REPORTS OF PILOTS IN WP 4

Development and implementation of new smart processes

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Contents

North Sea Connect

The North Sea Region is an important logistics zone in Europe.

The largest seaports, but also many intermodal transportation nodes are located here. Those intermodal nodes are important for the transportation of goods to and from the supply and demand markets. To increase attractiveness of markets, transportation networks are needed and should continuously be developed to meet the needs.

Currently, the Trans-European Network-Transport (TEN-T) policy is putting a strong focus on the development of the Core Network that includes the major transport axes across Europe. However, the whole trade and business network is not only depending on its major nodes but also on its hinterland.

To raise the efficiency of transport flows in a holistic approach, the project will thus include both major and remoter transportation nodes to establish learning opportunities.

2 OBJECTIVE

North Sea Connect is a project co-funded by the Interreg North Sea Region Programme and belongs to priority 4, Promoting green transport and mobility. The project is led by Port of Hamburg Marketing and was initiated in October 2019 and will be finished by the end of March 2023.

The project consists of nine project partners from five countries in the Interreg North Sea Region (NSR) and the partnership is seen in table 1.

Table 1: list of project partners and	
Project partner	**Country**
Port of Hamburg Marketing	Germany
Port of Oostende	Belgium
Port of Brussels	Belgium
Southeast of Scotland Transport Partnership	United Kingdom
The Ministry for Science and Ports, Free and Hanseatic City of Bremen	Germany
SSPA Sweden AB	Sweden
Business Vordingborg	Denmark
Vives University of Applied Sciences	Belgium
Hamburg Port Authority	Germany

The overall objective of North Sea Connect is to support smart intermodal growth in the NSR through efficiency enhancements.

The detailed project objectives are:

- Implementation of new smart processes and tools (smart intramodality),
- Developing of strategies for smart efficiency enhancements (smart involvement)

To meet this objective the project is structured around four work packages.

The objective of this report is to collects and present findings and learnings from the fourth work package:

Development and implementation of new smart processes.

The fourth work package consists of five pilots that has been carried out at as physical exercises in a port area or though desk-based studies that provide a port with opportunities to meet the overall project goals and the local challenge that the port is faced with. The five pilots are:

- Autonomous loading/unloading - Port of Oostende
- Smart City Port Distribution – Port of Brussels
- Smart remote nodes development – Vordingborg Business
- Smart seaport terminal accessibility – Port of Gothenburg
- Slot plan Integration into the Rail Port Community System – Port of Hamburg

In the following the five pilots are presented and a sum up of key learnings and experiences is provided at the end of the report.

3 PILOT: AUTONOMOUS LOADING/UNLOADING AT THE PORT OF OOSTENDE

In the NSR CONNECT project, VIVES is engaged in WP 4:

Development and implementation of new smart Processes, in the Pilot on Autonomous loading/unloading at the Port of Oostende.

Objective: The pilot wants to research how transforming certain operations in ports into autonomous tasks can enhance the use case for IWT and overcome some of the current challenges around sustainable transport alternatives. The pilot will also demonstrate this with a specific case of autonomous (un)loading of cargo in the Port of Oostende.

To support the above objectives, VIVES has been working on two main initiatives as part of the North Sea Connect WP4 Pilot:

1. Study of the opportunities for automation (with autonomous equipment/vehicles) in the logistics value chain of ports

2. Digital twin simulation of an autonomous forklift for (un)loading cargo at the Vlotdok in the Port of Oostende

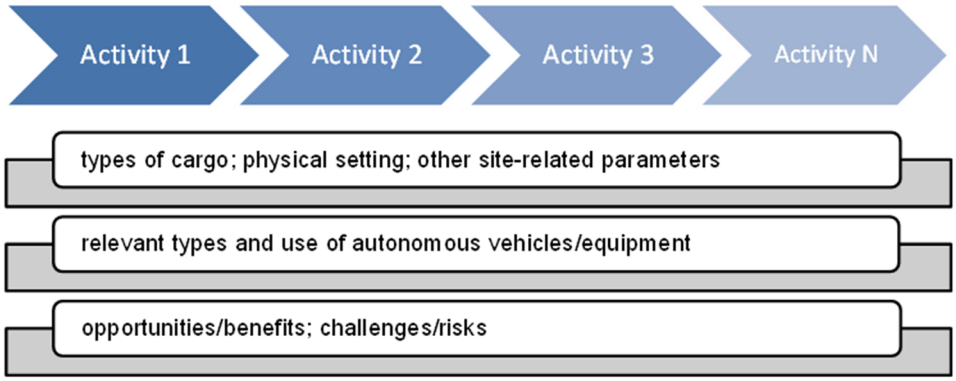
The following is a brief overview of the above two initiatives.

1. *Study on the opportunities for automation (with autonomous equipment/vehicles) in the logistics value chain of ports*

This study is currently in progress, and the main activities and target outcomes are described below:

1. *Literature study*
   An overview of the most relevant recent publications on smart port automation with autonomous equipment/vehicles (incl. robots, flying/underwater drones, etc.) will be provided. Trends and insights will be highlighted around what types of autonomous devices are being used to make port logistics more efficient. Relevant aspects that are applicable to the Port of Oostende will be identified.

2. *Value chain analysis and identification of opportunities for automation*
   The different activities in the port logistics value chain (both cargo-related and non-cargo activities) will be analysed in terms of eligibility for automation with autonomous equipment/vehicles. The aim is to identify the most likely target activities that will see significant benefits from being carried out with (support from) autonomous equipment/vehicles in the short term.



