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Rail Freight with the Fehmarn Belt Fixed Link - Forecasts, Challenges and Solutions

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Introduction and Background

The STRING transport corridor connects Hamburg and Oslo via Copenhagen, Malmö, and Gothenburg. The region is an essential part of the Scandinavian-Mediterranean transport freight corridor with 14 million inhabitants and many leading industries and important transport nodes.

The STRING geography has massive economic activities, particularly concentrated in and around Hamburg, Lübeck, Copenhagen, Malmö, Helsingborg, Halmstad, Göteborg and Oslo. Such a concentration along a single corridor is potentially favourable for the demand of rail transport and could ensure large volumes and hence high efficiency, economically as well as environmentally. However, the market share for rail freight is currently low, and the efficiency and costs of the rail services not sufficiently competitive.

The tunnel under the Fehmarn Belt between Denmark and Germany is planned to open in 2029. The Fehmarn Belt Fixed Link (FBFL) will remove a bottleneck and reduce transport times, contributing to efficient logistics between Scandinavia and Continental Europe. This could be an opportunity to realize the potential for more rail transport.

However, it is crucial to ensure the railway's capacity to avoid a situation where passenger trains and freight trains compete for time slots on the tracks. Capacity constraints and bottlenecks could effectively limit the potential positive impacts of rail transport.

It is also important to take complementary measures to increase the competitiveness of rail transport, for example by enabling a higher degree of competition between service providers and allowing longer and faster trains.

The purpose of this study is hence threefold:

- To describe possible future rail freight volumes across the FBFL in the years 2030. 2035 and 2040.
- To identify infrastructure problems and other obstacles or barriers that must be solved to fully utilize the FBFL and increase railway competitiveness.
- To propose solutions on how to overcome the challenges identified in step 2, thereby closing the gap between forecasts and EU targets.

Focus of the study is rail freight transport, reflecting the political ambition to transfer cargo from road to rail as well as the challenges for achieving this. Still, road transport is discussed extensively and scenarios for future road freight volumes are also included.

Organization

The study has been funded by the STRING network and the Greater Copenhagen Region. This extended abstract and proposed presentation at Trafikdage is a summary of the study with the same title delivered as part of the project.

The project team consisted of experts and consultants from Sweco. The experts are all professors in logistics at leading universities in Germany, Denmark, Sweden, and Norway;

- Otto Anker Nielsen is professor of Transport Modelling at DTU, University of Technology in Denmark.
- Ralf Elbert is professor of Management and Logistics at Technical University of Darmstadt in Germany.
- Harald M. Hjelle is professor of Transport economics at Molde University College, Specialised University in Logistics, in Norway.
- Johan Woxenius is professor of Maritime Transport Management and Logistics at the University of Gothenburg in Sweden.

The Sweco project team has consisted of senior consultants Henrik Andersson, specialized in strategy development and Johan Johansson, specialized in transport infrastructure.

The entire project team is responsible for the analysis, conclusions, and recommendations, while Sweco alone is responsible for numbers and data presented in the project report, that this abstract is based upon.

Data and Method

The study has combined quantitative data with qualitative assessments, addressing the purpose from various perspectives.

Many transport forecasts use advanced statistical or econometric models. Though these models have advantages, they may also be perceived as “black boxes” where it may be difficult to understand what happens between input and results. Hence, their transparency and usefulness as discussion material may be limited.

In this study, a different approach is chosen, partly due to budget and time constraints of the project, but also with the ambition to be highly transparent, allowing the reader to follow the analysis and judge whether they agree with the conclusions or not.

Central to the study is a combination of quantitative data with qualitative assessments. The project team has consisted of four professors within freight transportation, logistics and supply chain management from Norway, Sweden, Denmark, and Germany together with two senior consultants from Sweco. Experts from Sweco have participated to shed light on specific aspects.

To answer the three questions forming the purpose of this study, rail transport in the STRING corridor have been studied from different perspectives (Figure 1).

