# FinEst Link New Technologies Challenge

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# Executive summary

The key findings in this report:

- The justification for the construction of the tunnel is based on the daily commuting between Helsinki area and Tallinn area. The business potential of long term passenger transportation as well as freight transportation is of minor significance, and the business case is viable based solely on commuting traffic.
- The utilization of the artificial islands has not been discussed in this report, but the potential should not be underestimated.
- A 1435/1524 mm dual gauge track is the recommended solution, with 1435 mm tracks dedicated for Rail Baltica passenger trains ending underneath the Helsinki railway station. The 1524 mm track should join the Finnish rail network in Pasila.
- Traffic economy is based on commuter train services and van and truck shuttle train services that are operated by the tunnel operator. Other trains using the tunnel pay a tunnel fee which is based on the weight of the train.
- Dominating business of the tunnel is daily commuting with 100 daily services. The volume of the commuting is based on statistics from Helsinki commuting area. Peak hour demand may grow near the capacity of the tunnel. Best estimate of the annual result of the commuter trains is 215 M€/year.
- Conservative calculations give the tunnel an operational profit of 268 M€/year. After the 57,8 M€ maintenance and operating cost the ROI of the tunnel would be 210 M€/year.
- The size of the total investment is estimated to be 13.200 M€, ie. 3000 M€ less than the FinEst Link estimate. The initial breakdown of the investment could be:
    - 5200 M€ from EU (40 % financing)
    - 6000 M€ of private funding
    - 2000 M€ from the states of Finland and Estonia.
- The tunnel concept varies slightly from the FinEst Link concept. The main difference is the ability to connect the commuter services to high capacity public transport nodes in Helsinki and Tallinn:
    - The tunnel track levelling in Helsinki is <u>between</u> the Metro line (-23 m) and the Pisara railway loop reservation (-46 m).
    - Helsinki being the end of the 1435 mm Rail Baltica passenger services, there is no need for separate FinEst Link Pasila station. However, option for the direct Airport tunnel and the Hanko–Hyvinkää line connection as in FinEst Link concept can be maintained for the future.
    - The 1524 mm rail can be aligned with the Pisara loop reservation, joining the Finnish rail network in Pasila.
    - The Tallinn main station for commuters to be placed at Balti Jaam, requiring an alteration in the FinEst Link tunnel lining. The Ülemiste station (with a tram connection) should also be maintained in the plan, although it cannot serve the needs of the thousands of daily commuters using the tunnel train.
    - Freight transfer and gauge adjust terminal required only in Tallinn.
- The regional impacts of the Helsinki–Tallinn tunnel are expected to be significant. The most suitable proxy for the tunnel is the Øresund fixed link connecting Copenhagen and Malmö, although the potential benefits of creating a true Helsinki–Tallinn twin city can even higher.

# Goal

FinEst Link New Technologies Challenge asks for ideas for a conventional railway tunnel between Helsinki and Tallinn for the issues listed below:

- Facilitate daily commuting: travel time, ticket price
- Smooth travel chains: 60 min. door-to-door labour market accessibility, access to global flight connections
- Effective freight transport chains: delivery time, frequency, freight safety, price
- Improved sustainability: less direct emissions, improved life cycle sustainability
- Improved safety and security: implementation risks, risks of incidents and accident
- Improved traffic management in city centres: less congestion in city centres
- Economic viability: need of public support, effects on market competition

In this work a conventional railway tunnel is understood to mean a tunnel that is technically compatible with current railway rolling stock used on both sides of the Finnish gulf and on the Rail Baltica railway line from Tallinn towards central Europe. In practice this means railway rolling stock that conforms with the EU technical specifications for interoperability (TSIs). During the detailed planning phase of the tunnel it may appear, that certain aspects need to be taken into account to ensure the safety of the railway traffic in such a long continuous tunnel.

The aim is to create a feasible business concept with minimum investment for a proven and robust technology, but without limiting the future expansion potential of services and business.

# Service concept of the tunnel

# Traffic system level

The tunnel connects the railway networks of Estonia and Finland. It also connects the regional railway networks of Helsinki and Tallinn. The Helsinki and Tallinn railway networks are specified here as the part of the national railway network that serves the commuting of both cities. The third important system level connection is the connection to Rail Baltica, which is a connection to EU's TEN-T network.

The traffic at each of these three networks is of different kind, which is a common situation for all railway systems. The track network in general is flexible and able to serve different kind of traffic services. Different services just need suitable stations, terminals and railway yards for the management of the trains.

The time span in the system level planning is 50–100 years. In practice this means, that the current situation is not the base for the service dimensioning. Therefore it is necessary to estimate developing trends and permanent features of the human society as well as human behavior and needs.

Estimating the long term viability of a business case by just extrapolating fixed growth percentages for several decades, could lead into serious mistakes. When forecasting the potential demand for eg. transportation services in the 2040's, one should not fall into the trap of believing that the drivers behind the demand will remain the same.

In the case of Helsinki–Tallinna tunnel, long term trends impacting the business case include:

- The salary, price level and living standard differences between Estonia and Finland are currently the driving force behind commuting between Helsinki and Tallinn. These differences will fade away over time. However, there will be new reasons for travelling, when the standard of living goes up.
- Transporting passenger cars between Helsinki and Tallinn may be a viable business in 2017, but in 10 or 20 years the majority of people will have probably switched from owning a car to using various kinds of mobility services.
- GDP growth normally adds to employment as well as export and import volumes, but in 2040's things may be different. The perpetually evolving technology will probably free us from five-days-a-week work, and highly automated production will take circular economy to the next level, As a consequence, foreign trade volumes (as measured in tons) could start declining. Same impact is to be expected also from diminishing salary, price and living standard differences between Europe and developing countries, especially in Far East and China.

Ideas for some special services, like car transport in large profile rolling stock like in Channel Tunnel are discussed separately and studied as an impact study compared to a tunnel required for only TSI based trains.

# Service level

Services in the tunnel are categorized to the following types:

**Daily commuting** is ordinary commuting to work or education or any destination, for which it is typical for the commuting to start from home and return to home during the same day. This is same service that is ongoing at the regional commuter services in both Helsinki and Estonia. Based on statistics in Greater Helsinki Area, commuting region ranges for app. one hour distance from Helsinki city.

The volume of the daily commuting is estimated based on the number of Estonian citizens working in Helsinki region today and the commuting statistics from Helsinki commuting area.

The figures of Estonian citizens in Helsinki area are not precise, as the travelling between EU countries is free and not controlled. Current estimates are up to 20.000 weekly commuters, but there are over 50.000 Estonian citizens living permanently in Finland [Virolainen Jan Kaljura matkustaa viikottain Tallinnasta Järvenpäähän töihin – "Jos ajat työmaalle Viron kilvissä, niin joku katsoo vinoon" https://yle.fi/uutiset/3-9758938 ].

The commuting to Helsinki region varies from 18 to 31 % of the working citizens of the counties at one hour distance from Helsinki [ https://www.hsy.fi/fi/asiantuntijalle/seututieto/tyopaikat/Documents/Sukkulointikatsaus%202015_Versio%208.6.2015_3.pdf ]. Counted from the total number of citizens, the share is 8–14 %.

If daily commuting between Tallinn and Helsinki becomes as common as commuting within the greater Helsinki area is today, based on the HSY figures, the number of daily commuters from Tallinn to Helsinki could vary between 36.000 and 64.000. The smaller value is 180 % of the current weekly commuters. This estimate means that switching from weekly to daily commuting might increase the number of commuters by 2 to 3 times.

As daily commuting usually happens within 3 hours, with the mid hour covering some 40–50 % of the commuters, the passenger demand for the tunnel may vary between 14.500 and 32.000 passengers per hour.

These figures end up in a situation where the daily commuting is the dominant use of the tunnel. The estimated numbers require 10 commuter train services per hour using high capacity two floor rolling stock. With this density the peak hours must be reserved solely for the commuter trains.

**Long distance passenger services** means passenger trains for travelling between cities and between member states. Characteristic for these services is that they are typically used irregularly, eg. for holidays or other leisure or for business trips. The distance travelled is longer than for daily commuting and travel time to one direction is over one hour. Train travel in tunnel is only part of the trip.

Long distance passenger services may replace current ship and flight services on the route of the tunnel. But they may also support flight services as connecting travelling to international flights with the railway connections.