3. Interviews with Ports
   From the prior two activities, a questionnaire will be developed to investigate the practical relevance and feasibility of high-potential automation efforts in ports. The questionnaire will be used for interviews with participating NSR Connect ports (and potentially others).
   The results should provide a practical validation and further selection of the most attractive opportunities for port automation.

4. Summary of best target areas for autonomous tasks (feasibility, level of cost savings, short-term implementation likelihood)

   The key areas for automation will be summarized based on the outcome of the previous activities. Specific reference will be made to the relevance for the Port of Oostende of each of the identified opportunities and how such automation can enhance the use case for multimodal transport using IWT.

5. Conclusions, challenges and future research/innovation recommendations.

2. Digital twin simulation of an autonomous forklift for (un)loading cargo at the Vlotdok in the Port of Oostende

This initiative wants to demonstrate autonomous (un)loading by using a digital twin simulation platform. VIVES has been working with digital twin technology over the past years and wants to leverage its expertise to show a proof of concept for this autonomous task in the Port of Oostende. A specific location ("Vlotdok") has been selected by the Port because of the location between incoming/outgoing sea vessels and the IWT connections to local and European destinations. Autonomous barges coming from the inland waterways can nicely complement this as part of a smart automated transport process to transition towards more sustainable logistics.

This initiative is made up of several activities to achieve the targeted outcome:

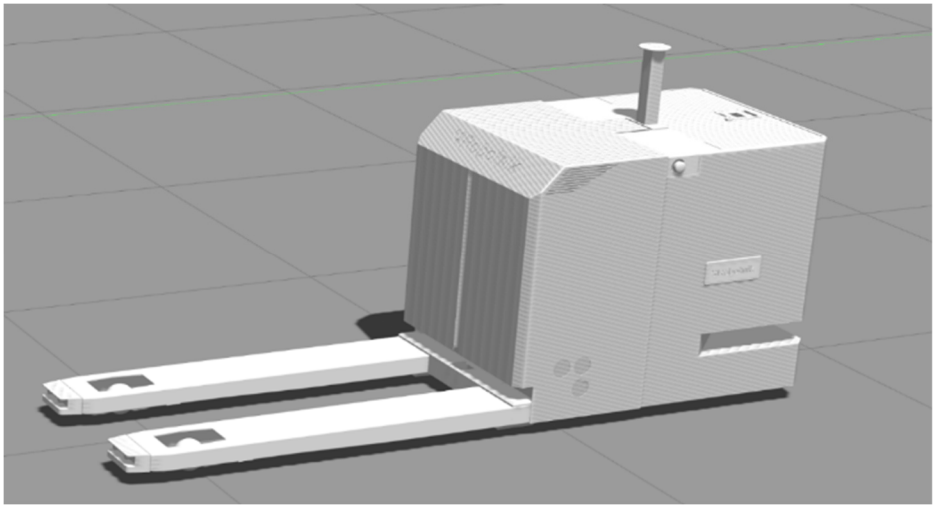
1. Dock environment scanning and integration in the simulator environment

The initial plan was to make a digital scan of the real-life environment at the Vlotdok where the autonomous loading could be implemented in the future. This activity has encountered several practical and technical challenges. To scan the site, a backpack scanner was required (instead of the trolley scanner that was foreseen) to mitigate negative impact from the uneven ground surface and old railway tracks on the site.

A major hurdle came up for the next step, i.e. the conversion from the point cloud (237,684,319 points) of the scan to a high-end mesh, made up by 79,228,106 polygons. The current simulator (Gazebo) is using continuous full rendering of all polygons, which requires excessive CPU capacity for handling such a detailed mesh. Future versions (e.g. UnrealEngine/Unity) will use dynamic rendering, which is more efficient. Migrating to the new simulator was however not feasible within the project time constraints.
Therefore, it was decided to create a digital dock environment (still sufficiently representative of the Vlotdok site) by using synthetic objects, i.e. a total of 372,041 polygons. The digital dock environment is shown in the picture below.

2. Digitization of the forklift

For the forklift, a digital version of the 'Robotnik Areas' will be used (see picture below). This forklift will be equipped with a number of sensors (e.g. wheel encoders, GPS-RTK, IMU, RGB DepthCAM, 3D Lidar 64 layers) in order to autonomously navigate on the site in a safe and smart way, while detecting any objects or humans during the task. SLAM-based navigation, as part of the ROS2 / NAV2 packages, is included in the robotics platform, enabling the forklift to dynamically update the map of its operations environment (allowing for any changes of the site layout).



3. Simulation for cargo lifting and movement at the dock:
    a. ability to avoid dynamic objects and people on the quay
    b. simplified pick-up of pallet and movement from A to B

Due to project time constraints and challenges in the prior activities requiring additional time to resolve, the autonomous (un)loading task is represented in a simplified version. Nevertheless, the demonstration still provides the necessary evidence that the robotics platform can enable the required tasks in a safe and autonomous manner. Finetuning of the loading task (based on type of cargo, other equipment to be installed at the dock, etc.) as well as variations on this task can be simulated by slightly modifying the software and adding time for additional AI training. The base platform and forklift specifications will (largely) remain the same. Several scenarios will be simulated, including some with objects and humans moving around on the site and interfering with the forklift.

Additional testing will also be required (outside of the project) to determine whether the speed of the operation can be increased while maintaining strict safety levels (subject to the actual set-up in the dock environment in terms of other traffic and activities potentially interfering with the forklift). That will provide the necessary insights to validate the business case for the automation and the broader IWT scenario.

Finally, more detailed weather and physical conditions on the site (including but not limited to light intensity, rain, slippery soil, mud/sand, wind, etc.) should be added into future digital twin simulations to determine the range of conditions within which the proposed forklift can be used to perform the (un)loading operations at the dock.