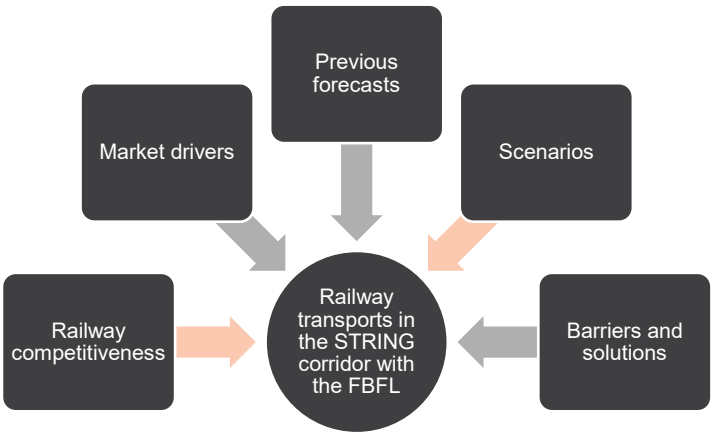

Figure 1. Analysing the issue from different perspectives.

The first step has been an explorative literature study on railway competitiveness, identifying the strengths and weaknesses of this transport mode in the light of logistics trends and market drivers. This establishes a background for studying the effects of the FBFL.

The results from the latest, model-based transport forecast from 2014 by Intraplan and BVU are compared with the actual development of freight volumes up until today. Plausible explanations of the gap between the forecast and the factual numbers are discussed. The forecast from 2014 was reviewed by Cowi (2015), concluding that the forecast was of high quality. The forecast is used as a starting point for this study.

To deal with the uncertainties associated with the forecasts four scenarios are formed. The basis for the scenarios has been railway freight volumes through, to and from Denmark together with volumes on the ferries between Southern Sweden and Germany. This is further discussed in Appendix 1. The uncertainties are highlighted to give the reader an understanding of the complexity involved.

Barriers to railway development in the STRING corridor have been identified as well as possible suggestions for dealing with them, hence increasing railway attractiveness.

The study has had a focus on the most important aspects to avoid getting too much into details. Freight transports between Norway/Sweden/Denmark and Germany/Belgium/Netherlands/France/Austria/Italy/Poland have been studied, since these are the relations that seem to be the most important ones for the future fixed link.

In general, the ambition has been to use long-time perspectives when analysing trends. That has not always been possible because of a lack of data. There have been no specific adjustments for the years of the Covid-19 pandemic.

Main Results

Over the last decades, rail has lost market share to road freight, which has generally responded better to the demand for reliable and flexible logistics with short transport times. It is difficult to draw unambiguous conclusions from different market drivers, but some tendencies together create an opportunity for rail freight to develop positively in the coming years. This applies, for example, to rising energy and fuel prices and a strong and growing focus on climate considerations, the environment and sustainability in general. However, a potential growth in volumes accentuates the limitations represented by a rail network with serious and increasing capacity constraints.

The latest forecast for the FBFL was performed in 2014 by Intraplan and BVU. According to the forecast, existing rail freight volumes through and to/from Denmark or via ferries between Southern Sweden and Germany will make up 98 % of the volumes on the FBFL. Only 2 % additional volumes will transfer from road transport. The general conclusion is confirmed by other transport models (TØI and SITMA AS 2019; Sweco 2023a) and by case studies (Atkins, Trafik- Bolig- og Byggestyrelsen 2020; Sweco 2023c). Although the FBFL will reduce transport times with about 2.5 hours for rail, this is a rather marginal effect. In transport chains being 24-48 hours long, it equals a relative saving of about 5-10 %. A similar effect is found when looking at transport costs, although there are examples when the effects can be larger. It could be noted that road transport will benefit from about 1 hour reduced transport time.

The forecast from 2014 lowered expectations of transport development relative to the previous prognosis from 2002 (Intraplan and BVU 2014). The actual development until today has been even weaker than the main scenario from the forecast from 2014 though, resulting in a “deficit” of about 1.3 million tonnes per year. This equals seven freight trains per day.[1]

Road freight volumes on the ferry lines Rödby-Puttgarden and Gedser-Rostock have increased by 45 % between 2011 and 2021, resulting in an annual growth rate of 3.4 %. Close to 92 % of future road freight volumes on the FBFL will come from the existing ferry line Rödby-Puttgarden (Intraplan and BVU 2014 p.153). Current road freight volumes on that ferry line are about 9 million tonnes today (Danmarks statistik 2023

[1] Using an average weight of a freight train of 724 tonnes (Trafikstyrelsen 2023 p.15) and 255 operating days per year (Intraplan and BVU 2014). About 30 freight trains cross the Öresund Fixed Link each day (Öresundsbrokonsortiet/Trafikverket 2022).

table SKIB32), clearly surpassing the forecast for 2025 of 6.9 million tonnes after the opening of the FBFL (Intraplan and BVU 2014 p.165).

