibility of the structure compared to the traditional approach.

Given the significant role that PPPs have adopted in the development of public sector infrastructure, in addition to the complexity of such transactions, the European PPP Expertise Centre (EPEC) was established to support public-sector capacity to implement PPPs and share timely solutions to problems common across Europe with regard to PPPs[23].

However, in the case of the TALSINKIFIX project, there are several arguments supporting the publicly owned and managed approach. Some of these are as follows:

- The Project is in a considerable part driven by socio-economic factors, whereas private sector is primarily oriented on financial targets;
- Technical uncertainties related to the unique length of the tunnel and geological aspects of the Gulf of Finland pose unpredictable risks;
- Relatively small hinterland when compared to projects of similar size (Eurotunnel, Øresund Bridge, Femern Belt tunnel) and respectively, higher risks related to potential revenue streams;
- Combining possible EU grants with private partnership raises difficult structuring issues;
- Rather negative experience with private Eurotunnel and a relatively positive experience with the state-managed Øresund Bridge;
- Financial institutions are more sensitive to risks in the current global economic environment;
- Long period for potential owners from the start of the investments to incoming cash flows from the project.

Besides the rather controversial Eurotunnel PPP project, there have been some highly controversial PPP road projects in Australia. Those examples include the Airport Link, the Cross City Tunnel and the Sydney Harbour Tunnel (all in Sydney).

10.2 Funding

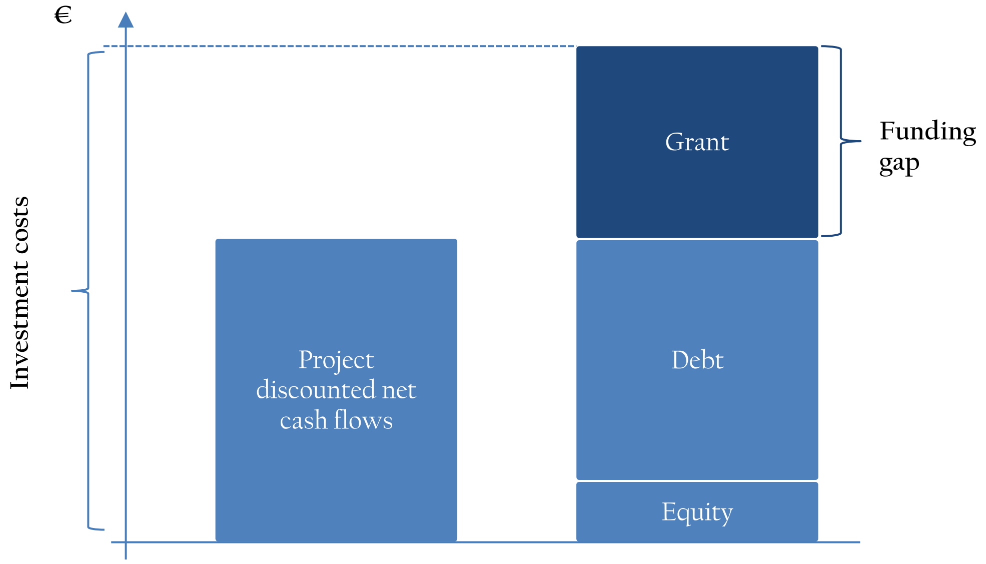
Typical project financing most commonly includes non-recourse loans, which are secured by the project assets and paid entirely from the project cash flows, rather than from the general assets or creditworthiness of the project sponsors. The financing is typically secured by all of the project assets, including the revenue-producing contracts. Project creditors are given a lien on all of these assets and they are able to assume control of the project if the project company has difficulties complying with the loan terms.

Equity contributions by the owner of the project company – also in the case the owner is the public sector – are sometimes necessary to ensure that the project is financially sound or to assure the creditors of the sponsors' commitment.

Financial modelling will give an indication of whether a project is financially feasible and can be financed from the traditional funding sources (debt and equity) or whether it needs public support, i.e. it has a funding gap (see Figure 40).

[23] http://www.eib.org/epec/

Figure 40 Project funding structure



The proportion of debt and equity in a particular project's funding structure depends on the risks related to the project. In the example of the Øresund Bridge project, the Swedish and Danish governments have jointly guaranteed the liabilities of the project company and it was almost fully financed by loans.

