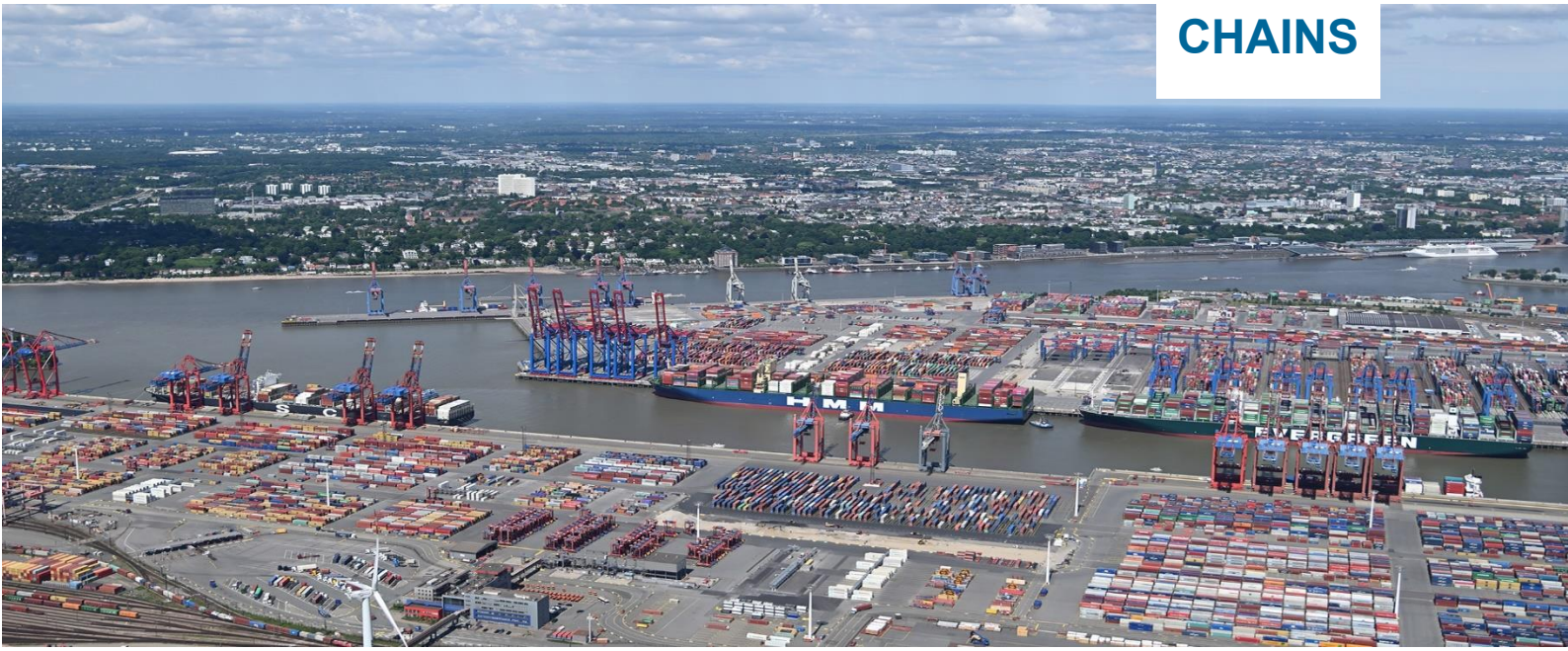
BLUE SUPPLY CHAINS



Role of port authorities in the set-up of green transport chains

Deliverable 1.3

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Green ports fostering zero-emissions in

BLUE SUPPLY CHAINS

Interreg Baltic Sea Region

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BLUE ECONOMY Blue Supply Chains

Agenda

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Blue Supply Chains Project

The Blue Supply Chains project supports port authorities and port operators to decarbonise port operations by advancing electrification, providing alternative fuels strategies and setting up green transport chains.

Ports are essential for global trade and prosperity, but at the same time contribute to the emission of pollutants through freight traffic and port activities. Ports can be an important factor in achieving European and national climate goals and will also play an important role in the storage and onward transport of alternative fuels in the future. The "Blue Supply Chains" project supports port authorities and port operators in implementing long-term measures to decarbonize port locations.

The project follows different approaches supporting decarbonization in ports:

- Evaluation and piloting of measures for the further electrification of handling equipment,
- Strategies for providing, handling and storing alternative fuel,
- Promotion of more environmentally friendly transport chains in the hinterland, with a focus on the development of combined transport.

The project runs from January 2023 to December 2025 under the lead of Port of Hamburg Marketing reg. ass. It received funding from the Interreg Baltic Sea Region Programme 2021-2027.

More information and all documentation available at: https://interreg-baltic.eu/project/bluesupplychains

1. Development of rail ferry services between Rostock and Trelleborg

The rail ferry between Rostock and Trelleborg is the last rail ferry in operation between Germany and Sweden.

Stena Line, the ports of Trelleborg and Rostock offer an efficient rail connection between Central Europe and Scandinavia. The Rostock-Trelleborg rail ferry connection is the only active alternative to the land-based rail connection via Schleswig/Holstein and Denmark to Sweden.

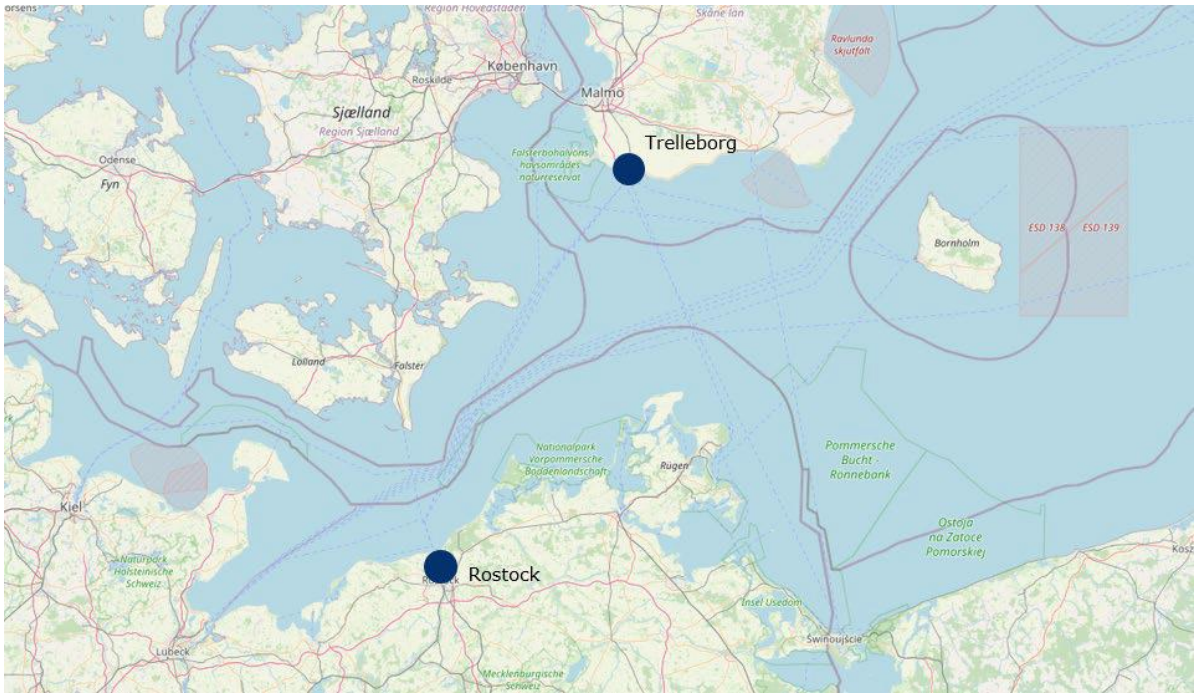

Figure 1 - Rail-Ferry Link between Trelleborg – Rostock.

Source: Ramboll Deutschland GmbH (2024): Analysis of Future Potential of Rail Ferries, p. 7, based on OpenStreetMap.

The Port of Trelleborg is one of the most important hubs for Swedish foreign trade, especially due to several important ferry routes to Germany and Poland. The largest volumes are transported to Germany, but trade with Poland is rapidly increasing. There are many indications that trade will continue to grow eastwards, increasing the Port of Trelleborg's importance for Swedish foreign trade.

Major investments are being made in the Swedish industry in northern Sweden, with an expansion of the steel industry, the battery industry, and the mining of strategic raw materials. Several of these initiatives are made in collaboration with German industries and/or has Germany as the intended market. The majority of the transportation will be by sea, but rail transports will also increase. An important part of the transportation routes of these types of materials and products, including steel products, are currently going through the Port of Trelleborg. It is therefore reasonable to assume that the Port of Trelleborg will attract increased volumes of cargo as a result of the investments in northern Sweden. The Swedish Transport Administration expects an increase in rail traffic as a result of the investments in the northern part of Sweden (Norrbotten and Västerbotten) on the Northern Main Line with an additional 6 to 17 daily freight trains. An increased traffic from investments in southern Norrland, Dalarna, and western Sweden should be added to those numbers. It will also require increased volumes of inputs. Due to the current layout of transportation patterns, it is reasonable to assume that a

considerable proportion of this increased traffic will also use the Port of Trelleborg to reach its destinations.

The Fehmarn Belt link will significantly improve the conditions for efficient rail transport to and from Germany, via Denmark. In a previous work, we have shown the potential for major cost reductions for rail transport because of the tunnel. Thus, it is reasonable to assume that rail traffic over Fehmarn belt will increase significantly after the completion of the tunnel. However, it should be noted that there is concern about the capacity of the railway system in Skåne (Scania) and of the connecting German railway network south of Fehmarn belt. It is likely that there will be capacity shortages on several routes, including Lund-Hässleholm and in parts of the German railway network, which will hamper the development of rail transports.

The Fehmarn Belt link will not, on the other hand, significantly affect truck flows, and it will therefore continue to be profitable for most road transports to use the Rostock-Trelleborg link. Rail traffic to and from eastern Germany (and markets south/east of it) will probably also continue to use the Port of Rostock. Germany is now improving the railway infrastructure to support this. There are ongoing infrastructure improvements south of Germany, such as the access to the Brenner Pass, which enables increased rail transport to and from the Port of Rostock from central, eastern and parts of southern Europe. These projects and improvements will create the opportunity for increased intermodal traffic through the Port of Trelleborg.

Important steps to improve the railway in southern Sweden were taken when the government added the expansion (2 more tracks) between Lund and Hässleholm and added measures around the Malmö railway freight yard to the National plan for the transport system 2022-2033. It should be noted, however, that the Swedish Transport Administration’s proposal for the direction of the next infrastructure plan entails a heavy burden on the investments in order to secure fonds for the maintenance of the existing infrastructure. If this proposal is adopted, it will be difficult to accommodate projects that are not under construction or are "locked" by, for example, agreements. It is important that the so-called business pot is maintained and strengthened to enable minor measures to benefit business transport.

The future for the Port of Trelleborg contains major uncertainties, but the port needs to be prepared for major changes in the outside world. The world around us is uncertain and several important policy instruments are being introduced that affect the flow of goods and the distribution between the modes of transport. A worrying, but conceivable, scenario is that the necessary infrastructure expansion does not come about. In that scenario the freight volumes through the Port of Trelleborg will probably increase anyway, but mainly by truck transports as intermodal traffic arrangements cannot grow significantly due to the lack of rail capacity. A more positive scenario for rail transport would be that the infrastructure measures will be implemented in a reasonable future, creating the possibility of a larger share of intermodal transport and "rail shuttles" between Trelleborg and Gothenburg and between Trelleborg, Mälardalen and northern Sweden.

There will probably be a sharp increase in the use of single trailers. There is already a trend towards both increased intermodal transport and increased use of loose trailers, which means that Trelleborg needs to invest in machinery and equipment for this.

Regardless of the pace of the expansion of the onshore infrastructure in Skåne, the Port of Trelleborg will need to invest to cope with larger volumes of electrified transport, including more intermodal transport. It is of great importance to ensure increased supply of electricity to the port to enable electrification of ferries and truck tractors to and from the Port of Trelleborg. In the event of insufficient allocation of capacity in the electricity grid, larger batteries could be installed to handle the difference between large power requirements during charging and allocated capacity and power output from electricity grid.