Scenarios for future freight transport on the FBFL

Six scenarios were used to illustrate possible future developments until 2040 (Table 1). Four cover rail transport and two road transport. Since the modal shift from road freight to rail because of the FBFL is expected to be very small, the scenarios could very well co-exist, as they depend more on the development of trade volumes than on each other.

Table 1. Six scenarios for future rail and road volumes on the Fehmarn Belt Fixed Link.

Scenario	Description	Purpose
Rail: Average of National Forecasts	Calculation of an average of national forecasts, weighted by the most important rail freight relations, based on volumes. The growth rate is applied on current land-based rail volumes. The volumes on the railway ferries are assumed to transfer to land and form a part of the growth for the land-based volumes.	This scenario makes use of national forecasts, considering for instance prognoses of demography, economic development, and trade. The scenario illustrates a development with growing rail volumes.
Rail: History High	Linear projection of the historical development 2010-2021, combined with effects of the FBFL according to the 2014 forecast (Intraplan and BVU 2014).	This scenario illustrates a development with growing rail volumes.
Rail: History Low	Linear projection of the historical development 2012-2021, combined with effects of the FBFL according to the 2014 forecast (Intraplan and BVU 2014).	This scenario illustrates a development with declining rail volumes.
Rail: Weak Competitiveness	Projection of the historical development 2010-2021 based on a more advanced mathematical trend analysis, combined with effects of the FBFL according to the 2014 forecast (Intraplan and BVU 2014).	This scenario illustrates a development with severely declining rail volumes, a "worst case" for the railway.
Road History	Linear projection of the historical development 2010-2021, combined with effects of the FBFL according to the 2014 forecast (Intraplan and BVU 2014 p.153)	This scenario illustrates a strong development of road freight transport.
Road Low	Calculation of a simple average of national forecasts in the STRING countries.	This scenario is included to show a much weaker development of road freight than the last decade, albeit also leading to increased volumes.

An underlying assumption for all scenarios is that population, economic growth, and trade will have a positive development in the STRING countries during the period, although there will surely be recessions as well. The assumption is supported by national forecasts as well as prognoses from organizations like OECD (ITF/OECD 2021).

EU targets are used as a benchmark for rail freight volumes. Rail freight transport should increase by 50% by 2030 and by 100 % by 2050 compared to 2015 (EC 2020a, p.11). The rail freight scenarios and EU targets are shown in Figure 2. Clearly, EU targets are much above even the most optimistic forecast of future rail freight volumes.