Such a guarantee, which will be accounted as a liability in public sector accounts, would have two main positive impacts on the financing of projects:

- Guarantee may allow to arrange debt on more favourable terms, e.g. regarding the length of the debt and interest rate;
- In some cases – when risks are very high – it will enable the project to receive loan financing at all.

ØresundsbroKonsortiet estimated in 2013 – based on the latest traffic forecasts – that the company's debt can be repaid within 34 years after the opening of the Bridge in 2000. Supported by the joint and several guarantees provided by the Danish and Swedish governments, the consortium has obtained the highest possible rating (AAA) from the credit agency of Standard & Poor's. (15)

It is common that multilateral financing institutions provide debt funding to big infrastructure projects of public interest. In the Nordic region, the following institutions are the potential providers of first-round debt financing:

- European Investment Bank (EIB)
- Nordic Investment Bank

For example, the EIB has lent over 1 billion euros to the Øresund Bridge project. In a usual structure, the financing consortia combine multilaterals as well as commercial banks, and in some cases also bond financing.

Besides bank loans ØresundsbroKonsortiet financed the building of the Øresund Bridge by issuing government guaranteed bonds on the international credit market.

Grant financing

The need for direct public sector support depends on the size of the funding gap. There can be two realistic sources of public sector funding or grants for the TALSINKIFIX project:

- State budgets of Estonia and Finland;

- Support from the EU budget.

The new EU infrastructure policy tripled EU financing through the Connecting Europe Facility (**CEF**) to EUR 26 billion for transport for the period 2014–2020. The EU support will effectively act as 'seed capital' to stimulate further investments by the Member States.

It should also be considered that the European transport infrastructure requires huge investments and the larger share will always come not from the central budget but from the Member States. The EU's role in terms of investment and co-ordination is to add value by removing difficult bottlenecks and building missing links and connections, and to support the creation of a real European transport network. It is estimated that the level of investment needed on the EU's core transport network for 2014–2020 amounts to EUR 250 billion.

The core transport network, the TEN-T, will form the backbone for transportation in Europe's single market, to promote growth and competitiveness.

The TALSINKIFIX project corresponds well to the main problem areas which are listed in the policy document of the European Commission and need to be tackled at the EU level:

- Missing links, in particular at cross-border sections.
- There is a considerable disparity in quality and availability of infrastructure between and within the Member States (bottlenecks).
- Transport infrastructure between the transport modes is fragmented.
- Investments in transport infrastructure should contribute to achieving the goals of reduction of greenhouse gas emissions in transport by 60% by 2050.

80% to 85% from EUR 26 billion for the period 2014–2020 will be used to support priority projects along the nine implementing corridors on the core network. The Helsinki–Tallinn connection is part of North Sea-Baltic Sea corridor, where the most important project is Rail Baltica.

The Commission will publish regular calls for proposals to make sure that only the best projects with the highest EU added value receive EU funding.

The **normal** co-financing rates for TEN-T projects on the core network will be:

- Up to 50% EU co-financing for **studies**.
- Up to 20% for **works** (for example exploratory works for a major tunnel)
- There are certain possibilities to increase co-financing for **cross-border projects for rail** and inland waterway connections (up to 40%).

For the Member States eligible for the Cohesion Fund, the maximum co-funding rates increase to 85%. Estonia belongs to the countries eligible for Cohesion Fund co-funding.

The aim of the EU policy is to ensure that by 2050 the great majority of Europe's citizens and businesses will be no more than 30 minutes' travel time from the TEN-T network. This gives hope that CEF funding will also continue in the subsequent period.

11. Project risks

Huge-scale projects such as tunnelling and underground projects are facing considerable risks – political, economic and technical. International Tunnelling Association (ITA) has researched this topic and in 2004 published the report "Guidelines for tunnelling risk management". These guidelines are focusing on tunnelling risk management throughout the entire project implementation from concept to operation phase. (43)

For a huge-scale project, the implementation period can be divided into three main phases:

- Early Design Phase
- Tendering and Contract Negotiation Phase
- Construction Phase

Systematic risk management throughout the different phases on tunnel project development helps identify potential problems and appropriate risk mitigation measures can be implemented in a timely manner. (42) The preparation of a construction risk policy with project scope, risk objectives and detailed risk management strategy should be added to the scope of the feasibility study. Requirements for the risk policy are described in the ITA report "Guidelines for tunnelling risk management".