4. Report on challenges, remaining gaps and suggested future improvements

    At the end of the simulation exercise, a brief report will be written to summarise the main challenges encountered in the initiative, as well as the key learnings/conclusions and suggestions for future research and optimization of the autonomous (un)loading activity.

4 PILOT: SMART CITY PORT DISTRIBUTION – PORT OF BRUSSELS

In the NSR CONNECT project, Port of Brussels has carried out the pilot project “Smart City Port Distribution” to tackle the following challenges:

Challenge 1: efficient transport of goods between seaports and their hinterland

Brussels is a major consumption center for the construction sector. More than 75% of the 2.5 million transshipped tons of building materials in the Port of Brussels come from the Netherlands or Antwerp. It is estimated that only 5 to 10 % of Brussels’ construction flows are currently transported by waterway. Congestion problems around Sea Ports and in Brussels are partly due to missing links between Sea Ports and their hinterland. Waterway transport is a solution to (re)create these links and reduce the extensive use of trucks for the transport of goods.

Challenge 2: mobility of goods within urban areas

Like many other big cities in the NSR, Brussels is dealing with heavy congestion problems, creating mobility and logistic challenges for the transport of goods within urban areas, particularly in the construction sector. Moreover, the following problems can be summed up:

- Split sector with multiple actors/no single interlocutor -> lack of reliability of deliveries (respect of planning and quality)
- Increasing concentration of activities in the city/limited space on site for logistics activities (unloading, storage, etc.) -> risks related to handling
- Increase of renovation projects and flows
- Lack of visibility on the delivery schedule
- Traceability of materials on site
- Accessibility to construction sites
- Limitation of transport in the city and binding delivery times -> lack of flexibility of deliveries (time and place on site) and lack of flexibility of the producers.

Taking the abovementioned challenges into account, this pilot had two aims:

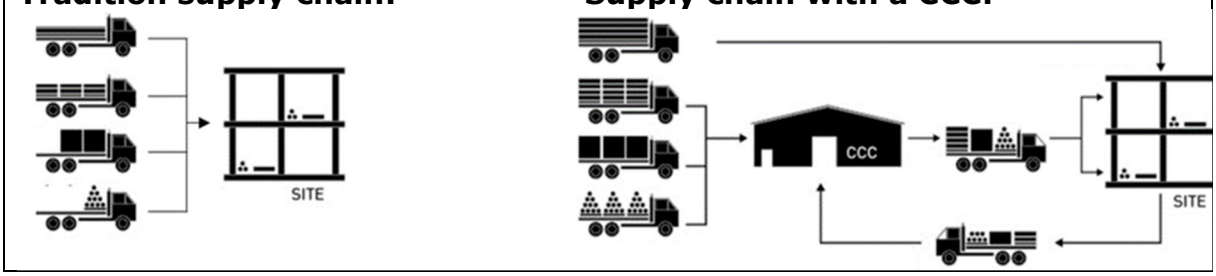
- Reinforce links between North Sea ports with their hinterland connections through the Antwerp-Brussels-Charleroi Canal;
- Optimize global supply chain and city distribution for construction sites.

Concretely, this pilot project aimed to test the possible extension of the Construction Consolidation Center for building materials (CCC) in the North (Vergote Dock)[1] to the South of Brussels (Biestebroek Dock), in order to further develop the use of waterway for unitized building material supply (pallets, big bags, mobile boxes, etc.) with a special focus on the organization of the last mile and the whole supply chain from building material producers to the end consumer (construction sites).

A CCC is a smart and innovative logistic concept that aims to improve the logistic chain of building materials in city centers[2]. It is an intermodal distribution facility through which the delivery of building materials is channeled to construction sites. The flow of building materials is bundled and consolidated to reduce externalities of the construction sector (congestion, noise, pollution, carbon emissions and improved reverse logistics).

This will contribute to intermodality growth as it directly fosters the hinterland connection with Dutch and Flemish Sea ports and indirectly the connections on the TEN-T corridors North Sea-Mediterranean and Rhine-Alpine. As shown in figure 1 below.

Figure 1: Supply chain structure



The current CCC North is operational since 2018 and exploited by Shipit Multimodal Logistics. One of the main requirements for success of a CCC is the distance to the building sites, this cannot exceed 5 kilometers. To increase intermodality and the supply of the Southern part of Brussels through a CCC it is thus needed to extend the concept to the South. A study carried out by Technum in 2013[3] "Study on the Development of Multi-Purpose Canalside Transshipment Platforms in the Brussels Region" indicated the Biestebroek Dock as an ideal location for supplying the South of Brussels through intermodal delivery.

Activities

The pilot consisted of the following activities:

[1] This CCC is operational since 2018 and exploited by Shipit Multimodal Logistics.
[2] https://www.youtube.com/watch?v=Gpv3Yi8ngIs and https://www.youtube.com/watch?v=Fci1sxkYcug&t=1s
[3] Co-financed by the INTERREG NWE IV programme in the context of the "Connecting Citizen Ports 21" project.

- Analysis of current situation CCC North and suggestions for improvement (including exchange with Wilson James London)
- Policy and regulation study to increase the use of the CCC's in Brussels
- Feasibility study CCC South (including business model)
- Test operation shuttle CCC North and South
- Test operation CCC South (including temporary stocking facilities)

Results and learnings

Analysis of current situation CCC North and suggestions for improvement including exchange with Wilson James London

The pilot started with an analysis of the CCC in the North of Brussels since it became operational in 2018. The overall evaluation was positive. Recommendations for improvement were given and taken into consideration for the expansion of the activities to the South of Brussels. Lessons learned from the CCC in London "Wilson James" were considered. The report was elaborated by the Port of Brussels in collaboration with Shipit Multimodal Logistics who is the current operator of the CCC's. The report was finished in May 2021.