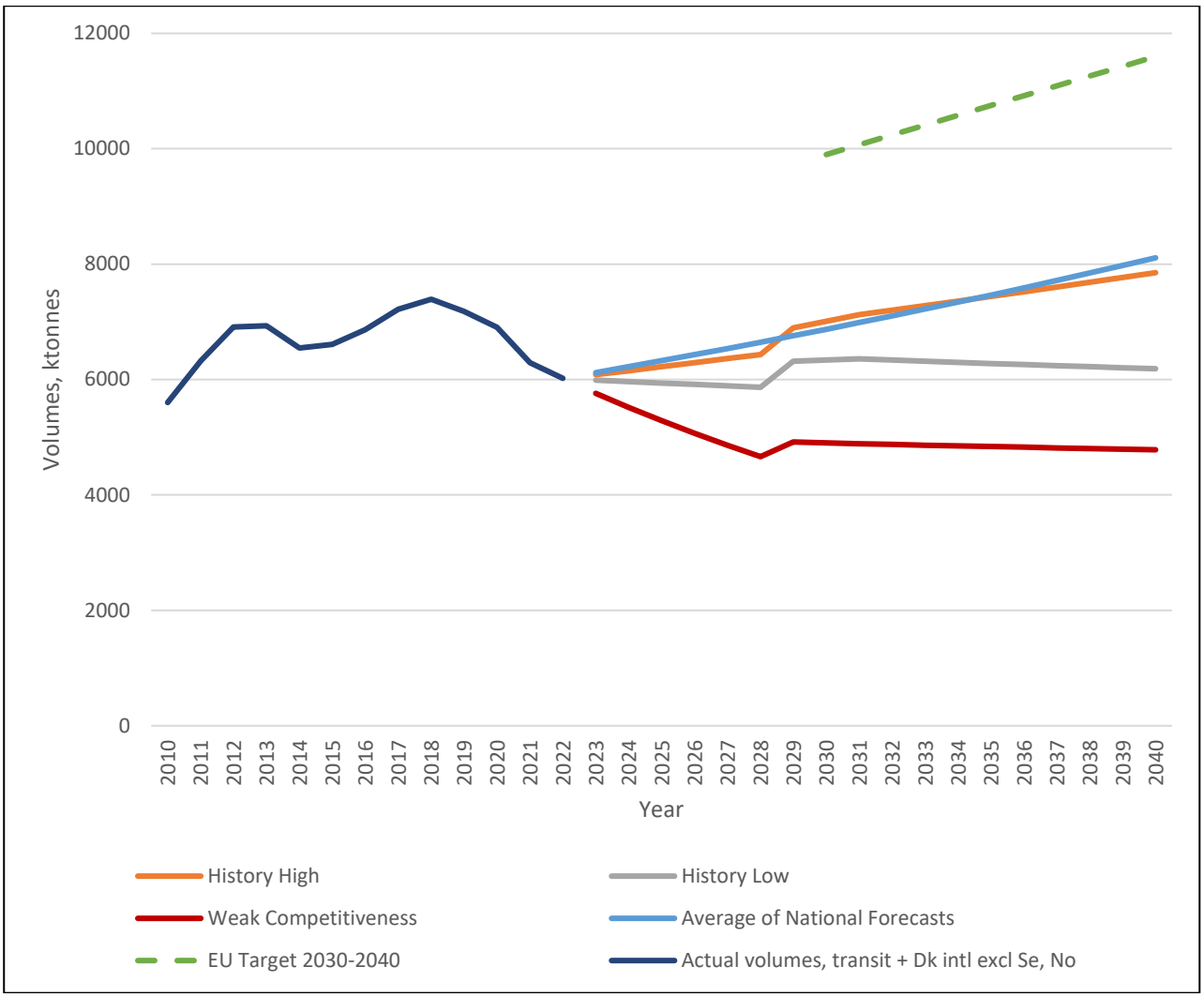

Figure 1. Four scenarios for railway volumes on the FBFL and the EU targets as a benchmark. Sources: Actual volumes: Danmarks statistik 2023 Bane1; Trafikanalys (2023) Sjötrafik; forecasts: Sweco

In the scenarios in the report, rail freight volumes are expected to increase with about 20 % or less until 2040. It cannot be ruled out that volumes would even decrease. Meanwhile, road freight across the Fehmarn Belt is expected to increase at least by 50 % and it might double. Annual rail freight is forecasted to increase from 6.9 million tonnes (37 trains per day) to 8.1 million tonnes (44 trains per day) or less. Annual road transport volumes could increase from 8.5 million tonnes (2 200 trucks per day) to between 12 and 19 million tonnes (3 200 to 4 900 trucks per day). Such a development will lead to serious congestion in the road network, but the effects could be partly remedied by longer/heavier trucks.

There are three main reasons why the FBFL alone will not lead to a significant modal shift from road to rail transport. Firstly, the FBFL improves road transport attractiveness as well, albeit not as much. Secondly, in transport chains lasting 24 to 48 hours, the time saving of 2.5 hours equals a reduction of 5-10 % and about as much for transport costs. Although being a significant reduction, it might not be enough for altering the competitiveness and attracting much road freight volumes. The third reason is capacity constraints in other parts of the railway network within and adjacent to the STRING corridor. Capacity constraints affect all factors important to the choice of transport mode, hence impeding the benefits of the FBFL. The FBFL and its connections will be one strong link in a chain with many weak links.

Rail competitiveness and the effects of the FBFL

Four factors are central to the competitiveness of transport modes: Reliability of service, Transport time, Transport costs and Flexible logistics.

Results from a transport purchasing panel organized by Chalmers University of Technology, University of Gothenburg and IVL Swedish Environmental Institute (2023) show a development towards demanding

better environmental performance, albeit slowly. It is doubtful whether this will increase the market's willingness to pay "extra" for rail transport, while measures that combine environmental gains with reduced costs are attractive.