There are several parties involved in tunnelling projects. The main roles are the Owner, the Designer, the Contractor and the Engineer (supervisor). Risk management is the primary interest of the Owner and it is the Owner's responsibility to delegate risk management to different parties throughout the project. The Owner's role is to control and lead risk management and to take into consideration all identified risks, needs and objectives of all project parties.

Table 42 lists the potential risks. It also includes different parties who might be involved in risk management in addition to the Owner, and identifies the project phase where appropriate risk mitigation measures can be implemented.

Table 42 Types of risks

Risk description	Parties involved in Risk management	Phase
General risks		
Political risks	Owner	Early Design Phase
Lack of communication and co-ordination between project parties	Owner + all project partners	Whole project implementation period
Loss of goodwill. Public opinion and mistakes in public relationship	Owner	Whole project implementation period
Economic risks		
Market risks – variations in predicted traffic	Owner	Early Design Phase
Possible underestimation of operational costs	Owner	Early Design Phase
Technical risks		
Uncertainty of ground properties – geology along the tunnel route	Owner + Designer	Early Design Phase
Unexpected groundwater conditions	Owner + Designer	Early Design Phase

Damage to a range of third party persons and properties in urban areas	Owner + Contractor	Construction Phase
Tunnel collapses during construction	Contractor	Construction Phase
Human factors and human errors	Owner + Designer + Contractor	Construction Phase
Harm to the environment	Owner + Designer	Whole project implementation period
Delays during design and construction phases	Owner + Designer + Contractor	Construction Phase
Very Large Scale and Unique Project execution risks	Owner + Designer + Contractor	Construction Phase
Changes in legislation and design regulations & requirements (especially safety issues)	Owner + Designer + Contractor	Whole project implementation period

The current study focuses more on economic and technical risks as well as risks which may be critical to be pointed out in the early design phase.

11.1 Political risks

Globally, the political risk for the project progress could be a culmination of the crisis between East and West. At present, the situation has already changed in an undesirable direction.

At the **European level,** the TALSINKI project is linked to the North Sea-Baltic corridor. The corridor status gives more importance and attention to whole project and puts pressure on the governments in both countries. However, the risk that the project would not be among the priorities of the EU should be taken into account. The EU financing for the project at its different stages will undoubtedly be a big risk.

TALSINKI is linked to the implementation of the Rail Baltica project. There are risks that Rail Baltica does not involve. Lithuania, Latvia and Estonia are hesitating, because the intended grant from the EU is not at the desirable level.

At the **national** level, cooperation and timing of the decision-making process in both countries may be very challenging. In both countries the decision-making process and culture is different and it is important to recognize these specific characteristics during the project process. At least in Finland the long-term decision-making of implementing infrastructure projects is difficult. Financial decisions are usually only made for the period of each government, at most four years. However, the decisions concerning the planning of the project will be much easier.

The political success of the tunnel project will depend on the wideness of its impact area and how it is combined with the whole transport system of both countries. The larger the impact area is, the easier it is to get political support for it. For Finland, the tunnel will be a very important connection to whole Baltic region and even to Central Europe. The tunnel can be widely appreciated in Finland if the connection to the current transport system is flexible and functional, and the benefits for people and cargo can be targeted almost for the whole of Finland. Furthermore, the connection to Helsinki Vantaa airport should be constructed using both the Finnish gauge and the European gauge as on TALSINKI. On the other hand, the tunnel project can be implemented only after completing the Pisara-rata.

Regionally and locally the fast tunnel connection may cause migration from South-Finland to Estonia. Commuting time between the Helsinki district and Tallinn will be as short as from Hyvinkää to Helsinki.

Estonia may be an attractive place to Finnish people for living, as well as to enterprises for locating their business activites because of lower taxes and the general level of prices. The possible loss of inhabitants and enterprises may cause resistance to the project at least in the cities of South-Finland. On the other hand, it is also possible that Estonian people will migrate to Finland. Finland may be attractive because of its higher living standard.

Connecting TALSINKI into the transport systems of both countries is crucial. For both passengers and cargo trains have to be reached and used flexibly. Travel or transport time must be short, including loading and shifting. That is why new terminals and possible stations have to be ideally located and also need much space which has to be allocated in land use planning in the vicinity of both capitals. A significant risk is that areas fair enough are not found or accepted.