Policy and regulation study to increase the use of the CCC's in Brussels

This study outlines a roadmap for the development of a favorable policy and regulatory framework to increase the use of CCCs in Brussels. It considers 11 inspiring examples from Belgium and abroad, including the following aspects:

- Overview and analysis of the current policy and regulatory framework related to the supply of building materials in the city.
- Considering the complex governmental structure in Brussels, at what level should steps be taken (regional, local) and which institutions should be involved at each stage of the regulatory process.
- Concrete action plan (with timeline) and recommendations for a favorable policy and regulatory framework.
- The expected impact of the proposed regulations on logistics flows to construction sites (compared to BAU).

Specifically, in the context described above, the following deliverables were/are expected:

- Interim report.
- Final report consisting of an action plan/roadmap outlining all the major steps to be taken to create a favorable policy and regulatory framework that increases the use of CCCs in Brussels.

The interim report was delivered in December 2022. The final report is expected by the beginning of March 2023. A workshop will be organized to discuss the results with all stakeholders involved.

Feasibility study CCC South (including business model)

This study provides a road map for the development of the terrain, taking into consideration inspiring examples from Belgium and abroad, giving an answer to the following questions:

- What technical requirements are needed for the CCC South (quay and soil adjustments, etc.).
- How will the mobility be organized, taking into consideration the surrounding and ongoing housing projects.
- How will the circulation plan look like for transshipment and last-mile logistics.
- What are the infrastructure requirements.
- What handling infrastructure, cranes and other equipment is needed.
- The quay needs to remain publicly accessible during night and weekends, how should this be organized in legal and practical terms.
- The first outlook is on building materials, what is needed to include FMCG's in the logistics of a multimodal consolidation center in the future.

In the abovementioned context, concretely the following deliverables were expected:

- Mid-term report
- Final report consisting of an action plan/road map that sets out all big steps to be taken in establishing a construction consolidation center on the Biestebroek Dock including:
    - Business plan
    - Circulation/mobility plan
    - Solution for the public quay
    - General map for the terrain (format 1/1000) and detailed maps for the specific areas (quay, circulation, accesses, etc.) (format 1/500)

BDO Advisory delivered the final report in December 2022. On 24/01/2023 a final presentation is organized to discuss the results.

Test operation CCC South and shuttle CCC North and South

Test operations between the CCC North and South took place on 20 May, 8 June, 25 October, and 6 December 2022. Large volumes of pallets were transported from Germany (Fensterbach) to CCC North out of which smaller volumes continued to be transported to CCC South. Several more shuttles that will

go from CCC North to CCC South are foreseen for the beginning of 2023. Study results highlighted the necessity for additional concretized surfaces on the Biestebroekdok and stocking facilities for a successful CCC model. Consequently a temporary stocking facility has been purchased and concreting works of 350m² have started in December 2022. Meanwhile plans are made for the design of a permanent warehouse (outside NSR CONNECT).

Conclusions

The extension from the CCC North to the CCC South is needed to make the transport of goods between the Flemish Sea Ports and their hinterland connection more efficient and to optimize the mobility of goods within Brussels.

The existence of both CCC's and the connection in between will make it possible to supply most part of the city in a consolidated way, making use of the waterway.

This will reduce road traffic and emissions. Building materials will remain the focus for the near future, but other types of goods such as FMCG's belong within the possibilities on a longer term.

5 PILOT: SMART REMOTE NODES DEVELOPMENT – VORDINGBORG BUSINESS

In the NSR CONNECT project, Business Vordingborg is engaged in WP 4: Development and implementation of new smart Processes, Pilot 3: Smart remote nodes development.

Objective: The Trans-European Network-Transport (TEN-T) policy puts a strong focus on developing the core network, the largest transport points in Europe. But world trade and business networks depend not only on the major traffic hubs but also on its hinterland.
Vordingborg is located on the TEN-T corridor but not on the core network. With the coming Fehmarn fixed link, the transportation between Denmark and Germany will be improved and Vordingborg has a good location to benefit from this increased activity. Business Vordingborg therefore wish to improve its position and become a green logistics hub on the TEN-T corridor. To improve the chances of succeeding with this purpose, Business Vordingborg has initiated studies and initiatives as a part of the participation in North Sea Connect:

-Baseline study: An analysis of the relevance of sustainability in the new Fehmarn Belt Corridor
-Business Case – Vordingborg Dry Port - Preparing the business for the Fehmarn fixed link
-Road Map – Potential of inland waterways for the Port of Vordingborg
-Study trip to understand and connect with German logistics operators.
-Seminar on “Strategies for building a sustainable future for ports and logistics corridors.”
-Examine the basis of a logistics business network across the border to Germany.

Below is a short sum up of the studys done:

Baseline study: An analysis of the relevance of sustainability in the new Fehmarn Belt Corridor

This study is finished, and a summary of the report is presented below:

The study analyzed logistics operators and local companies view on sustainable energy and infrastructure that may support the development of the Fehmarn Belt corridor. Greater economic activity and a deeper integration between Denmark and Germany are expected outcomes of the link. With approx. one hour decreased transportation time the dynamics will be seen in large parts of Zealand but the closer to the fixed link, the larger are the benefits expected to be. With a travel time of e.g., eight hours as it is from Gothenburg to Hamburg, the fixed link will only have a reduction of 12% travel time, while the journey from Vordingborg to Hamburg will be reduced by 26%.

