Connecting Finland to European Railway Network

A keynote presentation (Plenary session 2) on 22.6.2022 by Markus Helelä (M. Sc.), a Project Manager/Senior Specialist from Sweco, at the

21st Nordic Railway Seminar (NRS)

(Venue: Solo Sokos Hotel Torni Tampere)

The projects this presentation is based on were done at WSP in 2019

SWECO

Part 1: Overall Vision

Minimum Goal for the Years 2035–2050

Background and Content

BACKGROUND

Finland's climate and traffic/transportation goals and competence require growth in freight and passenger traffic. Investing on railway traffic is in line with EU's traffic/transportation goals. Large portion of Finland's potential in railways and multimodal transportations are yet to be fulfilled.

CONTENT

In this presentation, a developmental vision for Finland's railway network, including connecting its main track to European railway network, will be described (customer: **Council of Tampere Region). Also will be described**

- whether it is technically feasible to enhance main track's current 1524 mm gauge with 1435 mm standard gauge and
- what will be the approximate travel time between Helsinki and Tallinn in the case that FinEstBayArea tunnel gets built and opens for traffic (customer: A-insinöörit and Afry).

Finland’s Railway Network’s Developmental Vision 2035–2050

TRANS-EUROPEAN TRANSPORT NETWORK (TEN-T)

- EU wants to strengthen Finland’s traffic connections as part of its supplementation of TEN–T.
- Connecting main track to be part of North Sea–Baltic corridor would enable the eligibility of EU’s assistance package to Finland’s traffic investments.
- Developing Scandinavia–Mediterranean corridor as for railway traffic would attract international traffic.

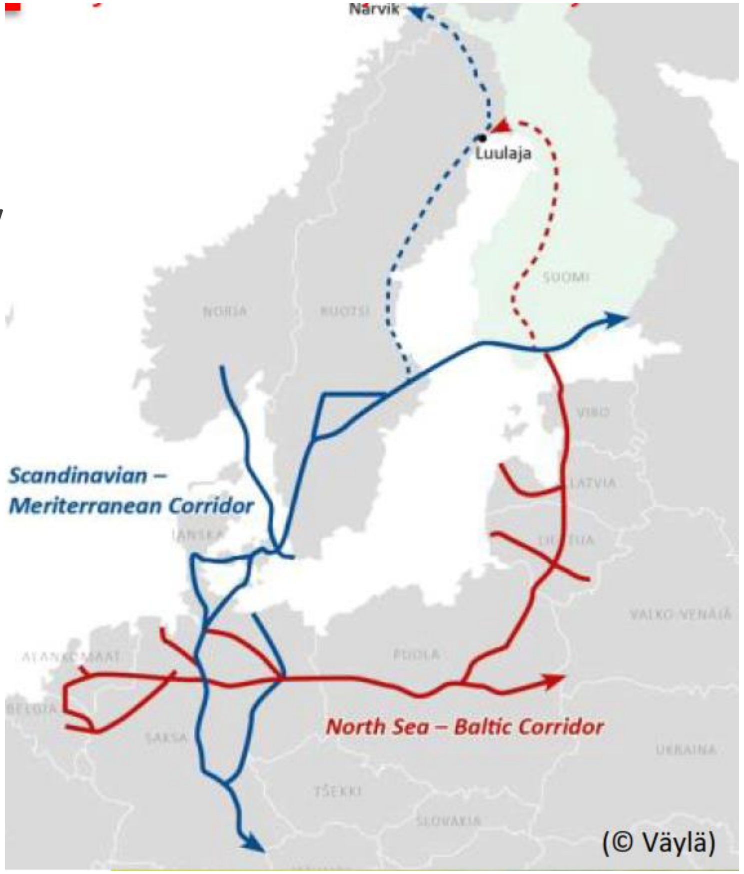
VISION

Stage I (by 2035)

- Turning Finland’s main track into a dual gauge corridor all the way until Tornio.

Stage II (by 2050)

- Connecting main track to Helsinki–Tallinn tunnel in the case it gets built, thus providing a railway connection to Rail Baltica.



Vision and Its Main Benefits

Stage I

- Connections through Sweden towards South and towards North (via Narvik to overseas markets) opens up.
- Northern Finland’s mining, forestry and energy production investments benefit from standard gauge if enrichments of mining industry get refined in Sweden.
- A logistics center planned for near Tampere would become a multimodal node by main track.