11.2 Economical

Market and financing risks are distinguished within the category of economic risks. The market related risks are mainly related to the deviation of actual traffic flows from forecast flows …

1. … due to variations in the general economic development; and
2. … due to competition.

Experience from the Eurotunnel project demonstrates the need for careful forecasting, including a thorough investigation of the customers' preferences, price sensitivities, competitive position etc (see section 6.1).

The financing risks include:

1. risks associated with the development of the macroeconomic environment, especially inflation and future variations in interest rates; and
2. risks associated with the financing structure adopted in the project, such as debt burden, and availability of guarantees.

It is essential to add a financial strategy and risk management plan to the scope of the feasibility study.

11.3 Technical

In addition to economic risks, underground works have inherent uncertainties such as different ground properties and unknown groundwater conditions. Therefore, risk management in the early design phase is significant in order to avoid cost overrun, delays during construction, and environmental risks.

Possible technical risks:

- Uncertainty of ground properties – geology along the tunnel route;
- Unexpected groundwater conditions;
- Harm to the environment.

Even though Finland has several tunnel projects (Päijänne tunnel 120 km, Katajaluotu WWT tunnel 8 km) and hard rock properties are well known, commissioning a detailed geological study for the whole tunnel project alignment is essential. (44) Complete studies of geology and environmental impact will help prevent technical risks in the early design phase.

It is essential to measure all the potential risks to the environment and therefore a detailed environmental impact study should be commissioned in the early design phase.

12. Conclusions and Recommendations

Different routes and tunnel options have been studied in the pre-feasibility study in order to determine the optimal alternative for traffic networks in Finland and Estonia. The objective was to find a solution where the travel time between city centres would be as short as possible and the fixed link technically feasible. In the study, five different solutions were assessed and the results of assessment showed that alternative 'A', Pasila–Muuga–Ülemiste, fulfils the most criteria for a suitable alignment. As a result of studying different tunnel options, the railway tunnel with two separate rock tunnels is recommended for further planning.

The fixed link between Helsinki and Tallinn is supposed to be connected to the current public transport networks in both countries. The objective was to achieve as short a travel time between city centres as possible. As a result of the pre-feasibility study the fixed link should be connected to the Central Railway station and Pasila railway station and the airport of Helsinki in order to create a functional traffic network and develop commuter traffic. In Tallinn, the fixed link is recommended to be integrated near the city in the node of traffic network at the Ülemiste passenger terminal, with the proposed cargo terminal to be situated at Muuga.

Based on today's statistics and our assumptions, the annual number of passengers between Helsinki and Tallinn could increase from 8 million in 2013 to 41 million passengers in the next 70 years. Today, 30,000 people commute weekly or monthly from Estonia to Finland. Everyday commuting will be a new segment in the Tallinn–Helsinki traffic. It is estimated that the number will be 25,000 in ten years after opening. Travel and business between Estonia and Finland is going to grow significantly when the fast connection opens. Container and trailer transportation via the link is estimated to increase significantly in the first ten years when the link opens. According to the estimate, about half of the cargo traffic will in the future go through the fixed link.

The figures also show that direct and indirect benefits during the construction and operation period to the economy of both countries are remarkable. The competitiveness of the twin-city area will be strengthened by improved accessibility, new companies and business, better image and a variety in living options. Significant improvement in accessibility via different traffic solutions will influence regional competitiveness as well as the competitiveness of the whole of Finland and Estonia. A benchmark study of the Øresund Bridge shows a stimulating effect on business life from the fix link.

The cost estimate of the tunnel and traffic solutions is 9–13 billion euros. According to the socio-economic analysis, income from the tunnel will cover the operating and maintenance costs and a part of the investment costs during the operating period. Financial support in the extent of 40 percent would be needed from the public sector (from governments and the EU). It should be studied more precisely in which corporation model the construction should be organized and how the operating and maintaining procedures will be done.

The financial analysis indicates that the tunnel project will not be sustainable without considerable support from public sector (EU, governments). The results are expressed on the assumption that 40% of the construction costs are financed from the EU and government budgets. With a discount rate of 6.0% the net present value (NPV) will be –5,319 MEUR and the internal rate of return (IRR) will be 3.4% for the Base Case scenario. However, it is assumed that TALSINKIFIX would be feasible – also considering state guarantees – as has been proven in the Øresund project and is also the case in the Fehmarn Belt project.