Sixteen Danish and three German companies and organizations participated in the study. Results from the study show:

- Environmental awareness is high on the agenda and most of the companies in the study believe that sustainability is important for future competitiveness.
- Most companies have the opinion that the Danish and German governments have the greatest responsibility for developing a green and sustainable Fehmarn corridor, but collaboration between companies and local municipalities is important.
- Most surveyed companies use green transportation alternatives and have implemented those within the past few years. It is stated that green energy will become more important for companies in the future, and that they are willing to embrace these opportunities.

Business Case – Vordingborg Dry Port - Preparing the business for the Fehmarn fixed link

The business case was finished in December 2022 and the main objective and result of the study is highlighted below.

This study investigated how a dry port can utilize the expected logistic impacts from the new Fehmarn fixed link. A dry port in the Vordingborg area should be based on a stronger integration between the Port of Vordingborg and the existing business and industrial parks in the area.

The business case shows a potential for a dry port in the Vordingborg area, and the location with the greatest potential is at Business Park Vordingborg mainly due to its proximity to the motorway. The main arguments for a dry port at that location is based on: The increased transport in the area, the reduced travel time to Germany and the potential of a dedicated management to fulfill the plans for a future dry port in the Vordingborg area.

Redeeming these potentials in realty - requires:

- A dedicated management of the dry port to identify potential companies, attract logistic providers with a green profile and a capacity to operate the development of the dry port.
- A masterplan with a business-oriented development strategy combined with accessible municipal development plans and regulation that are supportive of a dry port in the Vordingborg area.
- A focus on identification and achieving the potential synergies that exist between the Port of Vordingborg, and a dry port.

Road Map- Potential of inland waterways for the Port of Vordingborg

The road map was finished in December 2022 and the main objective and result of the study is highlighted below.

The objective of the road map is to assess the opportunities for the Port of Vordingborg to improve its position for goods transport in the European inland waterways. This will illustrate the development opportunities for a remote node on the TEN-T corridor and be supportive of a sustainable development in the region.

The road map shows:

- The Port of Vordingborg and the area of Vordingborg have a potential based on its geographical location to connect to the TEN-T as a hub to connect motorway, seaport, and dry port to the European inland waterways.

- The maritime entrance in the Northern European inland waterways is a natural position to the Port of Vordingborg – maritime restrictions and traditions in the inland waterways may diminish this potential to be activated. A mapping of potential local companies and shipping companies with ships that can call both the Port of Vordingborg and the inland waterways should illuminate the potential further.

- If the Port of Vordingborg should be seen as a potential northern part of the European inland waterways, the development in relation to the ongoing digitalization must be recognized and the eFTI-rules must be addressed to enable the port to fulfil the obligations in this domain.

Study trip to understand and connect with German logistics operators.

In June 2022 the Port director of the Port of Vordingborg, Jan-Jaap Cramer, Project leader from Business Vordingborg, Khady Tauber Koné, and consultants from GEMBA Seafood Consulting, Jens Henrik Møller and Kasper Teilmann went on a study trip to get a better understanding of the German logistics market and connect with relevant potential business partners. During the study trip meetings were made with: Nord-Logistik, Hamburg Hafen Marketing and China Logistics Center, Itzehoe. A report on the main findings was published in the fall of 2022.

Seminar on "Strategies for building a sustainable future for ports and logistics corridors"

On October 6, 2021, a partner meeting with a seminar was held in the municipality of Vordingborg. The first part of the meeting gathered participants from three different Interreg North Sea projects that could meet and discuss common challenges and opportunities while visiting the Port of Vordingborg. At the seminar there were speeches from among others, the CEO of Business Vordingborg Bolette Christensen, CEO of the North Sea Interreg Program Mr. Christian Byrith, and Tine Kirk Pedersen, CEO – Danske Havne. The seminar also included a tour of the Port of Vordingborg to see the great expansions and projects that takes place there. The picture below shows the partnership at the Port of Vordingborg.

Examine the basis of a logistics business network across the border to Germany

To prepare for the coming fixed link and improve the opportunities for engaging with the right logistics partners, a meeting between Business Vordingborg and the Wirtschaftsförderung LÜBEC that has a similar profile is scheduled for spring 2023. The objective of the meeting is to examine the basis of a logistic business network with Danish and German partners.

Challenges and learnings

The development of infrastructure along the TEN-T corridor has commissioned the development of the Fehmarn fixed link and the Vordingborg area is expected to see an increase in road transport on the highway passing by the town and through the municipality. This opportunity was the driving force for the Vordingborg Business to engage in the North Sea Connect project. However, it has been challenging to make a clear identification of how to realize a potential of this new opportunity caused by the increase in the traffic.

That was one of the first major challenges to Business Vordingborg and a starting point to identify what steps to take.

The identification of the right foci of the studies to be made was a longer process than anticipated and many discussions were taken to find the right approach. One of the leading causes for the identification of the right angle towards the studies was achieved during a workshop at the seminar on “Strategies for building a sustainable future for ports and logistics corridors” that was held in October 2021. All project partners were asked to provide their view on challenges and opportunities of the increase traffic that the Vordingborg area investigated and through a careful analysis of the results, the formation of the objective of two studies “Road Map- Potential of inland waterways for the Port of Vordingborg” and “Business Case – Vordingborg Dry Port - Preparing the business for the Fehmarn fixed link” was taken.

North Sea Connect has been very beneficial for Business Vordingborg in sharpening the understanding of the business potentials that the Fehmarn fixed link will suffice and providing tools and concepts to embrace, and hopefully implement, to achieve the benefits of the fixed link.