Long distance passenger services do not replace ship travelling between Helsinki and Tallinn for leisure spent in the ship. When the aim is to eat or have fun time using the services available at a ship, tunnel is not a competitor for a ship.

Long distance passenger services are planned as a part of the similar services on both sides of the sea. In Finland the base structure is to have one hour headway up to 2 hours distance from Helsinki and 3 hours headway for destinations over 2 hours. At the Estonian side there is not so strong potential as in Finland, because of the number and sizes of the cities in Estonia. Practical destinations for long distance services through the tunnel are Tartu (97.000 inhabitants) and Pärnu (41.000 inhabitants).

While Pärnu is on the route of Rail Baltica, also Tartu (app. 2 hours from Tallinn) is a suitable destination as a pair of a service in Finland and through the tunnel. Currently the line is electrified only to Aegviidu.

The passenger train frequency in Rail Baltica may not cause a meaningful load for the tunnel. For the gauge of the Rail Baltica, all the train operating at Rail Baltica will not be compatible for the Finnish rail network. For the sake of efficient tunnel capacity use it may be a good idea to offer a high quality change in Tallinn from Rail Baltica trains to commuter trains operating in the tunnel.

A special case of long distance passenger services are overnight services through Rail Baltica. Based on the current Finnish rolling stock, one train may accommodate app. 600 sleeping passengers (38 beds x 16 coaches). These trains may start from Helsinki and therefore pass the tunnel. But it is not necessary to place these services into the peak hours.

Long distance passenger services potential is estimated to be 2 services per hour. The rolling stock used can be capable for the other passenger trains speed in the tunnel so, that these trains do not use more tunnel capacity than any passenger train. Anyhow these trains may be longer than commuter trains, so their service is not similar to commuter trains by means of stopping.

**Freight transport** means freight trains carrying all kind of a freight suitable for train transport. In the case of this tunnel there are two separate business cases: **local freight** and **long distance freight**.

**Long distance freight** is more or less freight that currently is transported by ship. This includes also road freight, as lorries must enter Finland seaways.

The common practice in sea freight is containers. They are transported to and from harbors either by road or trains. It is not feasible to see the tunnel only as a replacement to ships between Helsinki and Tallinn. Instead the chain road–rail–sea–rail–road or road–sea–road will change to road–rail–road or rail-only in which the rail-section is much longer than the current sea-section. In case of rail-only the containers may be switched to wagon being more efficient both technically and economically.

Long distance freight will be distributed in Finland the way current train transport is organized. Long distance trains do not need any special railway yards, as it can use the current yards.

In case of the long distance freight may and presumably will be freight running on Rail Baltica, there is a need to solve the gauge adaption. The question of the site required for this is a question of the technology choice of the gauge adaption. For being efficient, the switching of the wagons by reloading is excluded as non competitive to sea transport.

**Local freight** means freight transport that usually is managed with lorries or vans as distribution traffic.

The volume of the local freight may be based on the number of inhabitants, as local freight is used to transport commodities that consumers use continuously. There has been long term development in local freight with the centralization of the grocery stores up to hypermarkets. With this development distribution traffic has been replaced with car traffic to shopping malls. Anyhow net shopping has returned demand for distribution traffic.

The distribution traffic has had some variation during the times. The past trend has been to make the distribution warehouses larger and more centralized, increasing the size of the trucks used and making the routes longer. This kind of evolution is connected functionally to the hypermarket trend and the disappearing of small shops. However, net shopping and interest towards urbanism works against the trend, increasing demand for smaller scale distribution traffic services.

Currently this type of local freight traffic is managed with the car ferries between Helsinki and Tallinn. With car ferries it is practical to ship the lorries and vans over the Gulf of Finland with their cargo. This is because the weight and space the vehicle uses in the ship is not meaningful when compared to the ship's own weight and volume.

For a train the extra weight and space of the vehicle is remarkable dead load compared to the actual cargo transported. Anyhow the rhythm of the local freight does not accept transshipment car-train and train-car in the ends of the tunnel. The time benefit will be lost and the cost of transshipment is presumably too high compared to market price of the transport.

Local freight is still not any problem in the planning of the tunnel. If there is demand for it, ordinary wagons may be used. The loading sites of the local freight vehicles may be organised where the terminals will be built, as the terminal will anyway be well accessible for road traffic. So there is no special requirement to be taken into account that would require special investments in the building phase. And on the other hand, if the tunnel is built for ordinary TSI requirements, it is suitable for local freight services too.

## Car transport in trains

Private car transport service is not included in the Alkutieto plan. Technically it could be executed in the same way as truck and van transportation, but our assumption is that there will not be enough demand for such a service. The rationale for the assumption is that as car transport is available in ferries, they can sell the service for such a competitive price that car owners are not interested in paying for the travel time reduction.

In long term, mobility as a service (MaaS) is expected to develop into mainstream. Instead of paying for a car transport, the customer who needs to have a car at other side, would rather uses a rented car included in the MaaS product. As an example, the commuter train operator may have a mobility product that includes a two way train ticket and a rental car at the destination.

# Variations of a TSI compatible tunnel

## Car transport in large profile rolling stock

TSI compatible rolling stock and tunnel infrastructure for Finnish and Estonian loading gauge allows one row of road vehicles to be loaded on a wagon or train. When carrying road vehicles, the economical solution is to fit the wagon length to the road vehicle lengths to maximize the load capacity of a train.

In **Channel Tunnel** the car train's the capacity was boosted by using a wide profile rolling stock. There are double decker wagons for cars, and all the wagons are wide enough for car passengers to walk and hang around outside their cars. This feature shortens the loading time of a train, as passengers of cars do not need to leave their cars before the train departure and there is no need to wait for a walking time and reserve passenger coaches into the train.

Widening of the wagon profile may also be used to arrange space for two parallel rows of cars. This is a simple way to double the capacity. For the sizes of current cars, normal loading profile width (3,2 meters) is not enough for two rows of cars.

To widen the wagon profile it would be necessary to also widen the tunnel profile. Depending on the excavation technology, widening of the wagon profile increases the amount of excavated stone either in linear ratio to the widening or in power of 2 (e.g. with a round bored tunnel).

Widening of the wagon requires separate station and terminal structures for the wide trains and for the standard TSI trains. TSI trains may pass by wide train terminals, but the wide profile wagons would cause some extra problems. Several stations with platforms for normal width TSI trains would be needed, and wide profile trains should be able to pass them. To organize this all the passenger stations should be organized with side tracks for stopping passenger trains. This increases the cost of structures. It also increases the travelling time for either the passenger trains or wide trains, if either of those must use a diverting track requiring slow speed before and after the station.

Technically it is possible to build platforms that have a mechanism to adjust the platform distance from the track. This is just one solution for the problem and an increase into the cost of the structures. But also an increase into the maintenance cost of the structures.

An initial estimation of the impact of the wide profile rolling stock is based on a 6,0 meter wide wagon, which is capable of carrying carry two rows of vans. The mirror width of a van is considered to be 2,3 meters. Internal width of 5,8 meters leaves total of 1,2 meters free width inside the wagon which in practice equals to two corridors of a 0,6 meters width each for the drivers to walk.

If the tunnel is built so that the widening does not affect to the height of the tunnel, one rail tunnel width increases from app. 5 meters to 8 meters, which is a 60 % addition and 60 % more stone to be excavated. If the tunnel is bored as a round tube and the initial diameter is 7 meters, the diameter must increase to app. 10,5 meters (based on the corner distance from the side of the bore). This means the bore area would increase 125 %, with an equal increase to the amount of stone to be excavated.

When calculated with the values used in FinEst Link cost estimation data, a 60 % increase in running tunnel cost is app. 6 Mrd € and a 125 % cost increase app. 6,25 Mrd €. Based on these figures it is obvious, that there is no use to estimate the station and terminal cost increase, either the cost of the special profile rolling stock. These figures already prove, that **the economical solution would be to double the capacity of the service by running two trains after each other**.

## Dual gauge track

As Rail Baltica is planned to be constructed using the European gauge 1435 mm up to Tallinn, it is worth considering whether the 1435 mm gauge should be extended up to Helsinki.

Because of the small difference between gauges, double gauge track must be built using a 4 rail track. Such a solution is used in the bridge and track between Haaparanta and Tornio over the Finnish-Swedish border, as well as in the current Rail Baltica section between Kaunas and the Lithuanian/Polish border. In this overlapped construction, the middle line distance of the gauges is app. 300 mm.