In addition, the positive economic impact – especially the passenger time savings – is estimated to cover the larger part of the financial deficit of the Project. Economic outcome in terms of the economic rate of return (ERR) is 6.7% and the economic net present value (ENPV) is 2,018 MEUR in the Base Case scenario.

In the next stage the technical options and possibilities of the tunnel and location possibilities for terminals should be studied in more detail. The possible positive and negative impacts on nature, as well as social and cultural impacts should also be assessed in more detail.

From the implementation perspective and especially based on experiences from the Fehmarn Belt project, a proposition was made to found a Finnish-Estonian project organization for further planning. It should have enough resources for manpower and funding to conduct the project. The joint organization would be responsible for communication, funding possibilities, interaction between different parties and authorities and overall control over project planning.

Sources

(1) Äripäev. "Enim Soomes tööl eestlasi", 11.04.2014; http://www.aripaev.ee/uudised/2014/04/11/soome-valistoojoust-kaks-kolmandikku-eestlased

(2) European Commission. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, 2011; http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm

(3) Global Property Guide. 2014; http://www.globalpropertyguide.com/

(4) Canterbury Christ Church University. The Channel Tunnel: Transport Patterns and Regional Impacts, 2012;

(5) Eurotunnel Group. "Annual review and corporate social responsibility report 2013", 2013; http://www.eurotunnelgroup.com/annual-review/2013/index.htm

(6) European Straits Initiative. The effects of the Channel Tunnel on the territories; 2012; http://www.fehmarnbeltdays.com/sites/default/files/press_files/prasentation_ko_12_09_26_channel_tunnel_fontalirand_0.pdf

(7) Iikkanen, P. Railway traffic operating cost models in Finland. Finnish Transport Agency, Transport Planning. Research reports of the Finnish Transport Agency, 15/2013;

(8) Financial Times. Eurotunnel: Complex case foreshadows issues for lenders in current financial crisis, 22.06.2009; http://www.ft.com/cms/s/0/7c13c392-5c65-11de-aea3-00144feabdc0.html#axzz3Kx9dy7yC

(9) Eurotunnel Group. Activity in the Third Quarter of 2014, 2014; http://in.reuters.com/article/2014/10/22/groupe-eurotunnel-idUSnBw216953a+100+BSW20141022

(10) Clements, R. A social and environmental impact assessment that examines the impacts that have resulted from the construction and operation of the Channel Tunnel, 2006; http://ir.canterbury.ac.nz/handle/10092/924

(11) Øresundsbro Konsortiet. 10 YEARS. The Øresund bridge and its regions, 2010;

(12) Øresundsbro Konsortiet. Fact worth knowing about Øresund bridge, 2008;

(13) Andresen Analyse. The effects of fixed link. Case studies from the Great Belt and Øresund; May 2013; http://www.femern.com/material-folder/documents/2013-publications/the-effects-of-fixed-links-case-studies-from-great-belt-and-oresund.pdf

(14) OECD Publishing. OECD Territorial Reviews: Oresund, Denmark/Sweden, 2003; http://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-territorial-reviews-oresund-denmark-sweden-2003_9789264100800-en

(15) ØresundsbroKonsortiet. Annual Report 2013; http://uk.oresundsbron.com/download/568

(16) Kable Intelligence Limited. 2014; http://www.roadtraffic-technology.com/projects/fehmarn-belt/

(17) Femern A/S. 2014; http://www.femern.com/

(18) Gromov, O., Gromov, G. The report of geophysical research in geological mapping on the Tallinn-Loksa area (in Russian). Geological Survey of Estonian, 1970;

(19) Ikävalko, O., Vähäaho, I. and Suuroja, S. Soil and bedrock conditions to be expected in Tallinn – Helsinki tunnel construction. Strait Crossings 2013, pp 790-799, Bergen, Norway, 2013; www.vegvesen.no/Fag/Publikasjoner/Publikasjoner/Statens+vegvesens+rapporter/_attachment/514239?_ts=140a4ee85f0&fast_title=svv+rapport+231.pdf