6 PILOT: SMART SEAPORT TERMINAL ACCESSIBILITY – PORT OF GOTHENBURG

Accessibility issues of getting containers to and from the hinterland transports at seaports is connected to long turnaround times, as well as slow and unnecessary administration due to inefficient port operations. Inefficient operations are in turn related to poor information exchange among the actors (terminal operator, road and rail operators) and poor quality of real-time information due to various non-connected information systems. An incompatibility follows when each actor uses its own information system that is not able to communicate with other information systems. These issues hamper port throughput and shift towards intermodal transportation. In attempts to improve the management of the container interchange between port area and hinterland transport various strategies have been suggested. The truck appointment system (TAS) constitutes an attempt to manage truck arrivals. The specifics of the TAS vary and depend partially on the terminal's intended use case of the TAS. The first use implies improving information on trucks' arrival time (in comparison to when unscheduled access is deployed) to schedule terminal capacity and thereby increase yard operations efficiency. The second use implies that schedules, limiting the number of trucks that arrive during certain time intervals throughout the day, are imposed to level truck arrivals and thereby increase terminal operations efficiency. As the second use also implies improved information on truck arrivals in comparison to when unscheduled access is deployed, it also facilitates scheduling of terminal capacity.

Process analysis for Pilot Terminal Gothenburg

The access processes for trucks in the pilot seaport aim at providing the hauliers with full flexibility. The processes differ slightly depending on import or export containers. Therefore, these two cases will be presented separately and are illustrated in Figure 2 below.

Figure 2: Container process in Terminal Gothenburg

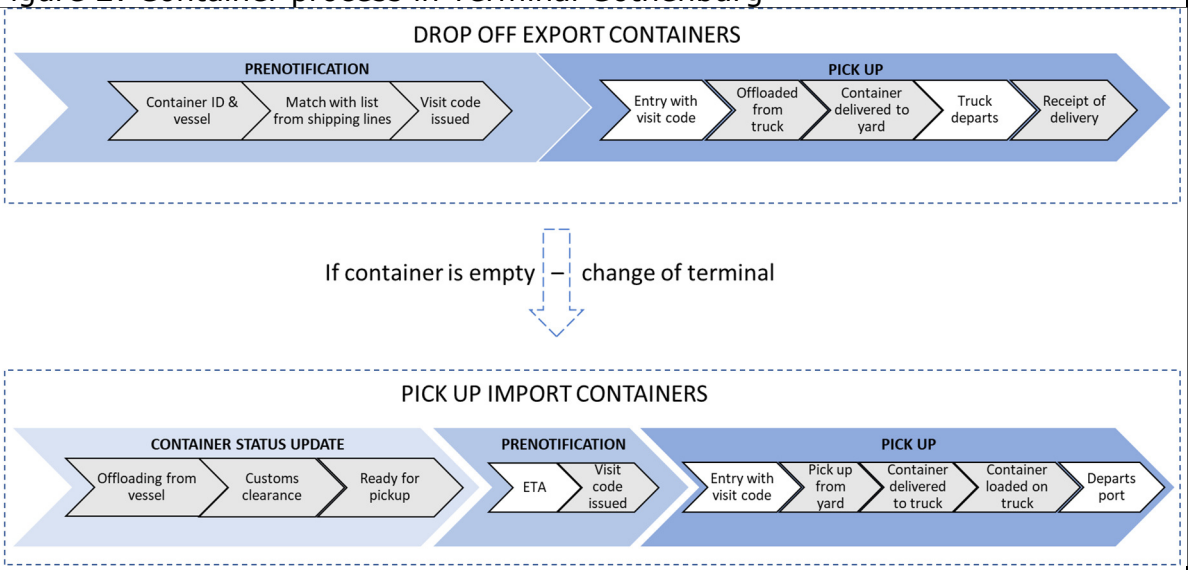


Figure: Overview of process for dropping off and picking up containers in the port of Gothenburg (Grey boxes are performed by the port terminal, and white by the haulier).

For import containers, the terminal operator provides updates to the hauliers regarding container status. These status updates include onloading from vessel, customs clearance and ready for pick-up. The hauliers provide, after receiving status ready for pick-up, a pre-notification on what day the container is planned to be picked up and receives a visit code. The notification regarding time varies in terms of reliability of when the container should be picked up and is not today used for planning in terminal and no further information is given on details around when the truck will arrive at the seaport. The visit code is used by the truck driver at arrival to seaport for access and is connected to a container-ID. The truck driver shows up at the seaport and via the visit code gets access to the terminal. The access provides a signal in the terminal operator system to trigger a pick-up activity from terminal yard of the specific container and delivery to truck. The container is loaded onto the truck by terminal operator.

For export containers the haulier books a delivery to the seaport by a pre-notification on container information. The booking code (includes what vessel to depart with) with container-ID is provided by haulier and matched by terminal operator to the given outbound containers from shipping lines, for confirmation. The truck driver arrives with visit code that triggers pick-up of container from truck to yard. The truck receives receipt on delivery when exiting the terminal area.

For delivery of export and pick-up of import containers, the procedure follows as above but if the pick-up is made of an empty container the truck will change terminal between drop off and pick-up. The second terminal entry means going via an arrival queue again also for this entry.

Process management service development

Various information types have been highlighted in previous intermodal freight transport research with focus on ports. The information value depends on what decision for what processes that are in focus. By facilitating for each actor to provide their insights on the various development possibilities for the service around the access processes, valuable data around different information types for that purpose were found. This data collection was done through focus groups with involved project partners of terminal operator and transport operators for the rail and road parts.

Three types of information were found, which could facilitate improved services for access processes. The information types various in the time it is shared before the actual access process is carried out and what it included. Nevertheless, the information types all represent real-time information at the specific moment of being shared. The information types are illustrated in relation to a timeline in Figure 3, below and the value of the different information types is given in an overview in Table 1.