This overlap distance requires some adjusting for the structures for the tunnel. However, for the overall cross section area the double track should not need any extension. This is due to the specifications on the speed of the trains and the air pressure the speed causes. The exact position of the train compared to the tunnel walls is not critical for this purpose.

Dual gauge track is not convenient for the passenger trains at the platforms. The gap between the platform edge and the doorstep cannot be increased with 300 mm. Platforms for different gauges may be built to separate locations or opposite sides of the track.

For freight trains dual gauge track in tunnel is not a problem, whilst in the terminals gauges are managed separately.

Dual gauge track may increase the cost of the track 1,0–1,5 M€/km for the rail and fastener cost being double. Based on the values used in FinEst Link cost estimation data, this may increase the total tunnel cost app. 250 M€.

# Service concepts of the trains

## Commuter trains

Commuter trains are high capacity electric motor units (EMU) that are TSI-compatible and able to operate on Estonian and Finnish railway networks. Their wheelset gauge is suitable for both Estonian 1520 mm nominal gauge and Finnish 1524 mm nominal gauge. Doors are suitable for 550 mm platform height. Electric system is 25 kV.

One train unit has 5 coaches and the length of one unit is 125 meters. Train has two floors and seating arrangement is 2+3 seats in a row. Main travelling mode is seated and the interior is designed to maximise the number of seats. Each coach has two wide doors that allow passengers to move in two rows. Total number of doors is 10 at a side. Total number of seats in a 125 meters train is app. 600.

The recommended operation of the trains is to operate from main commuter railway corridors of both Helsinki and Tallinn. An example is a route Kerava–Helsinki–Tallinn–Keila. The dense headway used in the tunnel between Helsinki and Tallinn stations is not necessary for the whole route.

# Road vehicle trains

Road vehicle trains are locomotive driven shuttle trains with flat wagons. Train is TSI-compatible and able to operate on Estonian and Finnish railway networks. Their wheelset gauge is suitable for both Estonian 1520 mm nominal gauge and Finnish 1524 mm nominal gauge. Electric system is 25 kV.

One train unit may have a maximum of 22 flat wagons designed for multi modal transport with a loading length of 25,5 meters. The wagon coupling is arranged so that a road vehicle can drive over the coupling. The floor of the wagon includes locking arrangement for secure fixing of the vehicle to wagon.

For loading and unloading these trains a special terminal is required. Road vehicle trains do not stop at the intermediate stations between their own terminals.

Train is loaded from one end by driving the vehicles on the train in a line. Drivers of the vehicles travel seated in the vehicle. The train is hauled to other end of the tunnel, where the locomotive is separated from the train and the train is towed against loading platform. This towing can be organised using a fixed train mover device. After the train is locked to loading platform, vehicles drive away from the train and new load of vehicles enter the train. Meanwhile the locomotive is shunted to return end of the train. When loaded, the train starts the return trip.

For safety reasons, using the service requires a valid safety certificate from the vehicle drivers. The driver must understand that it is strictly forbidden to exit the vehicle during the train trip. Also the driver must be familiar for actions in case of emergency. In practice this is organized as the drivers to be certified registered tunnel service customers. The service is not intended to private cars (see also chapter *Car transport in trains*).

# Long distance passenger trains

Long distance passenger trains are locomotive driven trains with ordinary passenger coaches used in Estonia and Finland or EMU's like Pendolino and Allegro trains in Finland and Flirt trains in Estonia. Train is TSI-compatible and able to operate on Estonian and Finnish railway networks. Their wheelset gauge is suitable for both Estonian 1520 mm nominal gauge and Finnish 1524 mm nominal gauge. Electric system is 25 kV.

The number of coaches and the capacity depends on the train operators interest and service formation.

Route of these trains connect several Estonian and Finnish cities. A sample route may be Tampere–Helsinki–Tallinn–Pärnu. Typically these trains stop only in cities main stations passing by smaller stops used by commuter train services.

# Night trains to Rail Baltica

Rail Baltica offers a possibility to offer an overnight service from Helsinki or Tallinn to Central Europe, e.g. Warsaw or Berlin.

These trains are locomotive driven trains completed with passenger, restaurant and sleeping coaches. Train is TSI-compatible and able to operate on Rail Baltica. If the northern end station is in Finland, either the tunnel must have dual gauge tracks or the train must be able to switch the wheelsets gauge. In case the train has double gauge functionality, it is capable of operating on Estonian and Finnish railway networks. Electric system is 25 kV.

## Freight trains

Freight trains are locomotive driven trains. The wagons may be used for operating on Estonian and Finnish railway networks or also on Rail Baltica. The locomotives used in the tunnel do not need to be capable of operating on Rail Baltica, as locomotive can be switched between Rail Baltica and local 1520/1524 mm railway network.

For the freight between Rail Baltica and local 1520/1524 mm railway networks in Estonia and Finland there are 3 technologies that can be used.

1. Containers can be reloaded between different gauge wagons. Reloading containers is easy and faster than switching bogies or wheelsets. Reloading is not convenient with small size cargo, bulk or liquids and gas.
2. Commercially known and experienced practice is to switch bogies or wheelsets of loaded wagons. This practice has been used largely in the past with train ferries that operated to Finland. Winter conditions has no impact to the practice, as work is done inside a hall.
3. The third solution is to use wheelsets with adjustable gauge. Technology is in daily use between Spanish and Portuguese railway networks. The train passes through the gauge adjust device with slow speed like 15 km/h. Proper experience of winter conditions is not available. The device can be located to in-house conditions, but cold wheelsets and ice formation may cause problems.

The solution used to solve the gauge difference is to be decided by the train operator and wagon operator. The role of the tunnel operator is to choose which services are made available. In the end this is a question of business model. The tunnel needs to have a terminal that operates between the Rail Baltica's 1435 mm gauge and Estonian-Finnish 1520/1524 mm gauge. Services available at the terminal are those that have demand for the reasonable price structure. The tunnel operator could also offer terminal space for customers, who could organize necessary system and devices at their own expense.

# Traffic economy

## Basics of public transport economy

By means of ticket pricing, public transport (PT) services are divided to two main categories based on the purpose of the trip. Major part of PT trips are daily commuting to work, education, shopping and taking care of other errands. This is called daily commuting. The other part is longer trips not done daily. When it comes to transport economy, these two categories differ strongly.

- **Daily commuting** is considered a public service that is a prerequisite for living. Therefore the consumer's cost for using this service is a political decision. The ticket price is not calculated and decided on the expenses calculation, instead it is based on what is considered to be fair by social basis. Usually the expenses of PT are higher than ticket incomes, and the gap is subsided from tax incomes.
- **Long distance travelling** is not considered to be a prerequisite for living. Therefore there is no reason to subsidize the prices of long distance travelling. The economy and pricing are based on the business economy and competition. Ticket incomes must cover the operator's expenses and the final ticket price is a market price for the service.

These assumptions and definitions form the base for the economy calculations of the train operations in the tunnel in this study.

# Train operating cost

## Commuter trains

Based on the patronage figures described before, the rolling stock for commuter trains is a two floor electric motor unit (EMU) with a capacity of app. 600 seated passengers per train with a length of 125 meters. A two train unit with a length of 250 meters can carry 1200 seated passengers.

In this calculation standing passengers are not taken into account, though they are common practice in commuter trains. Anyhow it is worth noting, that depending on the trains internal layout and accepted standing density, the capacity of a train can be at least double with standing passengers.

Operating cost of the trains is calculated based on the life cycle cost (LCC) of a train when operated in the tunnel traffic. LCC includes the following terms:

- Train investment
- Train maintenance
- General overhaul cost (e.g. interior refurbishment, technology update etc.)
- Daily cleaning and other service
- Energy
- Train personnel
- Unexpected repair (accidents, violence, technical faults)

The base for the LCC calculation is 40 years technical lifetime.

Operating cost estimate is based on information on relevant rolling stock samples used in Europe. For comparison operating cost calculation was done also using the unit cost guide values of Finnish ministry of transport. These values have been published to be used in the feasibility studies of railway infrastructure projects.

The average estimated LCC is 1270–2300 € per one service in the tunnel between the end stations of the tunnel infrastructure based on the minimum and maximum estimate of operating cost parameters. The best estimate is 1700 € per service. At annual level, commuter trains operating cost is 81–147 M€ the best estimate being 109 M€.