(20) *Koistinen, T. Map and explanation of Precambrian basement of the Gulf of Finland and surrounding area map 1:1* **000 000**. *Geological Survey of Finland, 1996;*

(21) *Koppelmaa, H., Kivisilla, J. Crystalline basement map of the North Estonia on a scale of 1:200 000. Maps and Explanatory note, 1998;*

(22) *Petersell, V., Puura, V. Deep geological mapping of the Tallinn-Loksa area on a scale of 1:500 000 (in Estonian). Report. Geological Survey of Estonian SSR, 1971;*

(23) *Suuroja, K. The report of the granite prospecting in the Maardu region (in Russian). Geological Survey of Estonia, 1979;*

(24) *Suuroja, K. The report of the granite survey in the Maardu region (in Russian). Geological Survey of Estonian., 1982;*

(25) *Suuroja, K., Niin, M., Suuroja, S., Ploom, K., Kaljuläte, K., Talpas, A., Petersell, V. The report of geological-geotechnical-hydro-geological studies Suur-Pakri Island and surroundings seabed (in Estonian). Geological Survey of Estonia, 2010;*

(26) *Suuroja, K., Shtokalenko, M., Gromov, O. Additional geological and hydro-geological surveys of the Maardu granite massif area. Report. Geological Survey of Estonia, 2010;*

(27) *Suuroja, K., All, T., Kaljuläte, K., Kõiv, M., Morgen, E., Ploom, K. 2003. The set of digitised geological-geophysical-hydro-geological maps on a scale of 1:50 000 and explanatory note. Tallinn (6334) and Rohuneeme (7312) sheets. Geological Survey of Estonia, 2003;*

(28) *Suuroja, K., All, T., Kõiv, M., Mardim, T., Morgen, E., Ploom, K., Vahtra, T. The set of digitised geological-geophysical-hydro-geological maps on a scale of 1:50 000 and explanatory note. Maardu sheet (6343). Geological Survey of Estonia, 2002;*

(29) *Suuroja, S., Suuroja, K., Ploom, K., Kask, A., Soosalu, H. Tallinn–Helsinki tunnel soil and bedrock construction conditions. Compilation of a geological database for the possible Tallinn–Helsinki tunnel area. Geological Survey of Estonia, 2012;*

(30) *Talpas, A., Kask, J., Väling, P., Mardla, A., Sakson, M., Genno, E. The geological mapping of the shelf area of the Baltic Sea on a scale of 1:200 000 on sheets O-34-VI,O-34-XII,O-35-I,II., Geological Survey of Estonia, 1994;*

(31) *Tamm, L., Salu, M., Metsur, M. Prognosis of the granite mining impact on groundwater. Environmental impact assessment report (in Estonian), Annex 4, Maves Ltd, 2008;*

(32) *Tallink Group. Annual Report 2013, 2013; http://www.tallink.com/reports*

(33) *Eurotunnel Group. Usage Contract, 1987; http://www.eurotunnelgroup.com/*

(34) *AECOM. Rail Baltic Feasibility Study, 2011;*

(35) *European Commission. Guide to COST-BENEFIT ANALYSIS of investment projects, 2008; http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf*

(36) *Philips, K., Loova, M. Madala kvalifikatsiooniga tööjõud Eestis, 2005;*

(37) *COWI. Economic and financial evaluation of a fixed link across Fehmarn Belt, 1999;*

(38) *CE Delft. Handbook on estimation of external costs in the transport sector, 2008;*

(39) *Estonian Competition Board. Juhend 2014 a. kaalutud keskmise kapitali hinna leidmiseks, 2014; www.konkurentsiamet.ee/file.php?25776*

(40) *Spiekermann & Wegener. Regional impacts of a railway tunnel between Helsinki and Tallinn, 2013; http://www.spiekermann-wegener.de/pro/pdf/HTTPS_SuW_FinalReport.pdf*

(41) *European Commission. European Commission. New EU transport infrastructure policy – background. 2014; http://europa.eu/rapid/press-release_MEMO-14-525_en.htm*

(42) *International Tunnelling Association. Guidelines for tunnelling risk management: International Tunnelling Association, Working Group No.(33) 2, 2004;*

(43) *International Tunnelling Association. Long tunnels at great depth, Working Group No. 17, 2010;*