Stage II

- With FinEstBayArea Helsinki–Tallinn tunnel, a ”dual city” will be formed.
- With Rail Baltica, a direct connection to possible Eastern European corridor (North to South orientation) would form.

Part 2: Supplementing Main Track with Dual Gauge Solution

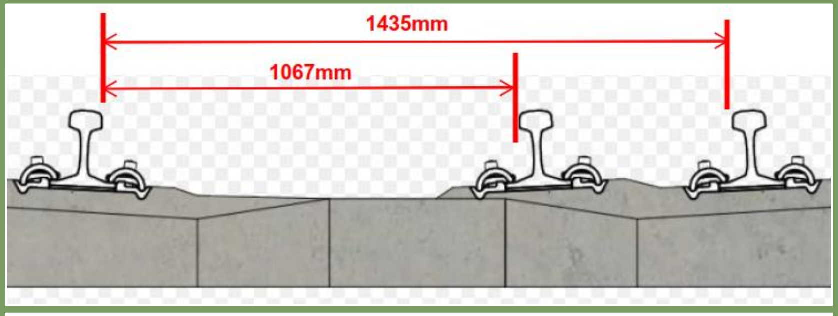
Polyvalent Sleepers with 4 Rails

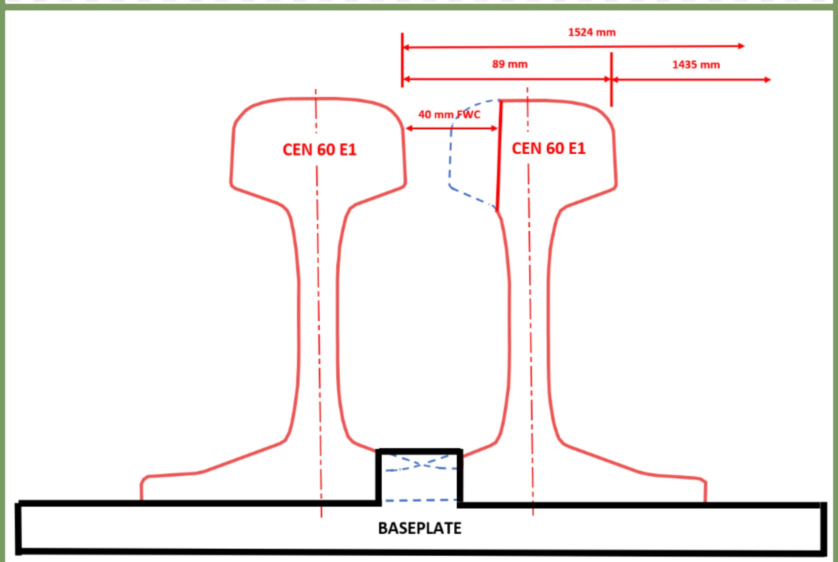
Background

- Finland’s 1524 mm railway track gauge is not compatible with the rest of Europe’s mostly 1435 mm track gauge railway network.
- The situation presents logistics challenges and restricts international passenger and multimodal freight transport growth and effective competition.
- One strategic enhancement to minimize or overcome rail transport access restrictions is to provide dual gauge corridors connecting the Finnish railway network with the existing standard gauge network in Europe via Sweden and/or via the proposed tunnel to Estonia.
- Feasible options for connections between the 1524 mm gauge railway and the 1435 mm gauge railway were investigated, along technical and other challenges.
- Extended polyvalent sleepers with 4 rails in an interlaced track configuration was chosen to further planning.
  - Polyvalent sleepers with less than 4 rails are not feasible for the movement of rolling stock with track gauge difference of only 89 mm.
  - One could theoretically consider replacing the 2 rails with one formed block incorporating 2 rail heads, a wider foot and single thick web. However, due to the complexities of this design, it is not considered feasible in application.
  - Tracks with different gauges may run parallel to one another as an alternative to using polyvalent sleepers. Although the track construction is less complicated, the provision of separated tracks requires increased land take, wider embankments and cuttings and wider bridges. In addition, separate arrangements need to be made at passenger stations and freight yards.
  - Automatic gauge-changing vehicles and equipment, and vehicle bogie change facilities aren’t optimal solutions.