The reference value for the operating cost from the ministry guide is 110–146 €/year. However, the rolling stock listed in the ministry guide is not entirely suitable for tunnel operations.

The purchase price for a commuter train given in FinEst Link material is 20 M€ for a 200 meters train. In this study the purchase price of a 125 meters train is 16 M€, thus a 250 meters 2 unit train price is 32 M€.

It is possible and recommendable to use the tunnel train forward from the end stations of the tunnel. The cost of that use is not calculated here, as it is a replacement use for existing commuter services, which is not within the scope of this work.

## Road vehicle trains

Based on FinEst Link background material, 17 services of a 750 meters long truck shuttle trains are operated in both directions. The archetype for these trains is the Eurotunnel large profile car shuttle trains, which are not TSI-compatible.

In this study the truck shuttle train is completed of a locomotive and flat wagons. A 750 meters train may include a locomotive and 27 flat wagons built for carrying trucks and buses. The full loaded train's weight is 2660 tons, which is over the train weight of latest Finnish Sr3-series locomotives (a version of Siemens Vectron). Therefore this study is calculated with a train of 22 flat wagons with 24,9 meter load length (VR class Sdggxxx). In practice this train can carry 22 full length trucks with trailers, 44 trucks of 2 to 3 axle for distribution services or 66 vans.

Operating cost estimate is based on information about rolling stock used in Finland. The speed of the train in tunnel in the calculation is 160 km/h. For comparison operating cost calculation was done also using the unit cost guide values of Finnish ministry of transport. These values are published for being used in the feasibility studies of railway infrastructure project.

The estimated annual cost of operating 17 services two ways each day of the year is 20 M€. This result is calculated from the 40 years LCC of operating these trains.

The reference value for the truck shuttle based on the ministry guide is 12 M€/year. In this study the purchase price for one train is 6,4 M€ and the Eurotunnel based trains price is 13,1 M€. If the purchase price is increased to 13,1 M€, annual operating cost would increase to 21 M€, which is insignificant for the result of this study.

## Other trains

Long distance passenger trains and freight trains used on Finnish and Estonian track networks and Rail Baltica may use the tunnel. The operating economy of these trains is not in the scope of this study, as their operating economy is based on other premises, which are not interconnected to the existence or non-existence of the tunnel. For a train to travel through the tunnel there is no extra operating cost compared to operating the train in any other track of the railway network.

From the tunnel operators point of view, other trains cause wear in the tunnel and they also use the tunnel operating services like traffic control services and safety services. In FinEst link background data the maintenance and operating cost of the tunnel is specified to 57,8 M€ per year. Based on the assumptions in this study, maintenance and operation cost of the tunnel is 0,01 €/ton-km. If all the train traffic covers the tunnel maintenance and operation cost based on ton-kilometers, the tunnel maintenance and operation share of other trains is 8,9 M€/year.

## Tunnel maintenance and operation

In this study the tunnel maintenance and operation is based on the FinEst link background information.

Tunnel maintenance includes service, repair and renewal of all tunnel and aboveground infrastructure that wears and ages out when in use. This includes also required buildings for depots and terminals and all energy consumption other than energy used in trains.

Operation of the tunnel includes operation and control center as well as safety and rescue functions and their staff.

The annual cost for maintenance and operation of the tunnel is 57,8 M€.

## Incomes

### Commuter ticket incomes

The ticket incomes for commuter trains is based on daily commuters using a season ticket and other commuters using a one way ticket.

Season ticket price is based on current commuter cost of weekly commuters including ferry tickets and accomodation during the week and current season ticket pricing in Helsinki region commuter trains. Estimated season ticket price is 500 €/month (incl. VAT 10 %).

Based on the estimate of 36.000–64.000 daily commuters, who buy the season ticket for 11 months a year, the annual ticket income (ex. VAT) is 180–320 M€.

One way ticket price is based on current ferry and Helsinki region commuter train ticket pricing. One way ticket price is considered to be higher than the ticket price in ferries because the travel time is much shorter and therefore the service has better quality. Estimated ticket price is set to 33 € (incl. VAT 10 %).

In Sweco study the standard one way ticket price was set to 36 € and a frequent travellers 20 % discount price was set to 29 €.

Based on the FinEst Link background material, the amount of other than daily commuters in commuter trains is 4,45 million per year. Annual ticket income (ex. VAT) is 134 M€.

The total ticket income from commuter trains is 314–454 M€/year (ex. VAT).

## Road vehicle train incomes

In the background material of FinEst link a base price for transporting a truck was set to 450 €/trip (ex. VAT) and annual freight volume was set to 4,2 million tonnes between Helsinki and Tallinn. The offered capacity of the 17 truck train services per day is 272.000 full length trailer trucks in a year. When estimating the load of a 60 tonnes trailer truck is 35 tonnes, the maximum annual payload capacity of the truck trains is 9,5 million tons per year.

The given tunnel freight demand of 4,2 Mton equals to 50 % usage of the offered capacity. If this is the business case, truck train operator must earn 150 € from one trailer truck to cover the operating cost of the trains.

If the given transport price of 450 € per trailer truck is considered as a price for reserving one wagon, the pricing scheme may be:

- 450 € for a trailer truck over 12 meters
- 225 € for a truck with max 12 meters
- 150 € for a van with max 8 meters

Current annual number of trucks and trailers between Helsinki and Tallinn is 250.000 and average payload 24 ton (Sweco-study). The structure of the current freight between Helsinki and Tallinn includes distribution traffic which has departure and destination points in Helsinki and Tallinn regions and long distance freight where trucks route continues towards Rail Baltica direction. When Rail Baltica is built, part of the truck freight will shift from road to rail. As a consequence, a part of tunnel train freight shifts from trucks to train freight.

Based on the Rail Baltica cost-benefit analysis (RB-CBA), the expected transit freight on Rail Baltica starts from 8,7 Mton/year in year 2026. This in roughly equal as is the freight volume estimation of 8,4 Mton/year in FinEst link background data, but RB-CBA estimates only 15 % of the Rail Baltica freight to transit to Finland. That equals to 1,3 Mton/year. Based on this volume, the road vehicle train freight share of tunnel freight volume is 2,9 Mton/year. This equals to 121.000 wagon loads (24 ton payload in a truck) per year and 54,5 M€ incomes for road vehicle trains.

## Other trains incomes

Other traffic in the tunnel are trains of the operators operating on Estonian and Finnish railway networks or on Rail Baltica. These trains do not require investments or train maintenance either drivers from the tunnel operator. The business model of the tunnel operator is to collect rent of the usage of the tunnel.

The base for the tunnel usage rent is the maintenance and operating cost of the tunnel and to cover the the tunnel investment.

In Sweco-study the price for a train in tunnel was set to 150 €/train-km based on the reference values of 73 €/train-km from Øresund bridge and 377 €/train-km from Channel tunnel. In this study the approach is to take the truck transport price proposed in Sweco-study as a base. When the price of a trailer truck is 450 € per tunnel trip, it leads to a train load of 10.500 ton-kilometers being priced at 450 €. This is equal to a tunnel rent of 4,3 snt per one ton-km.

The question of other traffic income is how many ton-kilometers other services generate. This is estimated with following train loads:

- 3 cargo train a day (two ways), train weight 2200 ton
- 9 long distance passenger trains a day (two ways), train weight 600 ton
- 1 sleeping car train a day (two ways), train weight 1000 ton

With the volumes used in this study, the price 4,3 snt/ton-km equals to average 43 € price per train-km.

When this service is operating 365 days a year, the income for the tunnel operator is 40,8 M€.

One must keep in mind, that the income from these trains does not depend on the payload or passenger numbers of these trains. For example, if the freight volume in tunnel is based on the 1,3 Mton/year from RB-CBA, the average per cargo train service is 593 tons. The capacity of a 2200 ton gross weight train is 1430 tons. If the demand level is constantly low on both directions, the train length will be shortened and the income base for the tunnel operator will be decreased.