(44) *HSL Helsingin seudun liikenne. Joukkoliikennestrategia, 2014; https://www.hsl.fi/sites/default/files/uploads/joukkoliikennestrategia_hlj2015_raportti.pdf*

(45) *Merenkurkun liikenteen ja Merenkurkun kiinteän yhteyden sosio- ja yritystaloudellinen analyysi, 2009; http://www.kvarken.org/assets/Publikationer/Merenkurkun-liikenteen-ja-Merenkurkun-kiintean-yhteyden-sosio-ja-yritystaloudellinen-analyysi.pdf*

(46) *Anttikoski, U. Preliminary feasibility assessment, Fixed transport connections across the Baltic from Finland to Sweden and Estonia, Finland, 2007; http://www.euregio-heltal.org/wp-content/uploads/2011/03/Fixed-transport-connections-across-the-Baltic-to-Sweden-and-Estonia-without-charts.pdf*

Appendices

Appendix 1 Finnish trade with hinterland countries

IMPORT	VALUE_IN_MILLION EUROS			QUANTITY_THOUSAND TONS		
PARTNER	2000	2013	2013/2000	2000	2013	2013/2000
BULGARIA	11	41	254%	15	22	49%
CZECH REPUBLIC	225	605	168%	138	114	-17%
ESTONIA	1 042	1 776	71%	1 702	2 060	21%
HUNGARY	106	225	112%	44	30	-32%
LITHUANIA	39	324	727%	99	248	151%
LATVIA	66	263	296%	499	1 367	174%
POLAND	282	1 255	345%	2 421	1 008	-58%
ROMANIA	7	74	903%	10	15	48%
SLOVENIA	24	58	145%	9	7	-18%
SLOVAKIA	49	145	199%	24	43	85%
TOTAL CEE	1 851	4 765	157%	4 961	4 916	-1%
AUSTRIA	358	679	90%	102	153	51%
GERMANY	5 585	8 169	46%	2 424	2 684	11%
FRANCE	1 331	1 810	36%	672	897	34%
ITALY	1 071	1 439	34%	272	333	23%
TOTAL OLD EU	8 344	12 097	45%	3 470	4 067	17%
BELARUS	4	72	1629%	29	144	395%
SWITZERLAND	454	403	-11%	27	15	-44%
KAZAKHSTAN	99	477	380%	367	843	130%
MOLDOVA	0	1	293%	1	0	-81%
UKRAINE	15	44	204%	24	48	96%
TOTAL OTHER	572	997	74%	448	1 050	134%
TOTAL	10 768	17 859	66%	8 878	10 032	13%

EXPORT	VALUE_IN_MILLION EUROS			QUANTITY_THOUSAND TONS		
PARTNER	2000	2013	2013/2000	2000	2013	2013/2000
BULGARIA	42	42	0%	20	26	32%
CZECH REPUBLIC	307	241	-22%	113	78	-31%
ESTONIA	1 539	1 748	14%	820	1 834	124%
HUNGARY	359	210	-41%	128	122	-5%
LITHUANIA	187	360	92%	97	286	196%
LATVIA	300	504	68%	295	507	72%
POLAND	799	1 362	70%	551	1 165	111%
ROMANIA	42	147	253%	14	72	400%
SLOVENIA	42	60	42%	22	22	2%
SLOVAKIA	70	101	45%	61	66	10%
TOTAL CEE	3 687	4 774	30%	2 120	4 178	97%
AUSTRIA	648	370	-43%	296	147	-50%
GERMANY	6 246	5 426	-13%	5 305	4 431	-16%
FRANCE	2 577	1 827	-29%	2 397	1 268	-47%
ITALY	2 173	1 312	-40%	1 160	1 046	-10%
TOTAL OLD EU	11 645	8 935	-23%	9 157	6 891	-25%
BELARUS	22	106	388%	8	34	335%
SWITZERLAND	776	733	-6%	330	85	-74%
KAZAKHSTAN	61	157	157%	32	51	61%
MOLDOVA	2	7	232%	1	7	597%
UKRAINE	111	349	213%	69	256	270%
TOTAL OTHER	972	1 352	39%	439	434	-1%
TOTAL	16 304	15 061	-8%	11 716	11 502	-2%

Appendix 2 Tunnel corridor alternatives between Tallinn and Helsinki

SWECO