The Port of Rostock is a major hub for European transport and the largest German Port at the Baltic Sea and plays a central role in international trade. Strategically located on the Baltic Sea, the port has developed into an important hub for maritime trade and logistics since its foundation in 1960.

The Port of Rostock has a first-class infrastructure that makes it one of the most modern and efficient ports in Europe. It includes Container terminals, general cargo terminals, Ferry and RoRo terminals and liquid goods terminals as well as special facilities for handling oil, gas and chemicals.

In addition, the port has extensive storage areas, logistics centres and rail connections, ensuring seamless integration into the European transport network.

Planned investments in infrastructure, the expansion of handling capacities and the introduction of new technologies are intended to further strengthen the port. In addition, the increasing importance of the Baltic Sea route in global trade will offer the port new opportunities for growth. This also includes the rail ferry between Rostock and Trelleborg.

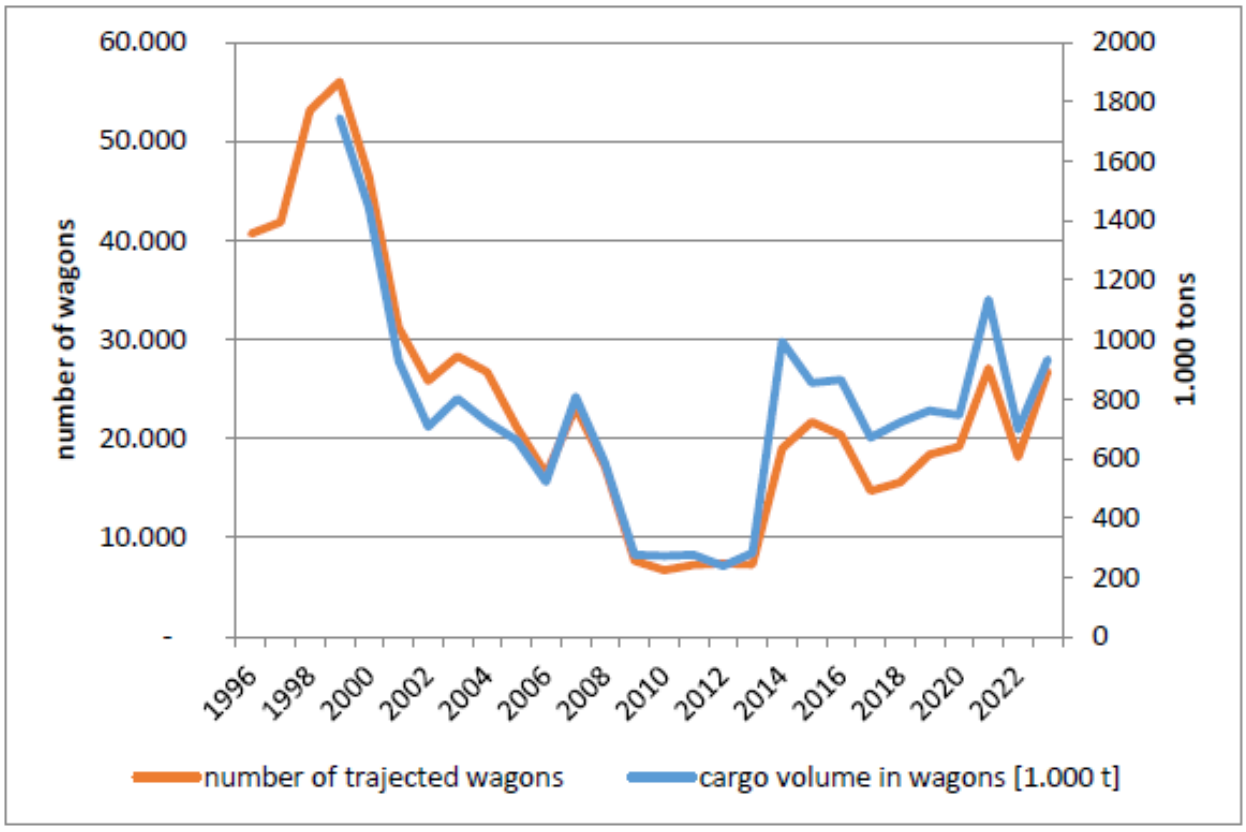

Figure 2 - Rail ferry traffic in the Seaport of Rostock (wagons and cargo).

Source: Baltic Marine Consult Rostock-Warnemünde & railistics Wiesbaden (2024): Analysis of existing track capacity for rail wagon ferrying in the seaport of Rostock, p. 5.

Since the commissioning of the two rail ferries M/F Mecklenburg Vorpommern and M/F Skane in 1996, the transport volume in terms of the number of wagons transported has declined continuously from around 55,000 wagons per year to less than 10,000 wagons per year in the first 14 years of operation.[1] After the discontinuation of the rail ferry service via Mukran, traffic increased again to about 26,000 wagons in 2023 (figure 2). In 2021, there were disruptions on the Jutland route via the Great Belt, so that rail freight traffic was temporarily diverted to the rail ferry connection. The volume of goods (net) shows a similar picture. Starting from 1.8 million tonnes in 1998, the tonnage excluding tare weights of the transported wagons fell to 14% of the initial volume (0.24 million tonnes) by 2014, before rising again

[1] During this time period the DB train wagons were swapped. 2 axle wagons were replaced with 4 axle wagons which are able to load nearly twice as much cargo which reduced the number of wagons drastically.

to about 1.0 million tonnes per year. It has remained at this level for almost 10 years, with the exception of 2021.

The ferries Mecklenburg-Vorpommern and Skåne each have approx. 1,000 meters of track and are the only ones that allow direct trains to be transported between Germany and Sweden without having to be reloaded in Rostock or Trelleborg.

The Rostock-Trelleborg rail ferry service is unique, combining the two most sustainable transport options and creating necessary redundancy in rail transport between Germany and Sweden. It relieves the congested and trouble-prone freight route via Denmark and the major crossings. At the same time, we are faced with the challenge of bearing the considerable additional costs of operating railway ships privately, for the benefit of the general public. In Sweden, this discrepancy has already been recognized, and the transport authority is currently investigating ways to support the rail ferry.

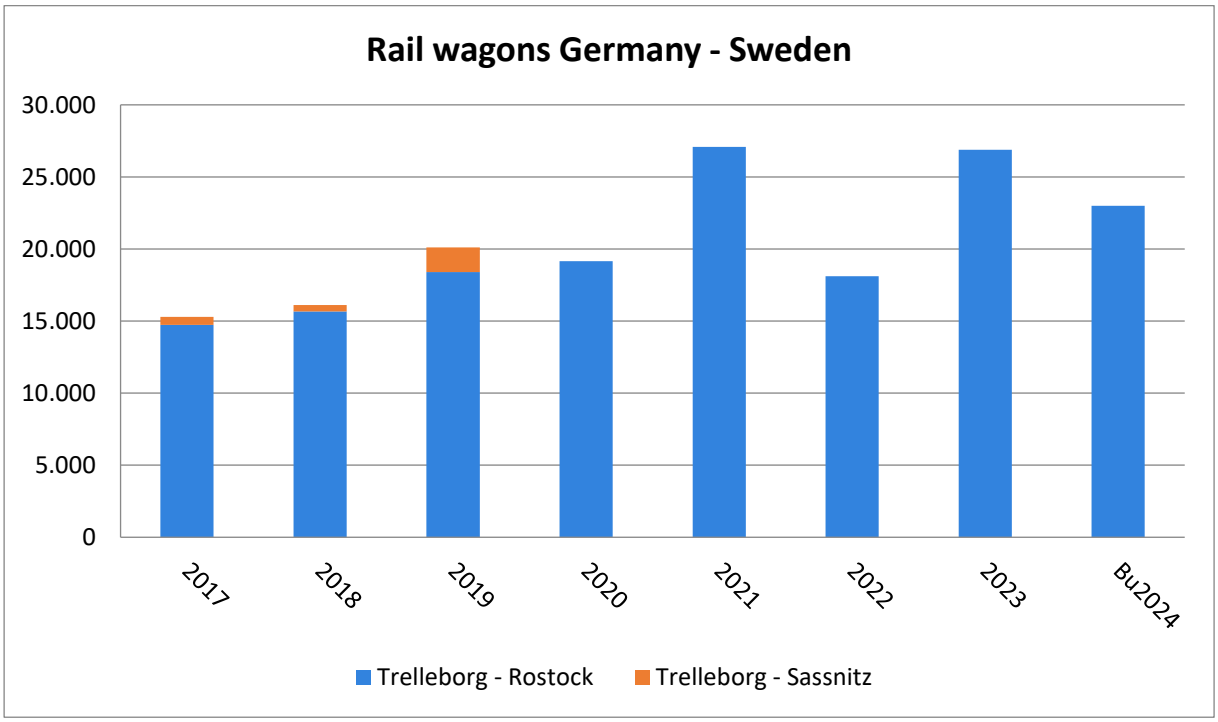

Figure 3 - Number of rail wagons transported between Germany and Sweden.

Source: Data: 2009-2022 Rostock Port, 2023-2024 Stena Line.

In Figure 3 the latest numbers of transported wagons on the Stena Line ferries are visualized. The majority of those wagons are running in single wagon traffic for the state-owned rail companies in Sweden and Germany.

Remarkable is the high volume in 2021. In this year a big accident happened on the Greater Belt bridge and thus it was closed for intermodal trains for many months. Trains have been rerouted on the Stena Line ferries between Rostock and Trelleborg but disappeared after re-opening the routing via bridges. Despite all efforts, it was not possible to keep the trains on the ferry on a long-term collaboration for different reasons such as operational circumstances, lead time or total supply chain costs. On the other hand, the conventional single wagon traffic and the high/heavy rail wagons still remain and have been increased over the last years. Based on higher demand and excellent high frequented services of Stena Line but also the understanding that a vital second link is necessary for resilience transportation flows.

Otherwise in such situations where the bridges between Germany / Denmark / Sweden are closed, there is no other infrastructure available for conventional and high & heavy trains.

Also, limitations for heavy trains playing a big role in considering the rail ferries as alternative. There are some weight limitations for the Rendsburger Hochbrücke, which is an essential infrastructure to go by train to Denmark. On this bridge only one heavy train is allowed to pass the bridge at once. Up to 4650t of wagons are allowed on both tracks in total. A heavy steel train transported on Stena Line ferries could weight up to 3800t. Such a train would block the transport of other trains on the Rendsburger Hochbrücke. Thus, these trains are running nearly on daily basis on the Stena Line rail ferries between Sweden and Germany.

Another noticeable trend is the higher occupancy in intermodal terminals. This leads to bottlenecks for intermodal trains. Especially the most requested slot times in the terminals are very occupied and mostly overbooked. For these situations the rail ferries are a welcomed alternative, and it allows also to avoid any trailer handling and damages (like cargo in tarpaulin, broken customs line etc.). One shunting operation for a full train is 38 intermodal trailers one by one (by crane or reach stacker) that increases the chances for damages.

2. Specifics/requirements of rail ferry services

The main obstacle to increased rail traffic to and from the continent on the Swedish side is the limitations in railway capacity in Skåne. Capacity utilization is currently at maximum on the Lund-Hässleholm route. Should the double track Lund-Hässleholm be completed, the capacity problem will be solved in that section, but the bottleneck will instead be moved up to the Hässleholm-Alvesta section. By 2045 Hässleholm-Alvesta will have a capacity utilization of almost 100%. The capacity for the Öresund link and the Trelleborg- Lockarp section will also be limited. If these limitations in rail capacity are not addressed, there can be no significant growth in the intermodal traffic arrangement. Limitations in rail capacity in Skåne will counteract increased rail traffic to and from the continent. At the same time the Swedish Transport Administration will raise track charges significantly in the next few years, at the same time as certain temporary state subsidies for rail transport are removed. The planned increase in track fees is part of the ongoing adaptation of the relatively low fees so that the fees cover the variable costs of the trains, i.e. the socio-economic marginal costs. The train operators will also have increased costs in connection with the introduction of the new signaling system ERTMS.