# Operational result

## Summary

The operational result is calculated from the tunnel operators point of view. It is assumed, that the tunnel operator’s business case is to operate commuter trains and truck shuttle trains for transporting road vehicles in the tunnel. These train types form the base of the tunnel operator’s business. In addition to these, tunnel operator charges rent from other train operators’ usage of use the tunnel.

| **Service type** | **Operating cost** | **Incomes** | **Operating result** |
|---|---|---|---|
| Commuter trains | 109 M€ | 314 M€ | 205 M€ |
| Road vehicle trains | 20 M€ | 54,5 M€ | 34,5 M€ |
| Other operators trains | (8,9 M€) | 28,6 M€ | 28,6 M€ |
| Sum | 129 M€ | 407 M€ | 268 M€ |

The operating cost for other operators’ trains is their share of the maintenance and operation of the tunnel. Based on the ton-kilometers of the tunnel traffic, the volume of this share of maintenance and operating cost is 8,9 M€. This is not included into the operating cost calculated from the commuter trains and road vehicle trains. So the 268 M€ total result of tunnel operations is used to cover the 57,8 M€ annual maintenance and operation cost of the tunnel.

### Commuter trains

The annual operating cost estimate of commuter trains varies between 81 and 147 M€, the best estimate being 109 M€.

The total annual ticket income in commuter trains varies between 324 and 454 M€.

The operational annual result of commuter trains is 167–373 M€/year. The best estimate for the operating year result is 215 M€.

The result stated above is operational result which is used to cover the fixed cost of the operator and the use of the tunnel.

### Road vehicle train result

The annual operating cost of truck trains is 20 M€.

The income from 2,9 Mton freight transported in trucks and vans between Helsinki and Tallinn in the trains is 54,5 M€.

The operational annual result of road vehicle trains is 34,5 M€.

### Other trains result

The annual tunnel maintenance and operating cost share for other trains is 8,9 M€.

In case the other trains operate with the planned lengths, and the price of a ton-km is equal to the payload cargo of trucks, the annual income from other train operation is 40,8 M€.

When compared with Rail Baltica estimates, the capacity assumed for “other trains” in this study is significant above the Rail Baltica estimate. For this reason, the income from other trains is decreased by 30 %, to be on the safe side. Based on this, the annual result from other traffic is 19,7 M€.

# Tunnel economy

## Return of investment

The operational result of the tunnel is 268 M€/year. The most significant factor in this result is the 215 M€ result of commuter trains for daily commuting between Helsinki and Tallinn. This means, that as the commuter service is the most important part of the tunnel economy, it must also be the main function of the tunnel and the tunnel must be planned and built around this function.

The operational result of tunnel is used to cover the 57,8 M€ maintenance and operation cost of the tunnel. As this includes all necessary expenses to keep the tunnel continuously in operable condition, what is left after operational cost is covered, can be used for the return of investment (ROI).

The ROI of the tunnel is 210 M€/year.

This ROI is based on the starting situation of the tunnel project. A general assumption is, that economy is first based on the population size and secondly on the economical development in the productivity. As a consequence, the calculated ROI of the tunnel should start growing after the tunnel is taken into service.

## Development of the ROI

Though the basic assumption is that the volumes in the tunnel traffic will grow, there may be phenomena that may function against the tunnel economy. The most significant ones are the phenomena that may impact the daily commuting.

There are assumptions, that the main driver for daily commuting from Tallinn to Helsinki is based on the different salary levels. Therefore the commuting may decrease as the economy in Estonia grows and salary differences diminish.

However, in this study the volume of daily commuting is not based on salary differences between Estonia and Finland. The figures are based on current Helsinki region commuting statistics inside Finland. Current numbers of Estonian commuters are lower than numbers from Finnish statistics.

The current commuting surely is based on salary levels. But the current travelling manner also is a big hinder for the commuting. In the future salaries are equal, but also the service level of commuting is equal between Helsinki and Tallinn as between Helsinki and its surrounding area.

In the future the tunnel will have larger demand than the current commuting connections to Helsinki region. This is because the current commuting is mostly one way towards Helsinki region. Because of its size, Tallinn will also be a destination for commuting from Finland. Thus, the potential growth for commuting between Tallinn and Helsinki may be larger than the growth based on just population and economy growth.

## ROI and size of investment

The value of the ROI depends on what the investors require and what is the share of private funding. Even though many large infra projects like Rail Baltica are financed with 100 % public financing, it would be frivolous not to use a combination of public and private funding for the Helsinki–Tallinn tunnel.

In this study the size of the total investment is estimated to be 13.200 M€, ie. 3000 M€ less than the FinEst Link estimate. The initial breakdown of the investment could be:

- 5200 M€ from EU (40 % financing)
- 6000 M€ of private funding
- 2000 M€ from the states of Finland and Estonia.

There are several reasons for inviting pension funds and other long term investors to take part in the tunnel project:

- Interest rates are at historically low levels and the demand for long term investment cases with low risk is higher than ever. Securing some billions of euros of 30–50 year financing from pension funds for a project of this kind has never been easier.
- Reaching the political decision to spend billions of taxpayers´ money on a fully public funded tunnel project would be extremely difficult. However, adding some renowned names in the list of investors would make the decision making process smoother.
- Public funded infra projects are notorious for being late and going over budget. Having some private sector executives looking after their own investments on board would raise the odds of having a successful project.
- Besides the tunnel itself, the potential of two artificial islands could be a major part of financing the tunnel project. However, in this report we will not dig deeper into the lucrative possibilities of zoning and utilizing the artificial islands.

To optimize the cost of private funding, the states of Finland and Estonia could offer a fixed-duration guarantee for the tunnel bonds. The state guarantee could be tied to the tunnel project reaching certain milestones, thus freeing the investors from the risk of failures in the execution of the tunnel constructing project. The expiration of the state guarantee probably would not be a major problem for the long term investors, once the tunnel is operational and the cash flow turns positive.

The demand for low risk long term investment cases has never been this strong. On December the 13th 2017 Elenia, the second largest electricity distribution and heating company in Finland, was acquired by a consortium formed by Allianz Capital Partners, Macquarie Infrastructure and Real Assets and the State Pension Fund of Finland. The acquisition price was estimated to be about 2500 million euros (source: Kauppalehti), which is a remarkable price for a company with revenues of 315 M€ and an adjusted business profit of 89 M€ in 2016.

# Tunnel concept

## Basic situation

As seen from the demand and economy structures described in this study, the main purpose of the tunnel is daily commuting between Helsinki and Tallinn regions. For the tunnel to cover this demand and to be successful, the tunnel concept must primarily serve the daily commuting, and other functions after that.

For daily commuting the critical issue is the door to door travel time. In this time the actual travelling time in a tunnel train is only a part. The tunnel is a back bone type trunk link of the public transport network in Helsinki and Tallinn, so the passengers of the tunnel usually use other transport services at both ends of the tunnel to travel from the origin to destination. In this situation, a significant part of the door to door travel time is the transfer time between PT services.

To shorten the total travel time, transfer points from the tunnel must be arranged to operate fast and the locations must be in the efficient nodes of both Helsinki region and Tallinn region PT networks.

## Helsinki end transfer

The challenge in Helsinki is that underground city centre area is densely built. In addition to existing underground structures there are large scale reservations for Pisara railway loop tunnel, Töölö–Laajasalo metro/Light Rail tunnel and east-west road tunnel Keskustatunneli.

The PT network structure in Helsinki is concentrated to city centre in the area of main railway station and Kaivokatu. This is the only place where trains, trams and metroline encounter. For this reason this is also the only place where the tunnel can offer short travel times to any direction in Helsinki region.

Kaivokatu is also a large concentration of working places. Therefore access time to street level is very important.

In the FinEst Link tunnel concept there is a station at Kaivokatu, but hidden under all possible structures and space reservations. The depth from street level is app. 70 meters. With roller escalators the travelling time to street level is app. 5 minutes.

The tunnel's space requirements should be compared to all the previous space reservations. There might be some meaningful synergies in combining the space reservations.