The FBFL adds strategic and operative **reliability** through Denmark. At the strategic level, there will be two railway lines through Denmark. At the operative level, the fixed link and the connecting, new and upgraded railway lines will reduce disturbances due to infrastructure problems. Still, many challenges remain. Rail transport perform poorly with respect to punctuality in the entire corridor, to a large extent because of capacity constraints and lagging maintenance. In 2021, punctuality for DB Cargo was 73 %[2], a figure that fell to 65 % during the first part of 2022. About 80 % of the disturbances are caused by the infrastructure (BMDV 2022). In the Scan-Med corridor, from January 2018 to June 2019, close to 25 % of all freight trains were more than 6 hours delayed (Cox 2022 figures 10 and 11). Considering this, the time gained from the FBFL will probably often be utilized as a safety margin.

The effects of the reduced **transport time** from the FBFL will span from increased safety margins, adding to the reliability, to reduced costs through potential threshold effects. For many logistics chains the effects are relatively limited, but it seems likely that the potential for direct shuttle trains will increase. This adds more time gains as coordination needs with other time schedules are reduced. To increase railway competitiveness, many more initiatives are needed, however. Faster trains would meet long-term logistics trends rewarding shorter transport times. They would play an important role in increasing railway capacity. Faster trains clearly have a large potential to increase the operational area, hence enlarging catchment areas and possibly leading to either or both of the following effects, a) making new freight train lines profitable, b) increasing the profitability of existing rail transport. However, running faster trains on single stretches might not give any advantage if bottlenecks remain, either in the railway network or in intermodal transport chains.

The FBFL will lead to a reduction of **transport costs**. Although the effects vary depending on the transport chain, case studies indicate a 5-10 % cost reduction. In some cases, the benefit could be considerably larger thanks to threshold effects, but the reduction could also be lower. Transport costs could also be reduced through faster trains. Of specific concern is the comparatively high fees for handling units at the Danish intermodal terminals. The potential for longer and heavier trains appears especially large as they reduce fixed costs per tonne moved, improve energy efficiency, and increase network capacity. Although the STRING corridor in general has comparatively favourable conditions for longer trains, there are serious constraints remaining in Sweden and Norway.

The FBFL and connecting, new and improved railways will increase **logistics flexibility** by allowing for more trains and more time slots. Outside rush hours, there will be three hourly time slots for freight trains through Denmark, two via the FBFL, and one via Great Belt Fixed Link (Trafikstyrelsen 2023 p.15).

Capacity constraints obstructing the development of rail freight

However, remaining capacity constraints in other parts of the railway system reduce the benefits of the FBFL. The reason is that bottlenecks, single-tracks, restrictions on train length or weight, speed reductions, steep gradients, lack of terminal capacity and other infrastructure shortcomings have a negative impact on every one of the most important factors when choosing transport mode. These capacity constraints appear in all parts of the STRING corridor as well as in adjacent regions (Figure 3). The major capacity constraints are presented below in two categories:

A. Elements already restricting the competitiveness of rail transport
B. Elements that will restrict railway transport competitiveness by 2030

[2] Defined as a freight train being no more than 16 minutes delayed.