Polyvalent Sleepers with 3 Rails (an unfeasible solution)

- Common running rail with 2 “gauge” running rails located on the same sleeper to provide dual gauge capability (top picture).
- Are currently in operation in various countries
- Can only be supported provided the difference between the 2 gauges is at least as wide as the foot of the rail and there is sufficient space to accommodate at least a single rail fastening element. Also, the free wheel clearance (FWC) between the 2 rail heads closest together should be a minimum of 40 mm to accommodate rolling stock wheel flanges.
  – These requirements are illustrated in bottom picture: it shows the rail foot overlap and the head of one rail cut to accommodate the FWC. It is not a viable solution given the loss of rail strength and the complexities of design, manufacture and installation which would not be cost-effective.
- It is therefore not considered possible to accommodate 1524 mm gauge with 1435 mm gauge using 3 CEN60E1 rails (which are typical rail profiles for standard gauge track in Europe) because the gauge difference is too small to implement a 3-rail solution.
- In addition, the design, installation and maintenance of railway turnouts in dual gauge track are more complex as trains are safely signaled and guided on both gauges and the degradation of the common rail is greater than that of the 2 “gauge” rails.





Polyvalent Sleepers with 4 Rails (a feasible solution)

- Dual gauge pairings which are too close to be accommodated by a 3-rail solution and therefore require 4 rails include the following:
  - 914 mm narrow gauge and 1000 mm narrow gauge (South America)
  - 1435 mm standard gauge and 1524 mm broad gauge (Finland, Russia, Eastern Europe)
  - 1524 mm broad gauge and 1676 mm broad gauge (India)
- The only significant length polyvalent sleeper section of track in Finland is at the border with Sweden between Haaparanta and Tornio (picture), where a 2 km section of dual gauge track supporting 1435 mm and 1524 mm can be found.
  - Rail marshalling yards lie at both ends of this Standard and Finnish dual gauge section of track to allow for the international shipment of freight.

Main Technical Constraints

TRACK

- Longer sleepers will be required to accommodate rails for both 1524 mm and 1435 mm gauge tracks.
- Horizontal alignment geometry will need to be adjusted to balance out the cant and cant deficiency effects to ensure passenger comfort is maintained and to optimize wear of track components.
- Ballast width will need to be increased to accommodate the wider sleeper and this may require subgrade/formation treatment and alterations to track drainage systems.
- It is unlikely that combined 1524 mm/1435 mm dual gauge turnouts will be feasible. This may necessitate providing separate turnouts and crossovers for each gauge.

ROLLING STOCK

- The requirement for bogie transfer/wheelset respacing between gauges should be addressed. This may be via automatic, variable wheel changers or bogie lift/drop facilities.

STRUCTURES

- Requirements for platform clearances and passenger stepping distances may conflict with rolling stock, the widths of which are different for Finnish and European gauge rolling stock.
- This will require either separate platform faces or additional train equipment (adjustable steps, or gap fillers for example) depending on the operating requirements.
- Structural clearances are less of an issue in Finland as the structure gauge is larger than that used in Europe.

Part 3: FinEstBayArea: Technical Travel Time Study of the Helsinki–Tallinn Tunnel Line