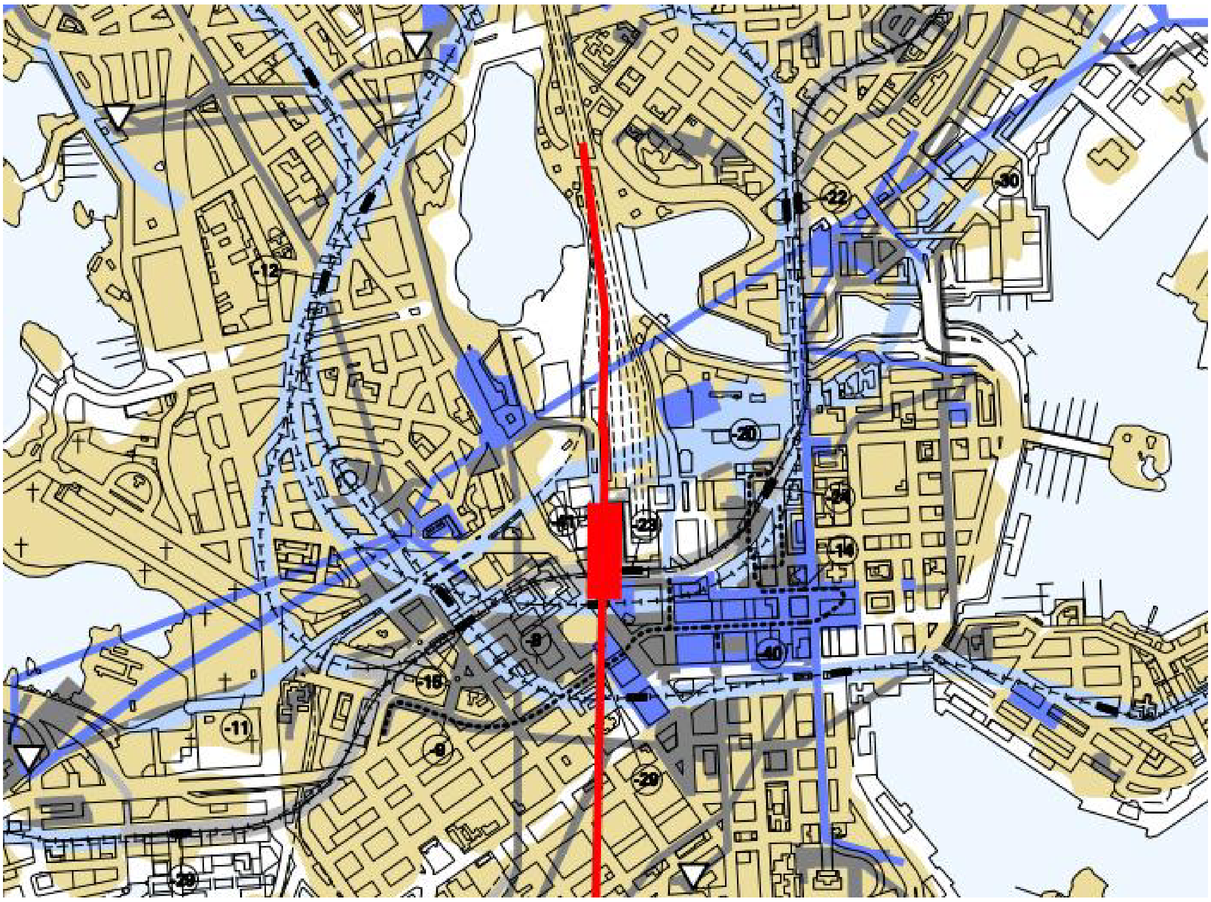
Also, the practice of constructing underground track routes is worth developing. The current practice is to excavate independent tubes to each rail line and to rely on the strength of the bedrock between these tubes. To reduce the space usage, transfer stations and crossings can be built to one large cave where levelling is built with steel and concrete structures. One sample of this idea is the current central railway station in Berlin, former Lehrter station. The diversion of the metro tracks west of Kamppi also have a concrete bridge built into a cave.

Based on the underground space reservations, following ideas for improving the tunnel passengers transfer in Helsinki are suggested:

- **Lining the tunnel at higher level under Kaivokatu between the metro line (-23 m) and Pisara reservation (-46 m) using bridge structures instead of having 10 meters of bedrock between the tracks**. Tunnel station would locate so that there are easy connections to both metro and planned Pisara stations. Tunnel track may rise to rail level between Helsinki and Pasila stations with access to the Finnish railway network.
- **Lining the tunnel towards Pisara space reservation under Töölö**. FinEst tunnel is linked to Pisara tunnel's western part, which may be extended to 4 track tunnel if necessary. FinEst commuters are a meaningful part of the future Helsinki region commuter train system, and this lining offers the fastest connection times between FinEst commuters

and other public transports, including the future Pisara loop trains and the Helsinki main railway station, as well as metro in Kamppi and trams on the ground level.

- **Lining the tunnel towards Pisara space reservation eastern tunnel to Hakaniemi**. FinEst tunnel is linked to Pisara tunnel, which may be extended to a 4 track tunnel if necessary. Anyhow FinEst commuters are part of the Helsinki region commuter train system and that way they are trains that are supposed to operate in Pisara loop. Transfer to metro and trams in Hakaniemi.



*Draft of tunnel line levelled between metro and Pisara loop positions and possible station hall location connected to metro, Pisara and on ground railway station. Map source Helsinki underground city plan.*

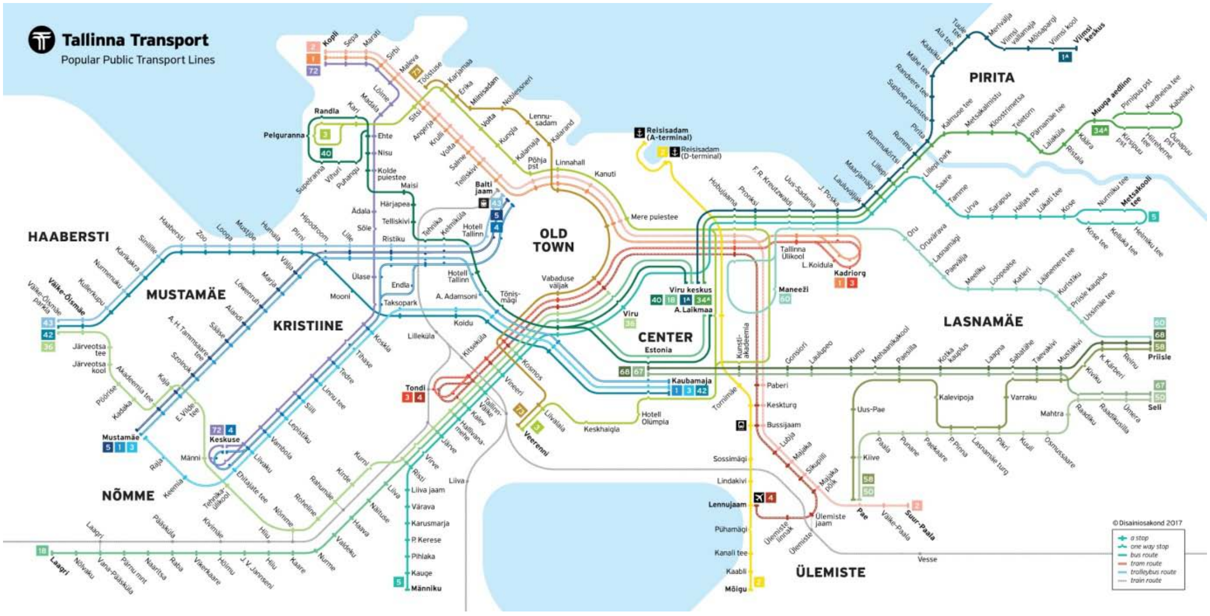
All the above-mentioned ideas combine FinEst Link to Pisara and reduce tunnel length compared to tunnel plan in background material. Lentorata and FinEst Link are not bound to each other, but in reality FinEst Link and Helsinki airport are easily connected with Kehärata. FinEst Link commuter train may be directed to Kehärata too, thanks to trains TSI and Finnish railway network compatibility.

# Tallinn end transfer

To connect the FinEst tunnel to Tallinn public transport network there must be smooth access to Balti Jaam railway station, which is the endpoint of Tallinn region commuter train services. The node of Tallinn tram network and also a busy bus network node is at the Viru hotel. Link between this node and Balti Jaam is the tram with app. 1,2 km distance.

The FinEst Link tunnel route is directed through Viimsi peninsula to Ülemiste, which is practically outside the Tallinn public transport network. Though the Sweco-study states that this route offers ”*the quickest alternative for passenger traffic between the city centres of Helsinki and Tallinn*”, actually the connection to Tallinn public transport network is very poor.

New tram connection to Ülemiste airport is app. 4 kms from the Viru hotel and the capacity of one tram line does not respond to the demand of the tunnel trains. Tunnel trains must at least continue to Balti Jaam, which is at app. 6 kms distance from the current Ülemiste train stop. This increases the travel time with 5–7 minutes, which is remarkable compared to the tunnel train travel time target.