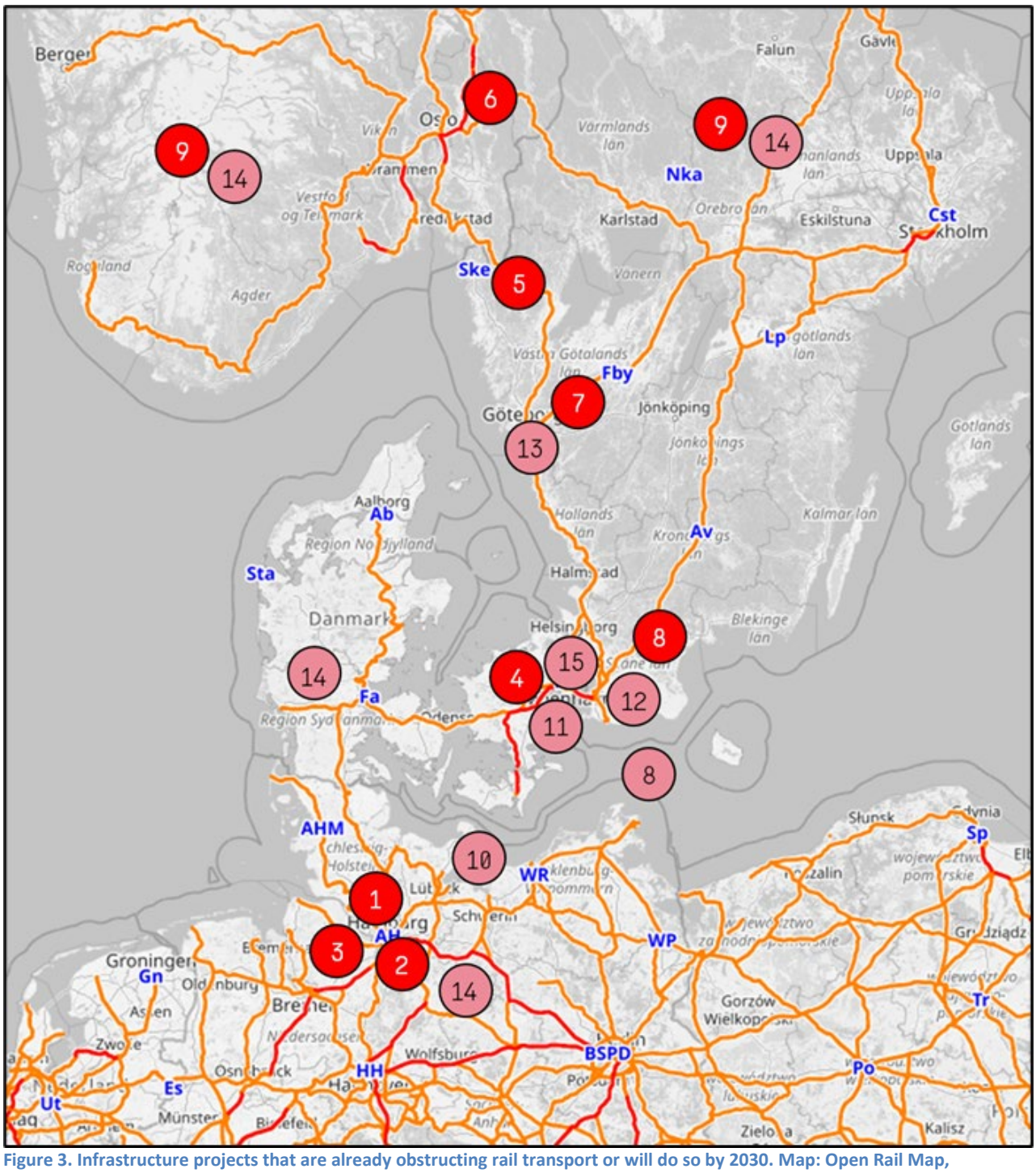

Figure 3. Infrastructure projects that are already obstructing rail transport or will do so by 2030. Map: Open Rail Map, www.openrailmap.org

Category A

1. Rail node Hamburg. Hamburg is not only a large metropolitan region, but also at the crossroads between three TEN-T corridors; the North Sea-Baltic, the Orient-East Med and the Scandinavian-Mediterranean. It is vital for rail freight in the STRING corridor.

2. The railway Hamburg-Hannover. The railway between Hamburg and Hannover is one of the most utilized transport corridors in Germany with an urgent need to increase capacity.

3. Hamburg terminal capacity. The Port of Hamburg is one of the largest logistics and industrial zones in Germany. Capacity is highly utilized, to the extent where it is causing waiting time as well as complicating logistics.

4. Terminal availability and prices in Denmark. There is a lack of open railway terminals in Denmark, hence competition is weak and the prices for using the terminals are high. The solution is not clear, but a new, open terminal capacity would improve the situation and make rail transport more competitive.

5. **The railway Oslo-Gothenburg**. The railway between two of the largest Nordic regions has major flaws concerning line speed, steep gradients and length restrictions affecting cost efficiency very negatively.

6. The railway system in the Oslo region and the Alnabru terminal. The railway network in the Oslo region has severe capacity challenges because of large passenger flows as well as freight volumes. The Alnabru terminal is the largest in the Nordic countries. It has capacity constraints and must be further developed to promote a modal shift.

7. The Western Main Line in Sweden. It might be the most important railway in Sweden with large flows of both passengers and goods, but lack of capacity has deteriorated traffic quality, leading to disturbances and longer transport times.