The extent to which the increased costs will negatively affect rail traffic is, however, more difficult to say. The operators seem to be more concerned about poor infrastructure and capacity shortages than the increased track fees according to the reports from the Swedish Transport Administration.

The possibilities of increasing the number of trains to and from the Port of Trelleborg from today's two trains to between eight and ten or even more if the proportion of loose trailers increases due the shortage of drivers and electrification of the truck tractors. This would lead to more than a doubling of the handling of loose trailers, and it would lead to even higher demand for rail transport on the Swedish side for transports over 300 km. The changes to the truck regulations allowing longer trucks, as well as the development towards electric trucks, will greatly increase the competitiveness of road transport. Above all within Sweden, the costs of road transport will drop significantly due to electrification and long trucks. This, together with limitations on rail capacity, means that a large part of the increased traffic to and from the continent will be by trucks. Road transport to Europe will also in future have a cost advantage by taking the route via Trelleborg.

On the other hand, what speaks against increased transport of lorries is the EU's directive for road charges (EU, 2022) which, among other things, enabled Germany's large increase in road charges for lorries. At the same time, the shortage of truck drivers is increasing, which prevents a greater transfer from rail to road transport.

There will be an increase in truck transport to and from the continent. Possibly this increase will be combined with increased rail traffic on the continent due to strong policy instruments and improved infrastructure.

The infrastructure situation in the Port of Rostock is a bit different. The Rostock seaport has the 550-570 track group, the feeder tracks to a ship berth (LP 64) and a railway ramp adapted to the ferries. The track facilities and the rail/ro-pax jetty are located in the southern area of the ferry and ro-ro terminal, in a port area heavily used by rubber-tyred transhipment and internal port traffic. The usability of the track facilities (e.g. overpass, parking of road units) for the port's internal rubber-tyred transhipment traffic is largely dependent on the utilisation of the tracks by rail ferrying.

The rail ferry track group 550-570 was designed with sufficient capacity for the rail connection to Pier 1, which was originally designed as a conventional breakbulk terminal. With the conversion of Pier 1 to rubber-tyred ferry traffic, the feeder tracks to berths 65 and 66 were redesigned, decommissioned and dismantled, reducing the need for siding capacity. Track group 550-570 is therefore designed for much higher volumes and more diverse requirements then actually needed. The capacity of the vessels in service throughout the period is also designed to handle much higher volumes. In the standard timetable, the vessels sail three times a day for six days (Monday to Saturday) and twice a day on Sunday.

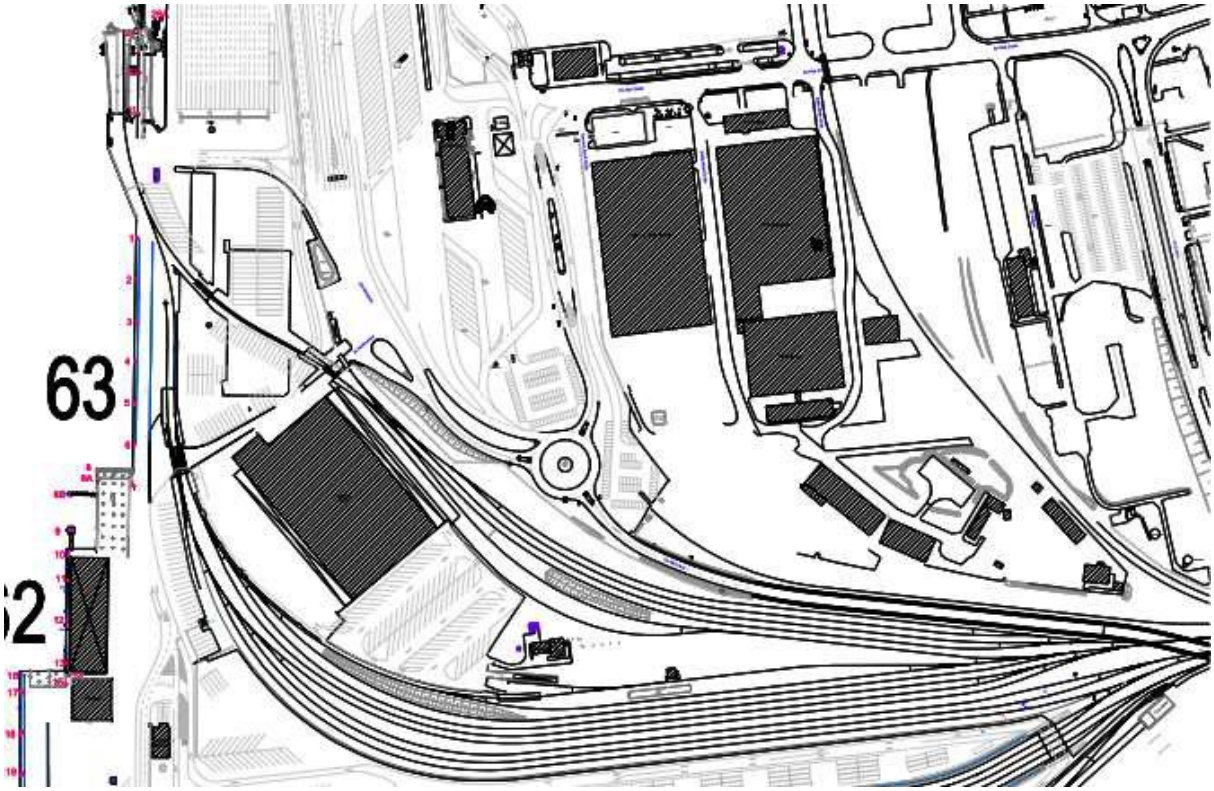

Figure 4 – Status quo of track group 550 & 570.

Source: Baltic Marine Consult Rostock-Warnemünde & railistics Wiesbaden (2024): Analysis of existing track capacity for rail wagon ferrying in the seaport of Rostock, p. 25.

Stena Line's two rail-ro-pax vessels are almost identical in their main dimensions. In terms of track capacity, they differ in the length, layout and operation of the loading tracks.

Parameter	[DIM]	M/F "Mecklenburg Vorpommern"	M/F "Skane"	M/F "Jutlandica"	Remarks
LOA.	[m]	200	200	183,70	
Max. width	[m]	28,90	29,90	27,80	
Design draught	[m]	6,50	6,20	6,00	
Stern ramp	[m]	5,10 x 20,00	5,10 x 20,00	19 x 16 giljotin type	**M/F "Skane + MV"** o road and rail o 6-8 tracks
Lateral upper deck ramp	[m]	5,20 x 6,50	5,20 x 6,50		o road
Main deck	[m]	945	906	571	**M/F "Jutlandica"** o concreted tracks o cannot be used as a railway ferry without considerable modifications
No. of loading tracks	[no.]	6	6	4	
Length of track 1	[m]	171	130	147	
Track 2	[m]	177	152	150	
Track 3	[m]	178	160	127	
Track 4	[m]	178	176	147	
Track 5	[m]	178	155		
Track 6	[m]	177	133		
Tweendeck	[m]		204		
No. of loading tracks	[m]		2		
Length of track 1	[m]		102		
Track 2	[m]		102		
Usable track capacity	[m]	900	1100		

Figure 5 - Railway RoPax ship parameters.

Source: Baltic Marine Consult Rostock-Warnemünde & railistics Wiesbaden (2024): Analysis of existing track capacity for rail wagon ferrying in the seaport of Rostock, p. 8. Some figures updated by Stena Line on Sept 2024.

Parameter	[DIM]	Real tonnage average 2019 - 2023	max. capacity tracks 2 vessels	Business plan Stena 2020 [1]	max. capacity tracks 4 vessels	Remarks
Number of wagons per year	[no.]	21,926	99,000	45,000	198,000	
Average wagon length	[m]	17	17	17	17	• Wagon lengthStena Line
Wagon fleet length per year	[m]	315,690*	1,683,000	765,000	3,366,000	
Cargo capacity of loading tracks on railway-RoPax ships	[m]	1,683,000	1,683,000	1,683,000	3,366,000	
Utilisation of trajectory capacity of existing railway-RoPax vessels	[%]	22.2	100	45,5	200	
Utilisation of berth 64	[%]	42	42	42	84	• Incl. 0,75 h harbour navigation

* average wagon fleet length for the years 2019 ... 2023

Figure 6 - Trajectory quantities, track capacities and utilisation of rail-RoPax vessels and berth 64.

Source: Baltic Marine Consult Rostock-Warnemünde & railistics Wiesbaden (2024): Analysis of existing track capacity for rail wagon ferrying in the seaport of Rostock, p. 10.

The following part is about the technical parameters on board of the vessels Mecklenburg-Vorpommern (MV) and Skane.

Even though Stena Line ferries can load up to 1100m of rail wagons per sailing, in daily business the most efficiency is based on a loading maximum of 850/900m currently, bearing in mind the 90min lay

time. Both ferries, Mecklenburg-Vorpommern and Skane, are capable to load different kind of wagons. Such as intermodal wagons, conventional wagons and high/heavy machines on rail with a total width of up to 3,45m and a height of maximum 4,85m. The weight restriction on the Stena Line ferries is up to 4100t. Heavy trains are quite often loaded with a weight of up to 3800t.

The figure 5 shows the full dimensions of machines that can be loaded on Stena Line ferries. The biggest crane loaded was in total 178m long.

Figure 7 - Crane loaded on rail tracks of M/V Skane.

Source: Stena Line.

During the timespan of the first three periods of the Blue Supply Chain project, Stena Line investigated in finding operational synergies. One example is the evaluation of different coupling systems on board of the ferries.

One big question was the compatibility of couplers on board of Stena Line's vessels. In the rail transport there are different existing couplers available that connect train wagons, locomotives, trains and of course the buffers in place (on bord of Stena Line ferries see figure 8).

Figure 8 - Coupler and buffer in board of Stena Line rail ferries.

Source: Stena Line.

The most common coupler in Europe is the UIC standard coupler. It is attached to all freight wagons and fits to the couplers on board of the ships. They are connected through a screw tension.

For new trains deliveries such as passenger trains (Flirt, Metro) it is more complex. There are also trains that uses standard couplers but most passenger trains, trams, metros etc. that are getting transported on the vessels are using a Scharfenbergkupplung. To secure such shipments on the buffers and couplers on Stena Line vessels a so called couplerwagon is required. These couplerwagons are special wagons that are using on the one end the standard UIC coupler compatible to the buffers and couplers on board and on the other end a Scharfenbergkupplung that can connect to the passenger train.

These couplerwagons are each approx. 20m long and have a weight of approx. 47t. Whenever they are required for a transport on Stena Line ferries the customers need to rent them and ship them together with the train on the ferry. Afterwards the coupler wagons return empty on the ferry back. This increases the transport costs and the CO2 emissions.

Due to this situation and to be more attractive to customers Stena Line was searching for alternatives to the couplerwagons.

During the research process Stena Line has found a coupler adapter. A so called Dellner coupler (emergency coupler see figure 9) can connect UIC standard couplers and Scharfenbergkupplungen. It is used in emergency cases to connect passenger trains and freight trains. The limitation in this case is that these couplers are not able to pull very heavy trains. As mentioned, it is only designed for emergency cases e.g. pulling out a damaged passenger train without ordering coupler wagons to the place needed.

Figure 9 - Dellner Coupler between ICE and locomotive.

Source: eepforum, in : www.eepforum.de/forum/thread/30759-kbs-442-g%C3%BCterwagen-mit-ak-kupplung-als-%C3%BCbergangswagen.

During further research Stena Line has realized that there seems to be another challenge. For example, trains for the Metro in Stockholm have a Scharfenbergkupplung that is developed to connect to the

buffers in the Metro in Stockholm. These buffers are only 750mm high. Due to this fact the coupler of these trains is also attached on a height of 750mm.

Standard UIC couplers are on a height of 1.600mm. These different heights are already included in the Kuppelwagen. The couplers on board of the Stena Line vessels are 1.000mm height. They still can connect to the UIC standard coupler but unfortunately the height of the couplers on board cannot be adjusted. Thus, a Dellner coupler to connect on board buffers with the Scharfenbergkupplung of these Metro trains is not working.