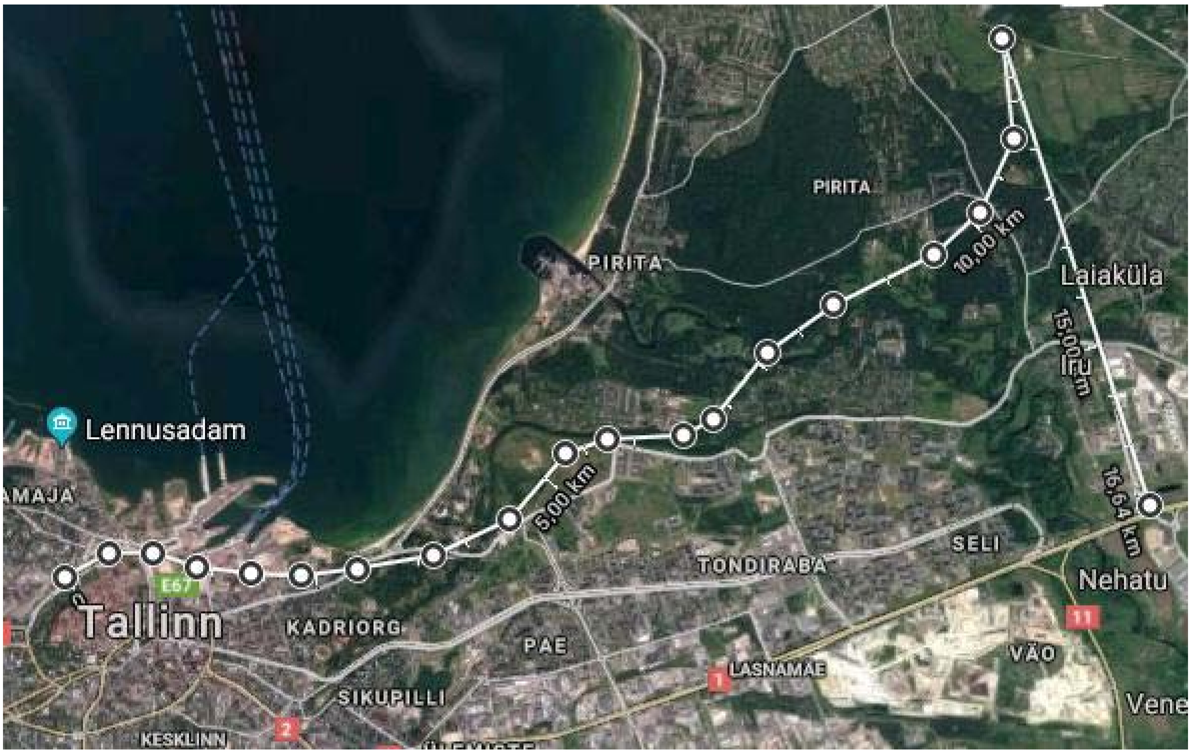



*Tallinn PT route map. Railway line from Balti Jaam railway station to Ülemiste (right down in picture) is seen as grey line. Source:* [https://www.visittallinn.ee/static/files/029/2017_transportation_map_eng.jpg](https://www.visittallinn.ee/static/files/029/2017_transportation_map_eng.jpg)

The proper solution to connect to existing railway network is to connect the tunnel track to Balti Jaam from east so that tunnel trains may enter the local railway network same way as trains leaving Balti Jaam station. Based on the seabed geology studies a tunnel cannot be built under the harbour sea area. Therefore, the railway line must be built between Balti Jaam and Viimsi peninsula. This requires that the FinEst Link railway line should be built underground at least until east of Tallinna Lauluväljak.

Tunnel trains station may be located under the current rail level and east from the station building at the location of former railway yard. This location shortens slightly the distance to Viru and towards ferry harbour. The station at this location may not be uncovered and the location gives plenty of architectural freedom for the station design.

Connection to Ülemiste airport exists through the existing railway line.




*Approximate railway route from Viimsi peninsula to Balti Jaam and the FinEst Link route to trunc route 1 to join the Muuga track line. Source: Google maps.*

## Road vehicle train terminals

For Helsinki, there is a large freedom in locating the terminal for road vehicle trains. Ilmala is very suitable location by means of road accessibility. Multimodal terminal existed at Ilmala already in the past.

In Tallinn road vehicle train terminal could be located west from Balti Jaam station or at some former railway yards like the one between Lilleküla and Tondi or between Ülemiste and Vesse. Both these have good road access but are still near the Tallinn city centre.

In Sweco-study for FinEst Link the road vehicle train terminal is expressed to locate in Muuga. As the connection of Muuga track yard to railway network is towards west and south, this means that the train from Finland at the route proposed in FinEst Link material must change the direction of driving for entering and exiting the Muuga terminal. The location of Muuga is also far from Tallinn city. By road the distance from Viru hotel is approximately 19 kms. For these reasons, Muuga is not recommended to road vehicle train terminal.

## Freight transfer terminals

A freight transfer terminal is needed for connecting the Rail Baltica normal gauge (1435 mm) railway to Estonian and Finnish broad gauge (1520/1524 mm) railway networks. Through the terminal, cargo or wagons are transferred between Rail Baltica and Estonian and Finnish railway networks.

Appropriate location for transfer terminal is a location that ensures shortest routes for the cargo and wagons to their final destination. As part of the cargo and wagons is destined to Estonia, **the terminal must be at the Estonian side of the tunnel**. Otherwise cargo destined to Estonia should pass the tunnel two ways.

In the FinEst Link plan the terminal in Tallinn is planned to Ülemiste, which is also the terminal for Rail Baltica. Location is suitable also for the freight trains to and from Finland, also in the case that the tunnel is directed to Balti Jaam.

Another terminal is planned in Finland north from Helsinki airport. **With the freight transfer and gauge adjust terminal in Tallinn, there is no need to haul 1435 mm gauge freight trains through the tunnel to Finland**. As long as this is the case, the shunting yard for FinEst Link freight trains in Finland should be the Riihimäki shunting yard.

## Tunnel track gauge

The service concept connecting the Helsinki and Tallinn region commuter train networks to one system requires a tunnel with broad gauge (1520/1524 mm) tracks.

As discussed in previous chapters, the convenient solution for road vehicle trains is that they should be able to operate on existing rails both in Helsinki and Tallinn sides. Therefore these trains must be broad gauge trains that use broad gauge in tunnel.

In Rail Baltica and EU TEN-T network plans the FinEst tunnel is seen as an extension of Rail Baltica with normal 1435 mm gauge. There have also been plans to extend normal gauge in some routes in Finland. In Sweco-study there is a plan build dual gauge railway lines in Finland from Helsinki to Turku, Tampere and Kouvola.

As discussed earlier, technically it is possible to build the tunnel for dual gauge tracks. Anyhow it seems to be not necessary in starting phase. The train volumes that might use the normal gauge in tunnel are insignificant. The only actual need is a sleeping coach train that may have origin and destination in Helsinki. At the starting phase there is only one two way service per day when the total number of two way services is 130 during a working day.

Though dual gauge is not required in the starting phase, if it will be built later, it has to be taken into account within the tunnel dimensioning and construction. Depending on the track bed solution in the tunnel, the tunnel may need to be fitted with dual gauge sleepers or rail fasteners in solid tunnel structures.

## Tunnel concept investment

The investment cost of the project will be reduced in the concept of this study compared to the FinEst Link plan. The reduction is based on following modifications of the concept:

- Total length is reduced in Finland when the tunnel rises to ground level before Pasila or the tunnel is connected to Pisara loop.
- Total length is increased in Tallinn when the tunnel is built to Balti Jaam instead of connecting to Rail Baltica by trunk road 1 near Nehatu.
- Iru junction and Hanko–Hyvinkää line connections are not required.
- Only one underground station is required in Finland.
- Freight transfer and gauge adjust terminal is required in Tallinn only.
- Road vehicle train depots and terminals are simpler and less expensive.

The estimated total infrastructure investment according to source material structure is 13.200 M€ instead of 16.000 M€.

# Regional Impacts

The regional impacts of the Helsinki–Tallinn fixed link form the basis of the project's viability. The public funding, however small or large part of the total funding it may be, is justified by the long term impact of increased mobility as well as the indirect benefits of the enlarged economic region.