8. The Southern Main Line in Sweden. This is also a competitor for the title most important Swedish railway. There is currently no decision to increase capacity to and from the Greater Copenhagen Area.

9. Train lengths in Sweden and Norway. Longer and heavier trains have a large potential of increasing railway competitiveness. Current restrictions in Norway and Sweden are obstructing that potential.

Category B

10. Hamburg - Lübeck - Puttgarden (Hinterlandanbindung FBQ). It is part of the state treaty between Germany and Denmark and must be ready when the FBFL opens, otherwise, it will be the most serious bottleneck in the STRING corridor.

11. Danish bottlenecks around Copenhagen. Existing bottlenecks around Copenhagen will be even more severe when the FBFL opens. There is a great need for track junctions separated in height in Ringsted and Ny Ellebjerg, and to ensure sufficient railway capacity at and to and from Copenhagen Airport station with new passing tracks and other measures. These projects are prioritised in the Danish Infrastructure plan (Transportministeriet 2021a). The double-track stretch from “Hvidovre fjern” to Høje Taastrup may be a future bottleneck.

12. Swedish bottlenecks around Malmö. There is a need to ensure capacity around Malmö and to and from the Öresund Fixed Link, not the least a grade-separated rail junction in Svågertorp and increased capacity of the marshalling yard in Malmö.

13. The West Coast Line around Gothenburg. South of Gothenburg, capacity constraints are obstructing the development of rail transport for passengers as well as freight.

14. ERTMS. The new European standard signalling system will, according to plans, have important benefits for freight transport. Though the time schedules are vague, the system will not be fully developed in the STRING countries until earliest the mid-2030s.

15. Strategic redundancy across the Öresund. There is an obvious risk that the railway ferries between Trelleborg and Rostock will cease to operate, due to low profitability. It would be troublesome to lose redundancy between Southern Sweden and Germany about at the same time as redundancy through Denmark is established.

Due to the long lead times for planning and construction all challenges in both categories must be addressed immediately.

Conclusion, Discussion and Future Work

The analysis in this study results in clear conclusions. The tunnel under the Fehmarn Belt makes valuable contributions to strengthening rail freight in the STRING corridor, but it is not enough to lead to a substantial modal shift. It therefore appears to be a necessary, but not sufficient, instrument for an enhanced role for rail freight in the corridor. None of the most positive scenarios in this study indicate that the EU's ambitious targets for shifting from road to rail will happen. A variety of complementary initiatives are needed to enable such a development and to fully utilize the FBFL. This study highlights the following measures and recommendations to strengthen rail freight in the STRING corridor:

- Removing infrastructure bottlenecks is crucial for railway growth. Capacity constraints have very negative consequences for all factors defining the competitiveness of transport modes.
- Ensuring full train lengths and faster trains in the entire corridor and its connections will improve railway competitiveness. It will increase rail freight transport capacity as well as enable more trains in the network.
- The infrastructure standard in the TEN-T freight corridors is not sufficient, but rather represents a minimum standard. The standard does not take into consideration capacity constraints hindering full utilization of the railway network, nor steep gradients (for example between Oslo and Gothenburg) and other bottlenecks.
- There is a need for more terminals in Denmark, or multiple operators within each hub/terminal, to ensure competition that contributes not only to railway cost efficiency, but also to increased reliability and capacity.
- A level playing field between transport modes regarding fees and taxes is necessary. This should ensure that all transport modes pay for their externalities.
- As road transport is expected to remain the dominant freight transport mode in the STRING corridor, any effort that minimizes greenhouse gas emissions from road vehicles would be just as important as paving the way for more rail freight. Providing necessary infrastructure for zero or low-emission fuels is crucial in this respect.

While railway transport has many advantages, sea transport could give significant contributions to the STRING corridor, primarily for transport to and from the corridor. Railway bottlenecks could be partially relieved if cargo is transported by ship to a seaport closer to the origin or destination, before being transferred to rail transport (see for example Stelling et al 2019)..

Acknowledgements

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STRING is a political member organisation for local and regional authorities in Northern Europe between Oslo and Hamburg. Major cities and regions in STRING join together to connect and align politically, industrially and geographically to accelerate the green transition and unlock new potential for green growth and sustainable transport infrastructure

Greater Copenhagen is a collaborative organization promoting growth and development in the largest Nordic metropolitan area, encompassing 4.4 million citizens in Southern Sweden and Eastern Denmark

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