This was a very important investigation because the team of Stena line has gained much more knowledge of the functionality of these couplers and the possibilities of loading trains .

As mentioned above there are different coupling systems used in Germany. At the moment one Stena Line customer and their partners are developing a new coupling system. This system is called DAC (digital automatic coupling). It is planned that all wagons in Europe will be equipped with this coupling in the future. This customer did a test on both Stena Line ferries. Please see the outcome in attached video https://www.youtube.com/watch?v=qXSETubUWuo&feature=youtu.be.

3. Specifics/requirements of rail ferry services

The future development of the rail ferries is dependent on several internal and external impact factors. This chapter outlines the potential of the rail ferries based on different approaches. The aim is to analyse both, the past development but also the expected potential in the future, taking into account available studies but also existing statistics. This considers the potential development without and also with the FBFL as this is a major infrastructure project which will have a competitive impact on the transport routes. Furthermore, political scenarios will be outlined, especially a two-carried strategy as favoured by the Swedish side or the potential use for military purposes (considering the geopolitical situation in the BSR). It is, however, noted, that the rail ferries have an age of 28 and 26 years. It is assumed that they will remain in service for at least 40 years in total. Stena Line is constantly maintaining the vessels and rail deck infrastructure. Investing necessary and beyond to run the ferries as long as possible. Beside necessary maintenance work Stena Line recently re shaped cabins and interieur on Skane and Meck-Pom.for example. According to STENA a longer operation is nevertheless possible and depends on the demand for these services in the future.

Initially, the Base Scenario considers a shift of certain cargo volumes from the Rail Ferry Rostock-Trelleborg to the FBFL once it is open. This is related to potential lower freight costs but also higher flexibility and other reasons. This has a negative impact on the projected volumes handled via the Ferry Route.

However, the past has shown, that there is a high risk of relying on one route for transporting cargo. Especially when it comes to bottleneck routes without a reasonable alternative in case of an incident or maintenance downtime. For resilience reasons, it can be assumed, that companies/operators may follow a Two-Corridor-Strategy.

The proposed Two-Corridor-Strategy is defined by the following hypothesis: For resilience reasons it can be expected that a certain percentage of the relevant rail cargo being transported between Germany and Sweden will remain on the rail ferry connection between Rostock and Trelleborg.

Certain assumptions were considered for evaluating the quantitative approach:

The future transport volumes via the Öresund-Bridge are projected based on past developments and adjusted existing forecasts. SWECO has estimated an annual growth of rail volume of 1.69 % until 2040. Before the FBFL is open in 2030, a slight growth of 0,11 % is assumed – the data of the SWECO-Analysis has been adjusted as actual data for 2019-2023 are now available.

The volumes via the Öresund Bridge are expected to reach approx. 270,000 units in 2030. Following the outlined growth rates, in 2045 a volume of 340,000 units is expected. Finally, in 2060 around 420,000 units are projected. It is assumed that 50 % of the cargo is of interest for the Rostock- Trelleborg Route from a geographical perspective. This appears to be a reasonable assumption without having carried out a comprehensive analysis of origin and destination.

The impact of the Strategy is shown by considering different percentages for estimating the potential future volumes. The percentages show a share of the "cargo of interest" that will be shifted or remain to the ferry link for resilience reasons. The sub-scenarios consider 5 %, 10 % and 15 % of the cargo to be shifted.

It is noted that no detailed analysis of the transported cargo types and the development of such has been carried out. Neither have the rail operators been analysed with regard to the current number of wagons, the share of cargo between the operators or the potential strategic orientation in the future.

By assuming that 5 % of the "cargo of interest" will be shifted to the ferry link, in 2060 almost the same level as the base forecast would be reached at approx. 10,500 units. Considering 10 % of the volumes, the handling volume would almost remain as of today with approx. 21,000 units annually. In the 15 %-sub-scenario, in 2060 more than 30,000 units would be reached which is a higher volume compared to current annual volumes. The approach is dependent on the individual operators and companies' strategy.

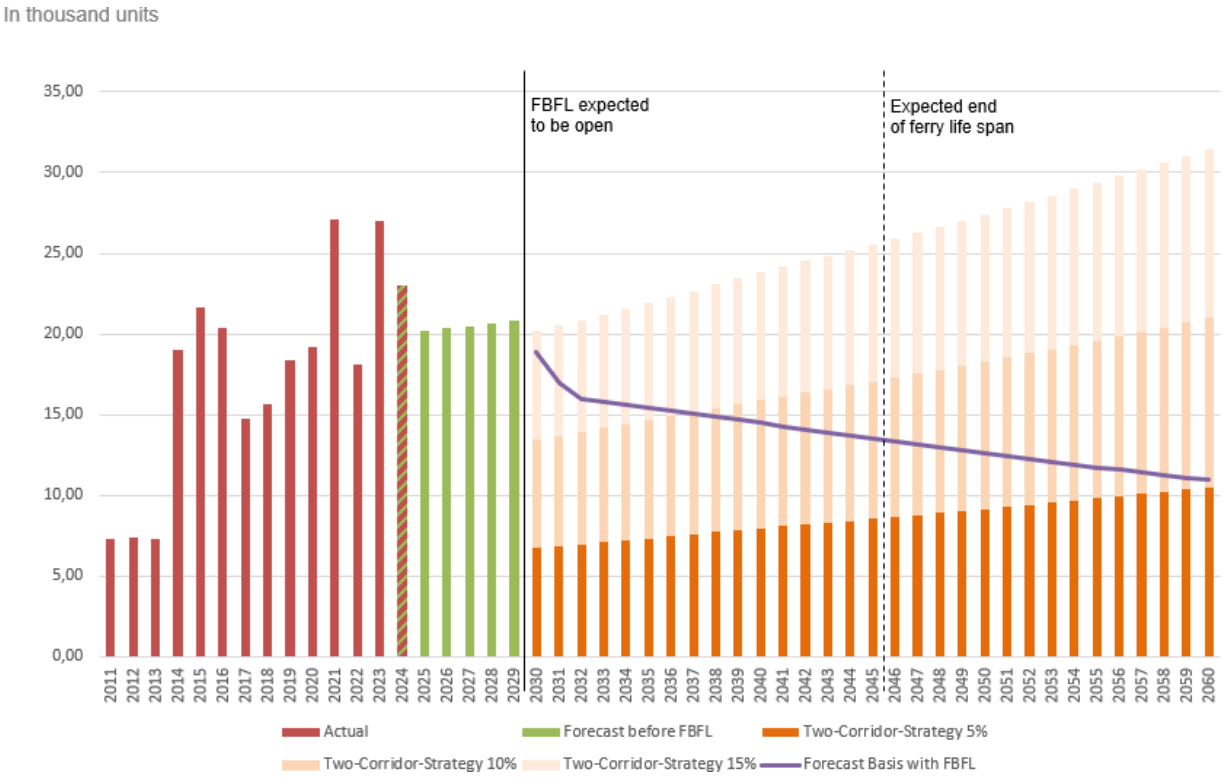

Figure 10 - Future potential wagonload (two-corridor-strategy-scenario).

Source: Ramboll Deutschland GmbH (2024): Analysis of Future Potential of Rail Ferries, p. 35.

Considering the two-corridor approach, until 2060 up to 30,000 units can be expected to be transported via the rail ferry per year.

Figure 26 also shows the development since 2011. In 2023 the number of transported units increased significantly. The basic scenario assumes that this is an exception and therefore did not consider it in

the forecast. However, transported units in 2024 (which has not been considered in the study) are developing in the same direction, consequently the base scenario might underestimate the real development.

There is another topic that is a potential for the rail ferry and that justifies political support to keep the service in operation.

Sweden is NATO Member since March 2024. NATO membership is expected to enhance regional stability and foster closer cooperation with other member states. Therefore, from a political perspective, it appears reasonable or even crucial to keep the rail ferry between Rostock and Trelleborg in service both for resilience reasons but also due to transport limitations via the fixed link.

The fixed link via Öresund and Fehmarn limit the axle load to max. 25 t. In combination with the limited cargo dimensions, very heavy military vehicles such as tanks are not suitable to be transported via the fixed link.

For estimating potential volumes, the NATO military exercise Grand Quadriga in May 2024 has been considered as a reference case for estimating potential transport volumes. For Quadriga, the Bundeswehr has moved around 200 military vehicles and tanks via a RoRo vessel to Klaipeda, Lithuania.

The number of NATO exercises is uncertain, but it is realistic to assume there will be at least one exercise per year. It is likely that it will be even more, considering the current geopolitical situation in the BSR. One exercise would go along with 110 wagons, 2 vessels, 4 shipments and 220 wagons/year.

A significant increase in volumes would occur if to consider five exercises per year or more (+ 1,100 units).

Figure 11 - NATO exercises and tank transport via rail.

Source: Bundeswehr (2024) Quadriga 2024: Landstreitkräfte üben den Bündnisfall [online] https://www.bundeswehr.de/de/aktuelles/schwerpunkte/quadriga-2024-nato-landstreitkraefte-ueben-buendnisfall.

Overall, it is not only the quantitative meaning having the impact on the volume. It is more the qualitative meaning from a political perspective that argues for keeping the ferry link. In addition to the NATO-corridors, the German National Port Strategy (Nationale Hafenstrategie für die See- und Binnenhäfen) published in February 2024 also considers the aspects of security in times of crisis and war. Even though the strategy generally aims to protect the port infrastructure from the German perspective, the aspects may also be taken further.

According to the paper, the port infrastructure must be protected and usable in all scenarios – peace, crisis, and war. This includes regular inspection and ensuring the continuous protection of the infrastructure as well as the personnel and users of the ports. For crisis management and defense, close cooperation between operators, municipalities, states, and the federal government is essential to ensure the resilience and protection of ports and port facilities, as well as the maintenance of logistical processes, particularly during crisis and in situations of tension or defense. However, this does not only apply to Germany but also transnational e. g. between Sweden and Germany.

Future Potential Summary

In the base case, it is assumed that cargo will be shifted from the ferry route to the FBFL once it is opened after 2029 (According current status it is not expected that the infrastructure on German side will be ready in 2029. So this shift of volumes will be delayed). Furthermore it is not clear currently how the targeted development of passenger trains for travel/ business will impact the capacities given to freight trains). However, it can be expected that the shifting process will take some years and will not appear as an ad-hoc-shift. Also, by considering the rail ferries to remain in service for another 12-15 years (minimum), it can be assumed that there will be wagon load transported. The base case projects a volume of 13,500 units in 2045.

For resilience reasons it can be expected that a certain percentage of the relevant rail cargo being transported between Germany and Sweden will remain on the rail ferry connection between Rostock and Trelleborg. By assuming that 50 % of the corridor volume will be of interest for the Rostock-Trelleborg Route from a geographical perspective, an increasing trend is shown. The 5%-Scenario shows, that the volume would almost equal the projected volume in 2060 while the 10%-Scenario would reach the level as of today without the FBFL being open.

Keeping the Rail Ferry Route from a political perspective appears crucial for strategic reasons both for resilience but also due to transport limitations via the fixed link. Transport limitations on FBFL/Öresund would have an impact on the military transport chain and connection between Scandinavia and the rest of Europe. While the qualitative meaning is very high, the quantitative impact is comparably at a low level.

Regarding the different market segments, Stena Line has investigated together with existing and/ or potential customers in more insides of WHY using bridge or ferry. Based on this investigation it can summarized that the biggest potential to gain on rail ferry is the intermodal trains, but the willingness of intermodal operator is limited for now. Seeing no value in two-way strategy which is extremely important for resilient transport chains. Furthermore, the industry plays a crucial role not forcing intermodal operator during tender process to offer a vital second link via rail only. The single wagon traffic very much depends on the overall development of state-owned companies offering single wagon traffic and the pressure from the EU on them for profitable rail solutions. The recent development SNCF faced pushed by EU was a step back from single wagon traffic. Same risk currently DB Cargo and Green Cargo are confronted with. The high and heavy market segment remains as the only way with the Stena Line rail ferries, but volumes are limited and not sufficient to run rail ferries. Each different market segment has its own requirements and needs.