The business case for Helsinki–Tallinn fixed link has been verified already in previous studies. The most recent studies on the tunnel are the Spiekermann-Wegener report from 2013 and the SWECO report from 2015.

## ”*Regional impacts of a railway tunnel between Helsinki and Tallinn*”, Spiekermann-Wegener (2013)

http://www.spiekermann-wegener.de/pro/pdf/HTTPS_SuW_FinalReport.pdf

The Spiekermann-Wegener report evaluated the regional economic effects of the Helsinki–Tallinn tunnel using SASI model, which is a recursive-dynamic simulation model. As the outcome of the process, one reference scenario and three different scenarios were created, varied by different outcomes of Rail Baltica, the tunnel and the implementation of TEN-T. The overall conclusion of the report was that the economic impacts of the tunnel would be positive, and the positives would be largely concentrated on the Finnish side.

The base scenario L0 was based on the assumption of GDP growth of 2,0 % until the year 2051 with no Rail Baltica or tunnel, while the outcome of scenarios L1–L3 was presented as the change of GDP growth when compared to the base scenario:

- Scenario L0: No Rail Baltica, no tunnel.
  - The base scenario
- Scenario L1: Rail Baltica built, no tunnel.
  - GDP growth vs. L0: Estonia +1,07 %, Finland +0,42 %

- Scenario L2: Rail Baltica built, tunnel built.
  - GDP growth vs. L0: Estonia +1,19 %, Finland +2,58 %
- Scenario L3: Rail Baltica built, tunnel built, full implementation of TEN-T.
  - GDP growth vs. L0: Estonia +2,07 %, Finland +3,35 %

Although SASI is just a quantitative model, and the outcome of this study can be criticized as overly optimistic, one should not completely dismiss the value of this report. Even if the real-life GDP growth impact would be substantially smaller than the estimates within the scenarios, that would still be significant in the current low growth and low interest rates environment. Besides, the Spiekermann-Wegener report did not contrate that much on the daily commuting of the Helsinki–Tallinn twin city, whereas they put more emphasis on the long range freight transportation. The Spiekermann-Wegener report was finished 5 years ago, and a lot has changed since then!

## ”*Prefeasibility study of the Helsinki Tallinn fixed link*”, SWECO (2015)

http://finestlink.niili.net/wp-content/uploads/2015/12/pre-feasibility-study.pdf

https://www.oresundsbron.com/en/start

https://en.wikipedia.org/wiki/HH_Tunnel

The Prefeasibility study of the Helsinki Tallinn fixed link (TalsinkiFix) was produced by SWECO in 2014-2015. The current FinEst Link -project is largely based on this report.

The SWECO report presents benchmarking info on Channel Tunnel, which, however, does not compare well with the Helsinki-Tallinn tunnel. Firstly, although the Channel Tunnel does connect two separate countries, there is practically no daily commuting between the two, as the main passenger flows travel between London and Paris or Brussels. Secondly, the Channel Tunnel was 100 % privately funded, and it was constructed at a time when interest rates in the U.K. hovered around 10-15 per cent.

Despite the high cost of construction and all the current uncertainty related to BREXIT, the Channel Tunnel a.k.a. Eurotunnel is and has been operating profitably for several years. On December the 15th, 2017 the Eurotunnel share (Getlink, GET.PA) was trading at 10,60 €, giving the company a market value of 5700 M€ and an enterprise value of 10.300 M€.

Another case example presented in the SWECO report is the Øresund Bridge connecting Copenhagen and Malmö, which is a more suitable benchmark for the Helsinki-Tallinn tunnel. The extended regional catchment area is of similar size both at Øresund region as well as the FinEstBayArea – about 4 million inhabitants.

The experiences from the Øresund bridge have been mainly positive. The number of Swedes living in Denmark as well as number of Danes living in Sweden has risen steadily, and living in the Øresund region has become a part of daily life. Kastrup Airport in Copenhagen has even become Sweden’s second largest departure airport. The advantages of the fixed link have been so distinct, that the Danes and the Swedes are even considering another fixed link across the Øresund – the HH Tunnel connecting Helsingborg, Sweden and Helsingør, Denmark.

## Regional impacts of the Helsinki–Tallinn tunnel

Above-mentioned reports and examples indicate that a fixed link connection between Helsinki and Tallinn would have a meaningful positive impact on the regional economies on both sides of the Finnish Gulf. Synergies between the mature and prosperous Finland and the fast growing Estonia could even be an order of magnitude higher than the synergies achieved in e.g. Copenhagen and Malmö, where the living standards and cultures were much more similar.

Although the level of education and know-how is high both in Estonia and Finland, there are some striking differences between the two countries. According to World Bank data (GDP per capita, PPP, current international $) Estonia's GDP grew in 1993-2016 a whopping 6,6 % annually, while Finland's GDP growth during the same period was 3,3 % per year. Though the Finnish society and economy may be more advanced in various areas, the Estonians' skills with managing fast growth and open-minded attitude towards new technology could benefit Finland.

# Conclusion

The daily ferry connection between Helsinki and Tallinn was launched some 50 years ago. Now it has grown to volumes and functional demand that there is a need to take the next step, and initiate a fixed link connecting Finland to Estonia and the rest of Europe. The Helsinki–Tallinn tunnel would benefit both Finland and Estonia, and it would also be in the interest the European Union. Even long term investors would warmly welcome an opportunity to invest in such a unique initiative.

The goal of FinEst Link New Technologies Challenge was to find a solution for a set of listed issues:

- **Facilitate daily commuting: travel time, ticket price**
  Daily commuting is estimated based on the existing daily commuting in Helsinki region commuting area. This study indicates daily commuting to be the dominant use and need for the tunnel. Daily commuting is also relevant and realistic business case when compared to the current commuting ticket price level and willingness to pay for work based commuting from Tallinn region to Helsinki region.

- **Smooth travel chains: 60 min. door-to-door labour market accessibility, access to global flight connections**
  Smooth daily travel chains for acceptable daily commuting time is challenging at both ends of the tunnel. In Helsinki the challenge is dense use of underground space in city centre. In Tallinn the challenge is the quality of seabed that limits the possible locations of the tunnel. The main ambition of this study was to seek radical improvements for the tunnel trains' accessibility in the core high capacity nodes of the public transport networks

both in Helsinki and Tallinn. Despite the adjustments to the FinEst Link plan, the tunnel trains still offer a smooth connection to airports in both cities.

- **Effective freight transport chains: delivery time, frequency, freight safety, price**
  Based on the existing information and future development estimations of the cargo volumes, the most remarkable mode of freight traffic is regional distribution traffic, that requires the transportation of trucks and vans through the tunnel. For this being effective, a reasonably priced and robust service concept with simple terminals at locations close to city centres is presented in this study. The planned concept fulfills the requirements for delivery time and frequency for reasonable pricing compared to current situation, as well as dramatically improves the reliability of the transport service.

- **Improved sustainability: less direct emissions, improved life cycle sustainability**
  Railway tunnel converts fuel based ferry transport to electric driven train transport with low initial energy consumption. Also the life cycle of rail transport is long which supports sustainability of the traffic compared to legacy solutions.

- **Improved safety and security: implementation risks, risks of incidents and accident**
  Railway tunnel is safe and secure transport solution by nature. Unlike road transport, safety culture in railways is based on zero accidents target. Railway tunnel is also totally risk free of climate conditions and offers service independent of seasons, storms and ice conditions. The tunnel also slows the growth of ferry traffic between Helsinki and Tallinn, which diminishes the environmental risks related to oil tankers cruising along the Gulf of Finland.

- **Improved traffic management in city centres: less congestion in city centres**
  Compared to ferry transport that require feeder connections between harbours and public transport network nodes, tunnel trains connected straight to high capacity nodes of public transport networks are easy to manage and reduce on ground traffic.

- **Economic viability: need of public support, effects on market competition**
  Though FinEst Link tunnel is a huge project and therefore as a single project has a high price tag, it also serves high volumes. The utilization rate of the tunnel is high, near its capacity in peak hours. This forms a solid base for a realistic business case. There are feasible incentives for both public sector and private sector to invest into the tunnel, which offers very long term secure return for the investment.

In the future a more precise study of the underground space circumstances in Helsinki end is required. A precise plan of the tunnel lining and station arrangements with the metro station and Pisara loop station reservation needs to be done. In Tallinn the lining between Balti Jaam station and Viimsi must be investigated and planned, as well as the arrangements at Balti Jaam.