Figure 3: Information types

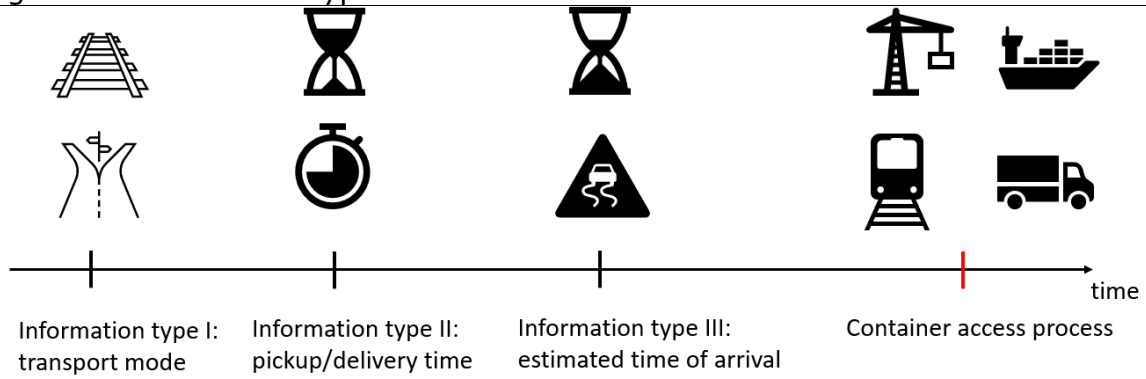


Figure. Information types elaborated on in the pilot.

Table 1: Overview of the value of the different information types

Information	Stakeholders	When shared?	Changes in procedures	Benefits
I. Planned rail/road hinterland transport of import container	Freight forwarder → Terminal operator	Before vessel arrives in port	Terminal operator can arrange containers in yard per road/rail.	Avoid reshuffling of containers. Quicker retrieval of container from the yard Reduce distance driven for forklifts.
II. Pickup/delivery time of hinterland transport	Freight forwarder/haulier /rail operator → Terminal operator	Day before pickup/delivery E.g. when booking a time slot in a TAS	Terminal operator can a) optimise sorting of containers beforehand, e.g. stacking containers needed imminently on top of others. b) plan resource utilisation based on more reliable demand	Avoid reshuffling of containers. Quicker retrieval of container from the yard Better joint planning between different port operations can lead to better resource utilisation.
III. Updates of estimated arrival time for hinterland transport, e.g. traffic status	Haulier/rail operator → Terminal operator	Near the access process is to be performed	The terminal operator can plan provision of specific containers to the access point in detail	Can capture disruptions in the hinterland transport Quicker retrieval of container from the yard

Process management service implementation in Gothenburg

In the project, the focus was on the information type that the actors deemed most reasonable to exchange. The information type of transport mode was chosen and shared via excel sheets from rail operators and hauliers to the terminal operator. The use of excel sheets was used due to lack of possibilities in the project to get permission to change application programme interfaces (APIs) that would connect the systems used by the actors. Using this manual solution for the other information types would have been possible and was discussed but would imply more frequent manual interruptions in the processes and therefore chosen not suitable for the project. The exchanged excel sheets was manually placed into the operational system of terminal operator to include in the yard planning for unloading vessels. Issues around using information for this planning purpose was encountered, due to high yard density at port terminal and therefore a present need to stack all containers on top of each other. This situation led to that the terminal operator did not have the luxury of allowing for space of two rows when unloading ship (one for outgoing with rail and one for outgoing with trucks). Rather all containers needed to be mixed to utilise the yard area. Some explanations for the situation experienced was container patterns due to covid-19, such as delayed containers and containers not being able to be shipped and left in yard area, and the invasion of Ukraine, such as not being able to ship intended containers to certain geographical areas.

Evaluation and recommendation for other North Sea seaport terminals

By evaluating access management, the project has contributed to knowledge regarding smart seaport terminal accessibility in three ways:

Increased understanding of stakeholder perspectives:

Firstly, putting together the actors and discussing the issues in various workshops during the project, combined with semi-structured interviews with experts at the project partners and another port have provided several insights. This has generated understanding between actors around different prerequisites for access management. Due to that the access operations are in the interface between different actors' activities, that therefore are sequentially dependent on each other, this understanding provides value for why some actors act in a certain way. The technical conditions in place at the various actors is an example of understanding other actors' viewpoints.

Comparison of different ports:

Secondly, by adding other seaport terminals with truck appointment systems to the scope have lifted outcomes for recommendations around access management.

Increased understanding of drivers and barriers of access management and specially a truck appointment system (TAS):

To understand the benefits and barriers around access management, the focus on truck appointment systems (TAS) was chosen to study. This focus comes from the understanding from the study pilot of various viewpoints around a possible implementation of TAS. TAS was examined for four European container ports (including pilot) with initialisation of TAS and the current pilot without appointment booking for trucks. Three of the four container ports are included in the North Sea Connect project and the fourth is outside the project partners. Empirical data was collected via eleven semi-structured interviews and relevant documents were reviewed. For one container port, a study visit was arranged to understand their access operations. This resulted in understanding barriers and drivers of a TAS with the purpose of improving access management for trucks. The result is put in relation to TAS design and cover the perspectives of both terminal operator and hauliers.

Recommendations for other North Sea Region seaport terminals

On the terminal side a TAS can provide planning benefits, but these benefits can only be achieved with a TAS that provide reliable information. For the hauliers the flexibility of a TAS is questioned and additional administration is needed, that need to be offset by the potential benefits of more efficient access management. The information exchange between the actors therefore needs a commitment from all actors and understanding regarding other actors' activities and need for various information types. It should be noted that understanding implications of access management service, such as TAS, depends on the context.