4. Mapping of needed stakeholders and stakeholder cooperation model to set-up green transport chains

Needed stakeholder to set-up the green transport chain (ferry link)

Still a lot of the freight is being transported by long-distance truck transportation, not considering combined- nor multimodal transport options. The Blue Supply Chains pilot activity to set up a green transport chain, focuses on a given infrastructure connection between central Europe and Scandinavia via the Baltic Sea Basin: The port of Trelleborg, the port of Rostock and the rail ferry link between the two ports (sea passage).

The last remaining rail ferry link between Germany and Sweden in the Baltic Sea Region offers greening potential for freight flows, which should not be ignored especially from an emission- and geo-political perspective.

However, infrastructure maintenance investments to keep the service running (rail tracks, shunt tracks etc), investments to reduce emissions during ships stay in port (e.g. on shore power supply), investments in next generation ferries as well as investing in marketing measures to ensure knowledge about the service and attract customers require cooperation and coordinated actions by the involved port authorities and the shipping line. Investment decisions are also based on future market potentials which requires the interaction with transport demanders.

Two main fields of activities have been identified to push the set-up and a future success of the green rail ferry transport chain between Trelleborg and Rostock. The mapping of key-challenges by field of actions and key-stakeholder interactions needed to overcome the key-challenges are reflected in below paragraphs. A first overview of the structured methodology is highlighted in the following figure.

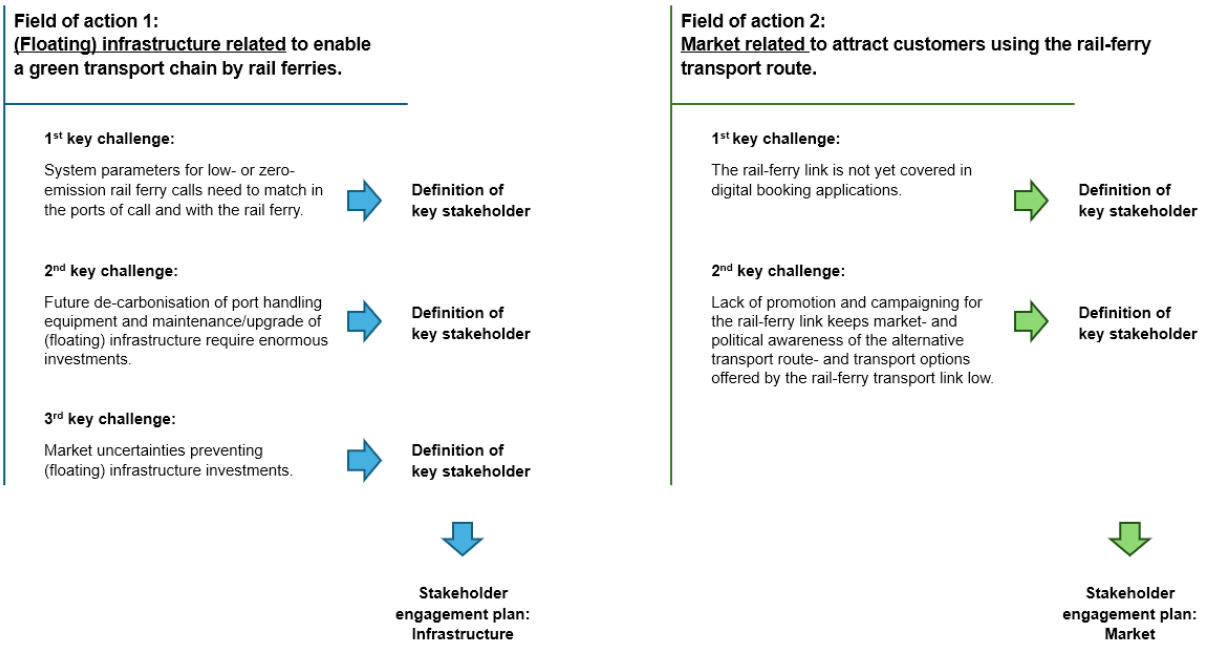

Figure 12 - Methodology and Structure of the stakeholder cooperation model.

Source: Blue Supply Chains project, own Illustration.

While the field of action 1 is regarded on a more theoretical bases in the future implementation, the field of action 2 will be implemented and executed in more detail.

Field of action 1: (Floating) infrastructure related to enable a green transport chain by rail ferries.

Maintenance and development of port infrastructure is in the responsibility of port authorities. Its development mostly is characterised being long-term investments. At the same time return on investments (ROI) are not always easy to achieve, especially in times of rapidly changing markets, energy transition aims in the European Union and geo-political instability.

Various challenges arise for port authorities and ship owners and require a good understanding of the market needs, future perspectives as well as own options for actions with the involvement of key-stakeholders.

1st key challenge:

System parameters for low- or zero-emission rail ferry calls need to match in the ports of call and with the rail ferry.

- *The rail ferry must be able to connect to OPS systems provided by the ports. Standards to be discussed and agreed upon. Sufficient energy supply and grit stability to be considered and discussed with local energy providers.*
- *In case of a future use of sustainable fuels for ferry operations instead of electric propulsion, the required fuel needs to be available and stored in the port(s). This might requires different planning procedures and investments (not covered by this project, but information about it has influence on BSC-activities).*

Stakeholder needs:

Workshops and/or working group meetings with parties involved to discuss and agree upon e.g. standards, needs, etc. to be prepared for future investments.

Key stakeholders to involve:

- Port Authorities: Port of Trelleborg, Port of Rostock
- Rail-ferry operator: Stena Line
- Energy supply: Local energy grit operator in Trelleborg and Rostock

2nd key challenge:

Future de-carbonisation of port handling equipment and the potential upgrade of (floating) infrastructure require enormous investments.

- *Ports as infrastructure providers and terminal operators have to ensure the accessibility of rail ferries berths by trains. This requires that the switches, specific ramps and track systems are maintained and offered in sufficient capacity at the port premises. Furthermore, the berth for a rail ferry must fulfil specific constructural requirements based on the unique ship design and is only usable for this single ship type. Ensuring the provision of such infrastructure in ports causes extraordinary efforts in comparison to normal RoRo/RoPax-ferries for cars, trucks or trailers. Investments in such infrastructure are very cost-intensive and are mostly not economically feasible. This might also cover -terminal operators handling equipment, which might require new loading and/or re-fuelling points on the terminal surface which might be in the responsibility of the port authorities.*
- *The national rail infrastructure must be prepared for the modal shift from road to rail. The future transport demand needs sufficient capacity (tracks, timeslots, higher speed etc.)*

- *Terminal operators handling equipment might require new loading and/or re-fuelling points on the terminal surface which might be in the responsibility of the port authority.*
- *Retrofitting of rail ferries is technically challenging, and new builds expensive, also due to small quantities which might be ordered.*
- *Political commitment and (financial) support is important for such long-term infrastructure investments.*

Stakeholder needs:

Workshops and/or working group meetings with parties involved to discuss and agree upon e.g. standards, needs, etc. to be prepared for future investments.

Key stakeholders to involve:

- Port Authorities: Port of Trelleborg, Port of Rostock
- Terminal operators: Port of Trelleborg, Port of Rostock
- Rail-ferry operator: Stena Line
- Rail infrastructure managers: DB InfraGo (Germany), Trafikverket
- Energy supply: Local energy grit operator in Trelleborg and Rostock
- Business support organisations: BPO, SKGV, UIRR, HHM
- Policy level: National- and European policy level in charge for funding measures for (maritime) transport, de-carbonisation, modal shift actions

3rd key challenge:

Market uncertainties preventing (floating) infrastructure investments.

- *The geo-political situation requires a resilient transport system, based on options and bypasses in case of interruption of any kind. The rail-ferry link provided by Stena Line, is serving for more than 20 years rail-based cargo on the ferries e.g. for long- and heavy cargo. Anyhow, political commitment and support is important for long-term infrastructure investments.*
- *Legislations which hinder- or even create modal backshifts prevent the use of combined-, multimodal-, and/or conventional train transport. The rail ferry is directly affected.*

Stakeholder needs:

Workshops and/or working group meetings with parties involved to address market uncertainties towards policy levels and find or suggest suitable supporting schemes. Legislation and its effects on transport routes to be addressed too.

Key stakeholders to involve:

- Port Authorities: Port of Trelleborg, Port of Rostock
- Rail-ferry operator: Stena Line
- Rail infrastructure managers: DB Infra Go, Trafikverket, Oresund Bridge
- Business support organisations: BPO, SKGV, UIRR, HHM
- Policy level: National- and European policy level in charge for (maritime)transport, logistics, economy

Field of action 2: Market related to attract customers using the rail-ferry transport route

The transport market is rapidly changing. Today's fast-paced and highly competitive global transport market brings major challenges for freight forwarders. On the one hand, it is very complicated to find the right connection at the best conditions given the mass of transport options and existing carriers. On the other hand, a large amount of manual effort is required in terms of organization and data exchange to find free capacities, agree prices and plan the operational handling. This is particularly true if it is not a regular customer relationship or if several modes of transport are combined in one supply chain.

In many B2C and B2B sectors, online marketplaces have therefore become established in recent years. They bundle and standardize offers from numerous providers and make them visible, comparable and bookable for customers.

Anyhow, the rail-ferry link is not yet covered in digital booking applications. This hinders better awareness about alternative transport routing as well as low-emission transport options including the rail-ferry. As an online freight booking platform, modility accepted the challenge and will integrate the rail-ferry in its transparent system.

1st key challenge:

The rail-ferry link is not yet covered in modility's digital booking applications.

- *Non transparent booking options hinder easy to find and comparable alternative combined freight transport routes.*
- *Non transparency might hinder the use of less polluting transport routes.*

Stakeholder needs:

Integration of the rail-ferry link in modility's freight booking platform in cooperation with potential customers to also cover their needs and consider their feedback to the system in future development steps.

Key stakeholders to involve:

- Freight booking platform: modility
- Rail-ferry operator: Stena Line
- Potential customers: Railway undertakings, freight forwarders and manufactures (e.g. TXLogistics, DB Cargo, GreenCargo, DB Schenker Logistics, SIEMENS, etc.)

2nd key challenge:

Lack of promotion and campaigning for the rail-ferry link keeps market- and political awareness of the alternative transport route- and transport options offered by the rail-ferry transport link low.

- *Combined transport in general still has the prejudice being complicated to organise and book, thus awareness is not always paid to.*
- *Resilience of the transport system has not yet played a big role, but especially here, combined transport can play an important role.*

Stakeholder needs:

Information campaigns towards potential customers, their associations and policy levels about the transport solution and its value for a resilient transport system.

Key stakeholders to involve:

- Port Authorities: Port of Trelleborg, Port of Rostock
- Rail-ferry operator: Stena Line
- Business support organisations: BPO, SKGV, UIRR, HHM
- Potential customers: Railway undertakings, freight forwarders and manufactures (e.g. TXLogistics, DB Cargo, GreenCargo, DB Schenker Logistics, SIEMENS, etc.)
- Policy level: National- and European policy level in charge for (maritime)transport, logistics, economy

Stakeholder cooperation model

Based on the two fields of actions identified and characterised above, two stakeholder engagement plans have been derived. Those engagement plans form the stakeholder cooperation model, supporting the project partners to involve key stakeholders to start overcoming the identified challenges during their pilot implementation. Once is clear, it is a starting point kicked-off by the BSC project. However, long-term investments require long-term strategies and the process most likely has to continue after the end of the BSC project.

The measures for involving stakeholders vary depending on the challenge identified and the actual depth of implementation in the project. For example, measures in the area of long-term infrastructure support will more likely be limited to information campaigns. In contrast, the implementation of the booking app will entail a broader catalogue of measures.

Below engagement plans are based on the latest knowledge and might be updated during the implementation process by the project partners.