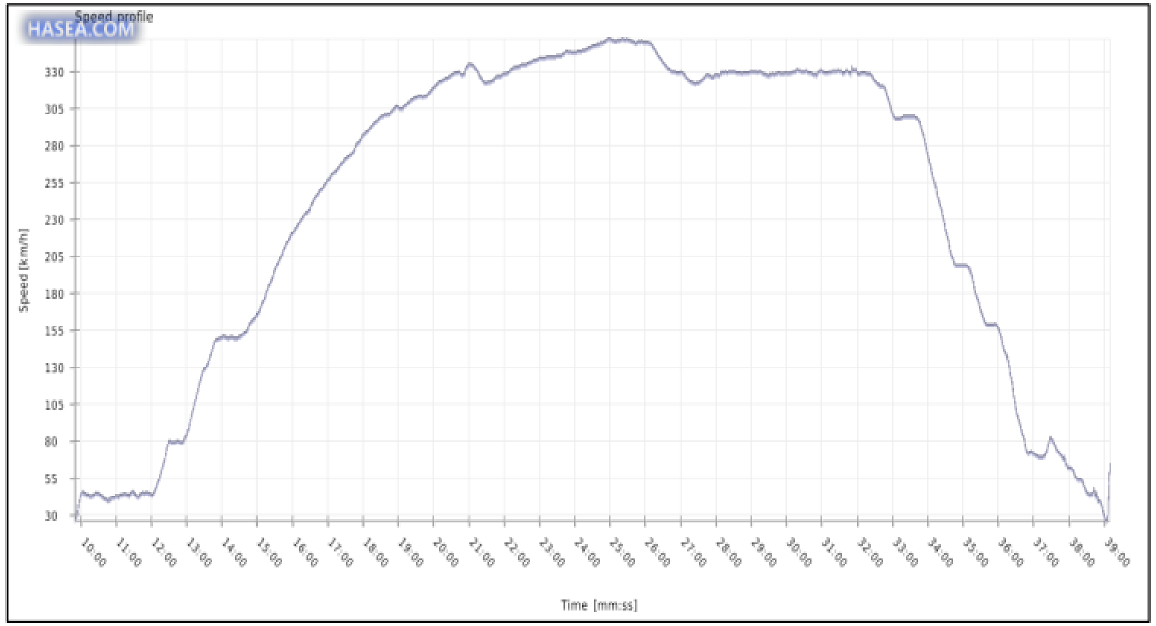
Minimum Travel Time for 350 km/h Operation

Background

- FinEstBayArea is an economic growth-spurring development project to construct significant infrastructure, including the currently planned and designed Helsinki–Tallinn tunnel and its four station areas, for the region between and around Helsinki and Tallinn airports.
  – It was started in 2016 after an initiative by the entrepreneur Peter Westerbacka, and its core consortium members are A-Insinöörit, Afry, Fira, and Trimble.
- As part of the planning and design stage, train travel times between end stations (GREEN OPTION; picture on the right) were studied by WSP in 2019 with necessary accuracy.

Assumptions

- Factors to consider to calculate a realistic travel time estimation were
  - accurate track layout (stations with km-points: Lentoasema 8+000, Otakeila 28+000, Ulkomatala 48+000, and Tallinn 121+250)
  - the gradients and speed limits of the planned track (gradient varied between +/- 0,4–1 %, meaning their influence on travel time wasn't substantial; speed limits were either 300 or 350 km/h),
  - rolling stock acceleration and deceleration specifications for N700 Series Shinkansen train with top speed of 360 km/h (both, theoretical ones as given by the manufacturer and practical ones as extracted from the empirical real-life operations data), and
  - technical timetabling principles (sufficient running time margin – estimated at 5 % – and station dwell times).
  - Automatic train operation in use, enabling the optimization and stabilization of train speed profiles, resulting in removal travel time-increasing fluctuations inherent in human drivers.
- Relating to the above-mentioned practical Shinkansen N700 specifications, average operational acceleration and deceleration, taking into account the passenger comfort requirements, were estimated at (see the graph on the right, based on non-automatic train operation, that was utilized in the estimation)
  - from 0 to 350 km/h, 0,31 m/s2 and
  - from 350 km/h to 0, 0,58 m/s2.



Plot of high speed train run between Tianjin and Beijing on 30 June 2011 using GPS tracking. It shows an average acceleration of 0.46 m/s^2 up to 150km/h and 0.13m/s^2 up to 330km/h. Braking averages at 0.4 m/s^2 .

Results and Analysis

- Travel times with 0,1 minutes accuracy for the between-airports line were calculated with operation speeds of 300 and 350 km/h for (a) trains with 2 stops between stations and (b) trains without any stops.
- Travel times were 36,71 / 35,33 min for 300 / 350 km/h operation, respectively.
  - In sections Lentoasema–Otakeila and Otakeila–Ulkomatala, trains managed to accelerate at most to 320 km/h before the deceleration phase.
  - The travel time difference between stopping and the theoretical non-stopping trains was calculated to be up to over 9 minutes (350 km/h operation).
- Future studies should focus on analyzing the possibility to
  - increase acceleration and deceleration rates in order to utilize the maximum line speed in each line section
  - run trains at 400 km/h between Ulkomatala and Tallinn (and the suitable rolling stock to do this with).

SWECO