Stakeholder engagament plan: Infrastrucutre			
1st aim	**Stakeholder(s) needed**	**Stakeholder(s) role**	**Stakeholder(s) engagement**
Finding (and ideally agreeing to) future system parameters to enable low- or zero-emission rail ferry calls in the Ports of Trelleborg and Rostock.	Port Authority Rostock	Discuss and agree upon e.g. standards, needs, etc. to be prepared for future investments in port infrastrucutre and the ferry.	Joint workshops
	Port Authority Trelleborg		
	Rail-ferry operator: Stena Line		
	Local energy grit operator in Rostock and Trelleborg	Discuss about energy needs, peak times and grit stability.	
2nd aim	**Stakeholder(s) needed**	**Stakeholder(s) role**	**Stakeholder(s) engagement**
Exchange on future de-carbonisation aims and plans for port handling equipment and the potential upgrade of (floating) infrastrucutre to support long-term decarbonisation aims in ports.	Port Authority Rostock	Discuss and agree upon e.g. standards, needs, etc. to be prepared for future investments in the electrification of terminal handling equipment and/or terminal vehicles.	Joint regional stakeholder workshops. And an interregional exchange between Port Authorities and Stena Line. Stena Line to organise working group meetings (alll PPs & AOs) to provide input to adjust the blueprint concerning general technical questions on the electrification of terminal equipment, on-shore power supply solution to provide energy for future e-ferries.
	Terminal operators in Rostock		
	Port Authority Trelleborg		
	Terminal operators in Trelleborg		
	Rail-ferry operator: Stena Line		
	Local energy grit operator in Rostock and Trelleborg	Discuss about energy needs, peak times and grit stability, in respect of a further electrification of terminal handling equipment and/or terminal vehicles.	
	Business support organisations: BPO, SKGV, UIRR	Supporting the Port Authorities, terminal operators and Stena Line in external communication, especially towards policy levels.	Joint workshops with Port Authorities, terminal operators, Stena Line.
	Policy level: National- and European policy level in charge for funding measures for (maritime) transport, de-carbonisation, modal shift actions	Long term planning support in respect of energy transition measures. Development of suitable funding measures and/or funding schemes.	Reached by individual contacts from Port Authorities, Stena Line and/or by business support organisations. Invitation to panels on conferences and/or workshop particiation.
3rd aim	**Stakeholder(s) needed**	**Stakeholder(s) role**	**Stakeholder(s) engagement**
Adressing market uncertainties towards policy levels to create awareness in the framework of future infrastructure needs to support resilient transport systems.	Port Authority Rostock	Providing facts and figures on investment needs and obstacles.	Joint internal meeting(s) and/or workshop(s)
	Port Authority Trelleborg		
	Rail-ferry operator: Stena Line		
	Rail infrastrucuture managers (DB Netze, DB Infra Go, Trafikverket, Oresund Bridge)	Feedback on infrastrucutre planning in the hinterland of the ports.	Individual meetings and/or workshops with Port Authorities to discuss about infrastrucutre measured planned in ports hinterland.
	Business support organisations: BPO, SKGV, UIRR	Feedback on general perceptions regarding markte uncertainties, existing funding measures and/or funding schemes as well as information towards the policy level about members needs.	Port authorities Trelleborg and Rostock as well as Stena Line invite to joint meetings to share their latest experiances and suggestions on funding schemes and support measures.
	Policy level: National- and European policy level in charge for (maritime)transport, logistics, economy	Long term planning and support of infrastructure. Development of suitable funding measures and/or funding schemes.	Reached by individual contacts from Port Authorities, shipping lines and/or by business support organisations. Invitation to panels on conferences and/or workshop particiation.

Figure 13 - Stakeholder engagement plan: infrastructure.

Source: Own Illustration by Blue Supply Chains project.

Stakeholder engagament plan: Market			
1st aim	**Stakeholder(s) needed**	**Stakeholder(s) role**	**Stakeholder(s) engagement**
Develop and provide a transparent, and easy to use booking solution for rail ferry transports via the Ports of Rostock and Trelleborg	Freight booking platform provider modility	Coding the rail-ferry transport leg into the modility tool. On-boarding workshops for new customers who will integrate their green combined transport routes in the modility tool	Working group meetings and joint workshops with Stena Line and potential customers.
	Rail-ferry operator: Stena Line	Provide technical details and input to the modility tool (e.g. price calculations, ferry schedules etc).	Working group meetings with modility to shape, test and release the CT-connections incl. rail ferry in the tool.
	Potential customers, like: Railway undertakings, freight forwarders and manufactures (e.g. TXLogistics, DB Cargo, GreenCargo, DB Schenker Logistics, SIEMENS, etc.)	Making use of the transport link between central Europe and Scandinavia via the Trelleborg-Rostock rail-ferry.	modility will provide: a) on-boarding workshops for new customers to integrate green combined transport routes incl. rail-ferries in the modility tool. b) customer workshops to proof functionality of the tool
2nd aim	**Stakeholder(s) needed**	**Stakeholder(s) role**	**Stakeholder(s) engagement**
Promotion and campagning for the rail-ferry link as alternative transport route and resilient transport system component, towards customers and policy levels.	Port Authority Rostock	Increase capacitiy to be able to promote the rail ferry freight service Rostock-Trelleborg in the market and towards policy levels.	All stakeholders needed are involved as PPs and AOs, thus they will be directly involved in workshops etc. Stena Line will lead the development of a marketing campaigning to promote the rail ferry freight service Rostock-Trelleborg in the market. --> Port Authorities and BSOs will be enabled to promote the rail-ferry link.
	Port Authority Trelleborg		
	Rail-ferry operator: Stena Line		
	Business support organisations: BPO, SKGV, UIRR		
	Potential customers, like: Railway undertakings, freight forwarders and manufactures (e.g. TXLogistics, DB Cargo, GreenCargo, DB Schenker Logistics, SIEMENS, etc.)	Considering the rail-ferry being a reliable and crucial part of their resilient transport system.	Stena Line will organise customer workshops, meetings & events to inform about the ferry solution and to transfer results.
	Policy level: National- and European policy level in charge for (maritime)transport, logistics, economy	Considering the rail-ferry being a crucial part of a resilient transport system linking central Europe with Scandinavia.	Reached by individual contacts from Port Authorities, shipping lines and/or by business support organisations. Invitation to panels on conferences and/or workshop particiation.

Figure 14 - Stakeholder engagement plan: market.

Source: Own Illustration by Blue Supply Chains project.

5. The path ahead

5.1. Capacity analysis: Adaptation needs in ports infrastructure and/or handling equipment to provide the necessary greening potential framework for the transport chain

A successful future development of the rail ferry requires sufficient capacity in the ports and on the ferry. Additional infrastructure needs to cope with rising freight flows.

A re-design of the terminal in Rostock (berth 64) is in discussion, covering:

- keeping the existing track infrastructure for the railway ferries
- creation of full train-length (740 m) tracks close to the berth
- bundling and concentrate the railway ferry processes on northern track group 550
- record the utilization of track group 570 due to the parking requirements of rail-bound intermodal transport

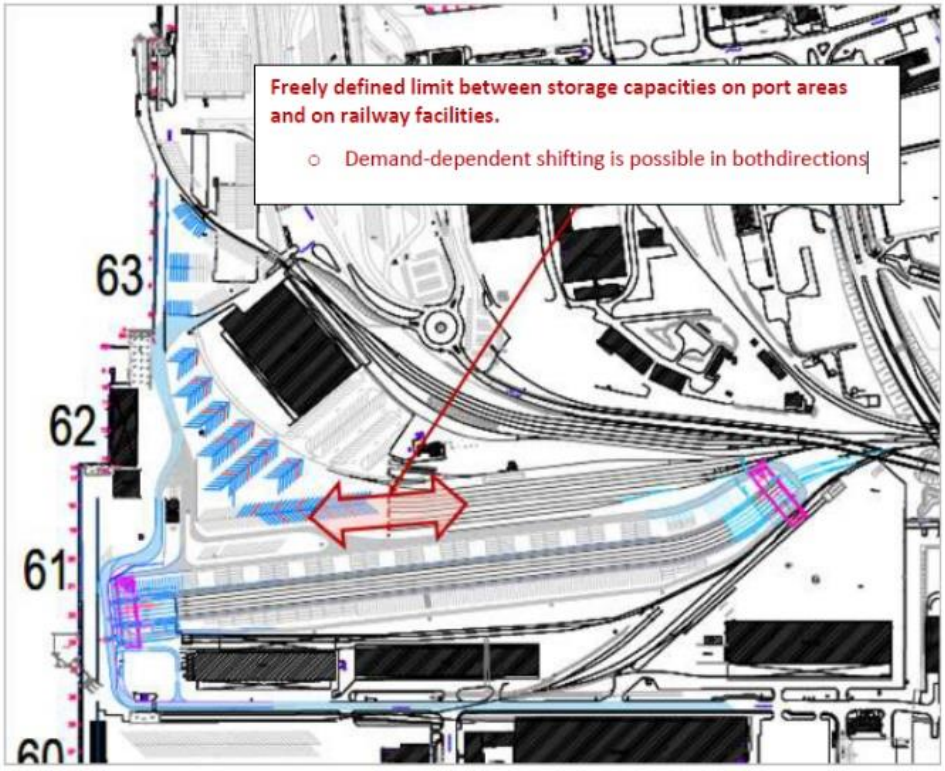

Figure 15 – Trajectory related preferred layout for the examination room tg 550, 570, RTM, LP 64.

Source: Baltic Marine Consult Rostock-Warnemünde & railistics Wiesbaden (2024): Analysis of existing track capacity for rail wagon ferrying in the seaport of Rostock, p. 65.

The Trelleborg-Lockarp section will have a high capacity utilization unless measures are taken. During 2022, the Swedish Transport Administration has investigated supplementary capacity-increasing measures on the railway system in Skåne. Among other things, the Swedish Transport Administration proposes that an expansion on the Lockarp-Trelleborg route should be studied. It can be noted that the Swedish Transport Administration expects 12 freight trains per day in its forecast for 2045. In the analysis of rail traffic to and from Trelleborg port, it is assumed that there is room for up to 24 freight

trains per day, given existing passenger traffic. The dimensioning section of the track is Trelleborg-Skytts Vemmerlöv, depending on the gradient that prevails on the section up from Trelleborg, the running time for departing freight trains is extended. An expansion of the partial double track Trelleborg-Skytts Vemmerlöv would relieve this stretch and enable at least one freight train per direction and hour.

At the same time, the Trelleborg line is not limiting for increased freight traffic to and from the Port of Trelleborg. What is primarily required is an improvement of both the railway in the harbor area and the train yard in Trelleborg. In the analysis carried out, nine desirable improvements to the railway system have been developed and demonstrated.

- Extended (separate) extension track along the Trelleborg line for 750m train lengths
- Electrification to the combi terminal (Gudrunbrygga)
- Staging track/buffer track (640-750m) for freight trains
- Extended I-group for 750m long trains (in the west)
- Expansion of the combi terminal with two new tracks and loading area
- Double track Trelleborg C – Skytts Vemmerlöv (in addition to the pull-out track)
- Double track Östra Grevie – Västra Ingelstad (in case of increased passenger traffic)
- Double track Västra Ingelstad – Lockarp
- Double track Östra Grevie – Skytts Vemmerlöv

The Rostock Trelleborg connection is part of Scandinavian Mediterranean transport axis and a bypass to the land connection Hamburg Malmö via Jutland. Trajectory and intermodal transport is in demand on the ScanMed transport axis. Rail and ferry shipping freight transport is favored climate neutral transport. The rail ferry is a relief of the main route of the core corridor Scandinavia Mediterranean.

Shunting at the port of Rostock

Two rail transport companies currently operate as trajectory service providers at berth 64. The fact that the trajectory to and from berth 64 is operated by two ferry service providers a priori increases the operational workload and the need to keep track infrastructure available for the rail ferry processes. On the other hand, it strengthens competition in rail transport and ultimately the attractiveness of the location for rail transport.

Not only for resilience reasons it is a need for Stena Line to have two rail shunting operators on each port side. But even more important for operational reason it is necessary to keep the rail infrastructure nearest to the berths to ensure a fast and smooth unloading and loading of rail wagons up to 900m (currently) in same port call. Furthermore, the high/heavy rail loads needs have a higher demand in rail capacity sometimes.

Both operators use their own traction units to transfer the wagon sets or individual wagons to/from the ferries and to drive them autonomously between the transfer tracks of Rostock seaport station and track groups 550-570. This is usually done directly in both directions without stopping in track groups 550-570, and in exceptional cases indirectly with stopping in track groups 550-570.

5.2. Specifications for the adaptation of the modility tool to marketing the green combined transport chain to European transport stakeholders

Today's fast-paced and highly competitive global transport market brings major challenges for freight forwarders. On the one hand, it is very complicated to find the right connection at the best conditions given the mass of transport options and existing carriers. On the other hand, a large amount of manual effort is required in terms of organization and data exchange to find free capacities, agree prices and plan the operational handling. This is particularly true if it is not a regular customer relationship or if several modes of transport are combined in one supply chain.

In many B2C and B2B sectors, online marketplaces have therefore become established in recent years. They bundle and standardize offers from numerous providers and make them visible, comparable and bookable for customers. This concept is being implemented by modility in Combined Transport, making it easier for freight forwarders to organize sustainable transport.

As an online freight booking platform, modility provides unparalleled convenience and efficiency. Traditional methods of booking freight, which often involved lengthy phone calls or emails, have been replaced by streamlined digital processes. This shift allows businesses to book shipments quickly and efficiently, saving valuable time and resources. With just a few clicks, companies can compare different carriers, select the most suitable options, and confirm bookings. This ease of access is particularly beneficial for small and medium-sized enterprises (SMEs), which may lack the resources to navigate complex logistics networks.

In this context, one of the most significant advantages is the transparency modility brings to pricing. In the past, rail freight pricing was often opaque, with rates varying widely depending on factors such as the carrier, route, and negotiation skills of the shipper. This lack of transparency could lead to inefficiencies and higher costs for businesses. The modility online platform, however, displays clear and upfront pricing, allowing shippers to compare rates from multiple carriers. This transparency fosters a more competitive market, driving down costs and enabling businesses to make informed decisions based on their budget and shipping requirements.

The logistics industry is under increasing pressure to reduce its environmental impact. Modility can contribute to sustainability efforts by promoting more sustainable and “greener” modes of transport like rail and ferry. By providing shippers with a wide range of options and the ability to choose the most efficient routes and carriers, these platforms can help reduce unnecessary mileage and CO2 emissions.

The goal of the modility tool implementation is to include Stena Line ferries in the existing tool options. The integration of the service works as follows: The Stena Line connection will be uploaded to modility by a train operator that offers the entire route, i.e. the ferry connection as well as a pre-loaded and/or post-loaded rail leg (see "Requirement 1" below). In the search results, both the operator's logo and Stena Line's logo will be displayed. As the main contractual partner for the transport, the operator receives all bookings made by freight forwarders on modility. Based on these bookings, the operator arranges the ferry service and books it with Stena Line, automatically through interfaces if available. Freight forwarders provide the necessary transport and cargo information in advance using input forms on modility.

Stena Line requires following data für processing:

- Route, date, time
- Kind of trailer (length and tare weight)
- Kind of loaded goods (weight, dangerous goods? plug-in?)
- Information about the price (sea freight + surcharges (ETS, BAF, DGD, Plug-in)

Discussions have already started with potential rail operators who could provide routes including the Rostock-Trelleborg connection via the modility platform. Once this is done, the responsible train operator, Stena Line as the ferry operator and modility as the matchmaker will discuss the content-related, operational and technical details for the exchange of all necessary transport and cargo data for the parties involved.

Since going live in 2021, the modility booking portal has enabled providers of sustainable rail transport to market their services to a broad customer base. It has been developed "by the market for the market“. This means that the agile development process is geared towards the pain points and needs of users. Every new implementation therefore begins with the identification of problems and hurdles in the transport booking process and the recording of specific user requirements to align the technical solution on this basis.

As an online marketplace, two different user groups are served, whose needs must be considered during further development: The providers and the demanders of transport. On both sides, adjustments or additions to the current product status are necessary to be able to map the ferry as an additional mode of transport in the future. Generally, the integration of the new mode of transport will not be a separate module, but a fully integrated feature in the existing modility environment. The following requirements have so far been identified in discussions with the project partner Stena Line and other market participants:

Requirement 1: Management of offers & transport responsibility

> Modility matches transport services between suppliers and buyers, supports communication and data exchange, but does not intervene in operational transport processing. This means that the responsibility for transport operations always remains with the provider. This is essential, as problems with processing and responsibility can arise when switching between different transport partners, which could threaten smooth operation. To ensure a single responsible contractual partner for the combination of several modes of transport (rail and ferry) on the main leg, the ferry operator itself will not act as the operator at modility. Instead, the transport responsibility remains with the train operator, who controls the entire transport route.

Requirement 2: Display of the involved providers

> Both the ferry operator and the freight forwarder making the booking have a legitimate interest in knowing which ferry operator is involved in the supply chain. From the provider's point of view, this is an important marketing tool. For the person making the booking, it is a potentially important decision criterion when selecting a transport. For these reasons, the list of results directly indicates co-operation with another provider, but not without clarifying the hierarchy in terms of transport responsibility.

Requirement 3: Showing the ferry run in the transport chain

> To enable transport bookings to be planned precisely, it is necessary for the freight forwarder making the booking to be informed about the various transport components, including the integration of the ferry. For this purpose, it should be visible directly in the overview of the search results whether and (if so) where the ferry run is located. To minimise the development effort for this, the existing layout should only be marginally adapted and supplemented. Initial mock-ups have already been created which visualise the display of the transport chain in the front end.

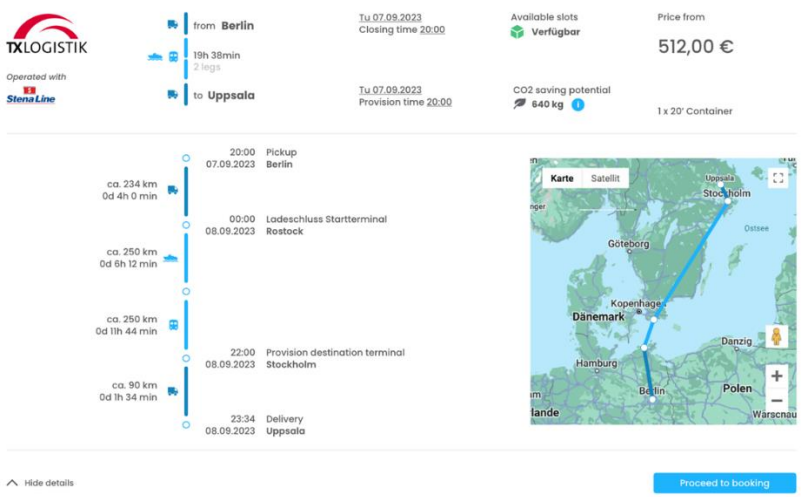

Figure 16 - Search results with overview of the entire transport chain incl. ferry in detailed view.

Source: modility.

Requirement 4: Consideration of "ferry-specific" pricing components

A key advantage of modility is the fast price information, as these are automatically calculated according to the entered criteria. In addition to the fixed price, there are further price components for various modes of transport, in particular surcharges. In the rail sector, all common surcharges are already considered, which means they can be entered directly by the operator when uploading offers. Of course, the same must now be ensured when integrating the ferry to guarantee high data quality in pricing. In collaboration with Stena Line, the composition of a ferry price has already been worked out. In contrast to rail, the base price is a fixed price based on the equipment length (per metre). Other specific surcharges are added, e.g. FUM and ETS. In future, these must be maintained in the modility tool and users must be able to view them when booking transport.

As the project progresses, these requirements might need to be adapted or supplemented following initial testing and user feedback. This procedure is part of the agile product development process at modility. Agile product development has proven to be highly effective in B2B startups. By focusing on customer-centric requirement gathering, precise effort estimation, efficient 14-day development sprints, comprehensive testing, meticulous implementation, and continuous feedback incorporation, modility ensures that its products meet the highest quality standards and are perfectly aligned with customers' needs. This iterative and flexible approach allows to respond quickly to changes and continuously deliver innovative solutions. By maintaining close collaboration with customers throughout the development process, modility builds strong partnerships and ensures that its products provide real value to their businesses.

Customer-Centric Requirement Gathering

The cornerstone of agile product development is a robust process of customer-centric requirement gathering. Modility prioritizes understanding the specific needs and expectations of its customers through detailed workshops and interviews. These sessions involve various stakeholders, including customers and end-users, to ensure a comprehensive collection of insights into operational challenges, pain points, and desired functionalities. By fostering open communication, the modility team translates these needs into precise User Stories. This method not only ensures that the development team has a clear understanding of what needs to be achieved but also aligns development goals with customer needs, establishing a strong partnership from the project's outset.

Estimating Development Effort

Estimating development effort is crucial for effective agile product development. Modility utilizes collective expertise and agile methodologies to estimate the effort required for each User Story as well as every single feature. This process involves assigning Story Points to each story based on its complexity and the effort needed. Regular reviews and adjustments of these estimates after each sprint ensure they remain accurate and relevant. This iterative process allows to continuously refine estimation techniques, improving planning accuracy, feasibility assessment, and resource allocation.

14-Day Development Sprints

The development process is organized into 14-day sprints, striking a balance between structured planning and flexibility. Each sprint begins with a Sprint Planning Meeting where the team selects User Stories from the prioritized backlog and sets specific goals. These stories are broken down into smaller tasks, and the team estimates the effort required for each task. Daily Stand-up Meetings are held to discuss progress, identify obstacles, and make short-term adjustments. At the end of each sprint, a Sprint Review Meeting is conducted to present the

results to the Product Owner and other stakeholders. This meeting provides a platform for feedback, which ensures transparency and continuous alignment with customer requirements.

Testing and Implementation

Testing ensures the delivery of high-quality products. Continuous integration testing is performed throughout the development cycle to detect and fix issues early. This practice involves automatically testing code changes as they are integrated into the main codebase, allowing modility to identify and resolve issues promptly. At the end of each sprint, comprehensive system testing is conducted, including both automated and manual tests. These tests are based on the acceptance criteria defined in the User Stories, ensuring that all requirements are fully and correctly implemented. Regression testing ensures that new features do not negatively impact existing functionality. After successful testing, new features are meticulously implemented into the production environment. This process involves detailed planning and close coordination with customers to accommodate specific requirements and provide necessary training. By involving customers in the implementation phase, modility ensures they are fully supported and can promptly address any issues.

Incorporating and Implementing Feedback

Modility actively seeks feedback from customers and stakeholders during Sprint Review Meetings and through regular communication channels. This feedback is crucial for ensuring that the product meets customer expectations and for identifying areas for improvement. Post-implementation, the team gathers detailed feedback to assess customer satisfaction and refine the product further. By promptly addressing feedback and making necessary adjustments, modility ensures that its products remain relevant and valuable to customers.

5.3. Strategies for a future ferry operation with alternative fuels (incl. e-ferry)

Stena Line aims to be a leader in the transformation towards a more sustainable future within the maritime industry. As the shipping industry is part of the climate problem, Stena Line has an obligation to provide solutions. Stena Line is also working to maximize their positive social impact and ensure the industry is characterized by equality and diversity. To keep track of progress, Stena Line has structured their efforts into five focus areas, all designed to help achieve a leading position in sustainable shipping. This is Stena Line's Sustainability Strategy. Each of the focus areas will have ambitions, targets and a road map. In figure 17 the focus areas are displayed.

Figure 17 - Stena Line sustainability focus areas.

Source: Stena Line.

In terms of emissions, Stena Line has set itself the goal of reducing GHG gases emissions by 30 percent by 2030, based on Stena Line's emissions levels in 2019. In the long term, the shipping company wants to achieve fossil fuel-free operations. When it comes to alternative fuels, Stena Line sees bio-based fuels as the most realistic alternative to achieve a positive impact in the short term. Stena Line has launched the world's first methanol-powered ferry (Stena Germanica, 2015) and is determined to convert

more ships and introduce entirely new, methanol-capable hybrid ships in the coming years. The most recent new construction project is two freight ferries for the Irish Sea (link).

A major challenge for the future is that Stena Line's goal of operating emission-free with electricity and renewable fuels is currently being hindered by the inadequate electricity grid infrastructure. A ramp-up of corresponding energy capacities and facilities in the ports is desirable. Stena Line believes that hybrid solutions with partial electrification and other fuels are the best way to optimize the use of available technologies.

Stena Line is also implementing various projects to make operations and processes more efficient, such as tools that use data and artificial intelligence (AI) to monitor the ships' fuel consumption and emissions. This enables crews to make optimal decisions about routes, cargo loads and other factors to minimize fuel consumption and emissions on each individual voyage. Furthermore, Stena Line is testing different types of paint on the hulls of the vessels to reduce harm to the ocean. Finally, Stena Line is also pushing partnerships with energy companies and fuel producers to promote a long-term ramp-up of non-fossil fuels for use in shipping.

5.4. Strategy and next steps to implement the pilot

Infrastructure

To increase the green transport line in the railway ferries, the following steps (also mentioned above) should be considered as part of a national planning:

- Extended (separate) extension track along the Trelleborg line for 750m train lengths
- Electrification to the combi terminal (Gudrunbrygga)
- Staging track/buffer track (640-750m) for freight trains
- Extended I-group for 750m long trains (in the west)
- Expansion of the combi terminal with two new tracks and loading area
- Double track Trelleborg C – Skytts Vemmerlöv (in addition to the pull-out track)
- Double track Östra Grevie – Västra Ingelstad (in case of increased passenger traffic)
- Double track Västra Ingelstad – Lockarp
- Double track Östra Grevie – Skytts Vemmerlöv

Geo-political recognition and resilient transport system set-up (rail ferry is a strategic route)

It should be envisaged to keep the rail ferry service between Rostock-Trelleborg for resilience reasons and due to transport limitations via the fixes link in operation.

Through the Swedish Transport Administration, the government has investigated the conditions for maintaining the railway ferries between Trelleborg and Rostock. This traffic is not extensive but takes on an increasingly important role as a strategic alternative to the Öresund Bridge in the event of disturbances or, in the worst case, armed conflicts. However, this has not led to concrete proposals on how traffic can be secured. In an initial situation, life extension of the ferries is assessed to be possible until the 2040s.

The ferry connection between Rostock and Trelleborg will be included in modility as a first test offer. Discussions have already started with TX Logistik to offer the service via the platform as soon as the technical development and implementation is done. As one of modility's 12 development partners, TX Logistik already has a close and trusting relationship with modility to build on.

Once the integration requirements have been thoroughly documented, the next step for modility is the technical integration, which involves coding. To better plan the overall scope and duration of the development efforts, all requirements were divided into three distinct work packages (WPs), which will be implemented sequentially.

WP1: Technical Preparation

Work package 1 (WP1) involved the technical preparation for the rail ferry integration. This included adjustments to internal data structures to enable the sequencing of multiple main legs. This foundation allows combining transport legs, such as rail and ferry, on a single transport offer. Additionally, a refactoring of the search algorithm was necessary to account for the combination of multiple main legs in a single transport search. This enhancement allows end-users to find connections consisting of various main leg segments, which may also include different modes of transport, by simply entering a start and destination point in modility. Alongside these backend adjustments, several frontend preparations were made for the ferry integration. To appropriately reflect the increased complexity of transport involving additional routes and transport partners, the layout of transport details within the search results was redesigned. This redesign makes the presentation of segments, waypoints (addresses and terminals), dates, and times not only clearer but also allows for the display of additional operator logos alongside the respective segments. As a result, the overview will be even more detailed and organized than originally planned (see Requirement 2 in Section 5.2). An in-house software developer, who joined modility at the beginning of March, carried out the implementation of these technical foundations. The lower costs of internal development allow modility to extend the scope of this project without increasing the overall budget. As the developer was already familiar with the modility tool and our development process due to a previous service relationship, the project team achieved a seamless transition without the need for extensive onboarding or training.

WP2: Enabling Data Provision

The implementation of the second work package is scheduled to begin in August. This phase will enable transport providers to upload combined schedules and price data for rail and ferry (e.g. via importers). This will also include information about other operators involved in the overall transport, such as the names and logos of service providers. Furthermore, user interface (frontend) adjustments will be finalized during this phase. Upon completion of this work package, the technical requirements for depicting multiple main routes and multiple transport providers in a single transport will be fully implemented.

WP3: Integration of Ferry Pricing

The third work package will focus on the addition of ferry-specific pricing components. This includes the general calculation bases for ferry pricing as well as specific surcharges. This feature will enable the responsible operator to display a total price for rail and ferry in a single transport.

The technical implementation of the work packages is planned according to the following Gantt chart:

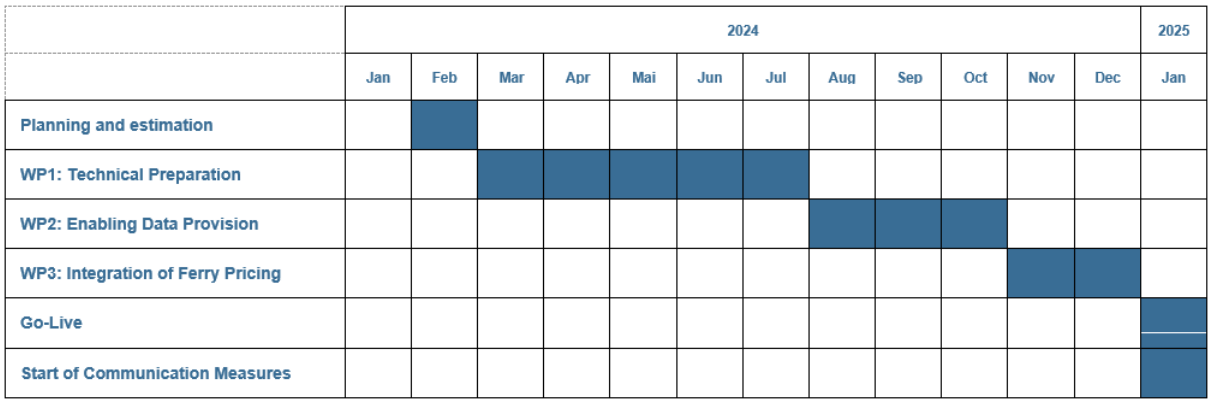

Figure 18 - Timeline for modility software development and communication measures.

Source: Own illustration by modility.

Once the service has gone live, all existing forwarders at modility will be informed via various channels and advertised in the market, e.g. via marketing campaigns, targeted sales activities and events such as the SGKV Terminal Day. In addition, further ferry operators and train operators will be acquired so that they can market further ferry services via modility in the sense of a neutral marketplace, particularly in the North Sea region.

Stena Line plans to participate in various events in the upcoming periods. It is planned to attend during the upcoming UIRR event, the SGKV Congress and of course during further events with partners out of its EU project. The company is also inviting customers on regular basis to watch rail ferry loadings to give them the opportunity to see the product. Additionally, Stena Line will of course use the Modility tool as a further promotion canal.

Greening potential for combined transport terminals

The analysis of greening potentials for Combined Transport (CT) terminals covers three areas, projects, policy, and industry best practices with special focus on greening potentials for CT Terminals and rail ferry services. Thereby, three catalogues have been finalized, clearly specifying the greening potentials for CT terminals based on the European projects, regulatory measures, and industry best practices. For the preparation of these catalogues, apart from desktop research, various methodologies like surveys, interviews, case study analysis, policy insights, and workshops were followed to produce an industry-oriented result. An overview of the three catalogues of greening potentials are as follows.

Catalogue of European Projects

The catalogue of European projects with relevance for greening potentials at CT Terminals were prepared based on the repository of projects in the CORDIS platform. The specific research programs that were considered as a part of this study are FP7 with three projects, Horizon 2020 with fifteen projects, Horizon Europe with three projects, and Interreg Baltic Sea Region with three projects. Accordingly, five ongoing and nineteen completed projects were analysed with focus on greening in terminals and ports. The main research areas of the projects can be classified into four areas- digital tools, green infrastructure, or devices, monitoring and reporting tools, and best practices dissemination.

Specifically, greening aspects like green assets, renewable energy, environmental footprint, regulation and policies, and economics were addressed in the research projects with varying emphasis. There was a notable emphasis on the environmental footprint across all selected projects, with few of them successfully incorporating the renewable energy aspect. Incorporating this analysis, each project has been presented in the catalogue with a General project overview (goals and expected outcomes), an Outcomes section (list of actionable results), and an Infographic (emphasis on the five greening aspects). Along with these, the project credentials, duration, funding source and amount, contact information, and the details of partners in the project consortium are also included.

Catalogue of European Policies

The second catalogue of European greening legislations related to ports and terminals is based on the EU Parliament platform ‘Legislative Train Schedule.’ To complete and verify the website’s information, newspapers and the official websites of the European Parliament, the Commission or the Council of the EU have also been reviewed. Two priorities namely, Transportation and environment, and Freight, logistics, ports and terminal were chosen for identifying the legislations. This catalogue is structured as packages with simple explanations of the legislative actions contained in them to enable the users to understand the macro-objectives quickly.

The packages (legislations) presented in the catalogue are the Sustainable and Smart Mobility Strategy (CO_2 emission standards for Heavy-Duty Vehicles, Revision of the Trans-European Transport Network (TEN-T), Ports Services Regulation, Eurovignette), the Fit for 55 package (Alternative Fuels Infrastructure Regulation, Revised Emission Trading System (EU-ETS), Effort Sharing Regulation,

Energy Efficiency Directive, Energy Taxation Directive, FuelEU Maritime 2 regulation, Renewable Energy Directive), the Greening Freight Transport Package (Revision of the Combined Transport Directive, Rail capacity allocation regulation, Weight and Dimension Directive Revision, CountEmissionEU Regulation), the Maritime Safety package (Port State control directive, Ship pollution control regulation), the Marine Strategy Framework Directives (Birds Directive and Habitats Directive, Water Framework Directive), and the Zero Pollution Action Plan (Revision of the Ambient Air Quality Directive, Environmental Noise Directive).

The structure of this catalogue comprises a Description of a legislative package along with its background and objectives, a List of relevant legislations in the package, and an Illustration of the package in the first page. This is followed by a series of pages introducing the individual legislations contained in each package. The legislations section of the catalogue is structured with objectives, illustrations of the legislations and the status of the legislative process, its relevance to logistics, and an overview of the implementation actions.

Catalogue of Industry Best Practices

The catalogue of Industry best practices for greening activities in ports and terminals has been prepared in three perspectives focusing on the European Ports and Terminals outside the Baltic Sea Region. The best practices are identified from the perspective of the industry organizations or associations, the ports, and the terminals. The International Maritime Organisation (IMO) and the International Association of Ports and Harbors (IAPH) leading the UN-backed World Port Sustainability Program were two international organizations studied and documented in this catalogue. Apart from their initiatives at the international scale, organisations like the European Sea Ports Organisation (ESPO) and Green Marine Europe were studied for a European perspective. This section of the catalogue contains the objectives, strategies, and tools suggested by these four organisations.

The next section of the catalogue focuses on case studies at four ports of Europe namely, the Port of Rotterdam, Port of Antwerp, Ports of Genoa, and the Port of Marseille. A detailed overview of the strategies adopted by the ports in managing the environmental conservation, climate change, energy transition, ensuring health and safety are presented. A tabulated list of initiatives undertaken by the four ports have also been added as an annexure for a quick reference.

The last section of the catalogue focuses specifically on the greening strategies adopted by the hinterland CT terminals. The initiatives and certifications related to greening by CFL Terminals, Interporto Bologna, Contargo Terminals, and Terminali Italia are summarised here. The key strategies encompass energy efficiency, water management, waste reduction, green building design, transportation and logistics optimisation, community and employee engagement, digitalisation, pollution control, and supply chain sustainability. Furthermore, the interviews and surveys conducted as a part of this study with ports and terminals have also been included in the annex. The conduct of this exercise between ports and terminals enabled to understand the different approaches to greening initiatives.

Therefore, the three catalogues provide a holistic guideline for identifying the greening potentials for CT terminals and also introduce the various measures to achieve the same. This, along with the process visualisation created for the rail ferry operations in the project will form the foundation for the implementation phase of the project.