The context could be exemplified with the specific challenges for a seaport terminal. If the main motivator of TAS is to reduce TTT and truck emissions in port area a TAS that control the arrival of trucks in a strictly manor is needed. If other drivers are the main reason behind TAS, such as terminal yard and capacity planning, a scenario for a less restrictive TAS for the hauliers could be introduced. A less restrictive TAS can build in flexibility for hauliers, such as adopting arrival information for different time stamps before actual arrival (planned arrival a day before or planned arrival hours before arrival). Such a type of TAS could be implemented in phases, where the first phase includes hauliers to give best estimate (a certain time before arrival) of their arrival times but missed appointments are not penalised. With this information the terminal operator cannot steer the access operations but rather plan yard operations better. The terminal operator can also get an understanding on accuracy on arrival information given from hauliers, which is important to understand to set reasonable windows for time slots and provide feedback to hauliers regarding their accuracy if there is need for further advancements of TAS to provide more accurate information. Nevertheless, the extra administration needed from hauliers for TAS indicate need to provide value for access operations connected to gate, for hauliers to also benefit from improvements and not being limited to terminal operator, such as improvements in yard operations.

Additionally, information prior access operations can provide benefit for terminal planning, such as transport mode information when vessel arrival to seaport terminal. With regards to type of information to share and at what point in time.

7 PILOT: SLOT PLAN INTEGRATION INTO THE RAIL PORT COMMUNITY SYSTEM – PORT OF HAMBURG

Within the North Sea Range Connect project, the Hamburg Port Authority A.ö.R. (HPA) is creating a demonstrator for an integration tool between the slot plan system of a large intermodal terminal and hinterland transportation by rail.

Motivation: Increased Planning Harmonization in Rail Transportation

Currently, mainline train operations from hinterland towards seaport are planned mostly on the national rail network, sometimes also on the trans-European rail network. Besides, maritime port terminals typically focus on their planning first on the maritime side.

Furthermore, incidents like the Suez Canal blocking or the COVID-19 pandemic led to major distortions within the worldwide maritime shipping networks. Their impact leads to significant stress on the resources management of the multimodal maritime port terminals, i.e. container loading/moving equipment, but also storage space or hinterland transportation capacity.

This in turn leads to the situation that the public rail infrastructure within the port area (comprised of mainline sections and shunting yards and operated by the HPA) needs to handle not only mainline trains and shunting consists, but also needs to serve for temporary freight wagon storage. With the politically desired ongoing move towards rail transportation, the rail infrastructure will reach its physical limit sooner or later. Building additional trackwork is often only a theoretical option as in existing port structures there is usually simply not enough empty space available near the intermodal terminals as the connecting point between sea and rail transportation. This mandates an efficient usage of the existing trackwork in vicinity of or surrounding this point – the public port railway network.

In case of railway operations in port areas (big or small) alone, there is also a high demand of communication for data exchange between stakeholders. Figure 4, below illustrates schematically the various communication lines. Each line represents a specific information exchange.

Figure 4: Various communication lines in train operation at port area

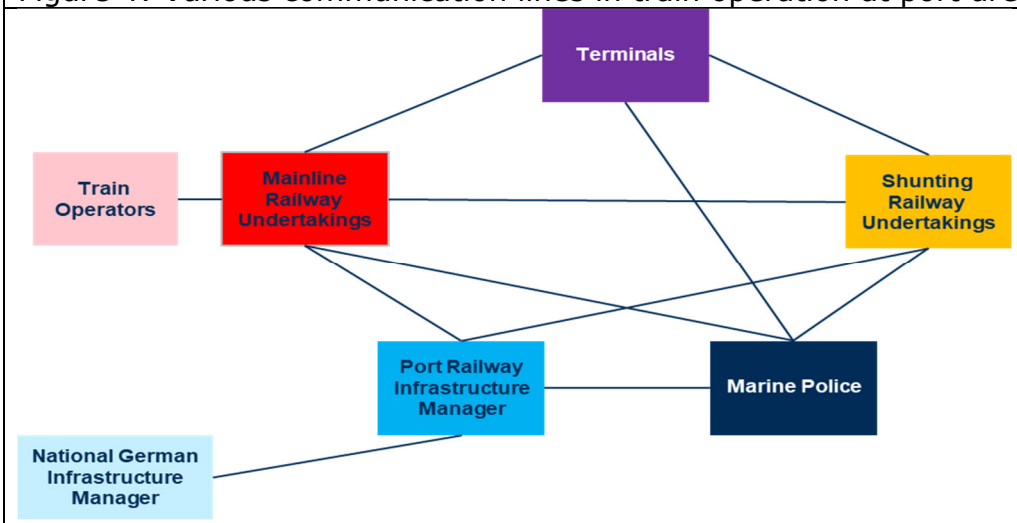
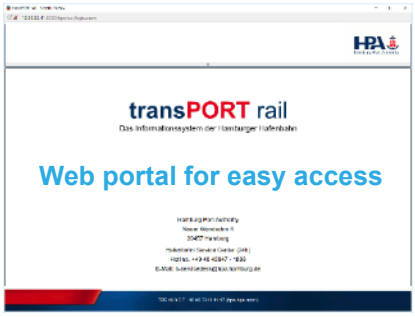


Figure: Communication needs by rail freight within the port area.

The larger both the port and the railway operations become the more the interdependency of these communications become visible. A high amount of rail freight also increases the data exchange frequency. Furthermore, it simply becomes a necessity that the different stakeholders synchronize their activities. This mandates that all roles need to get their information both fast and identically.

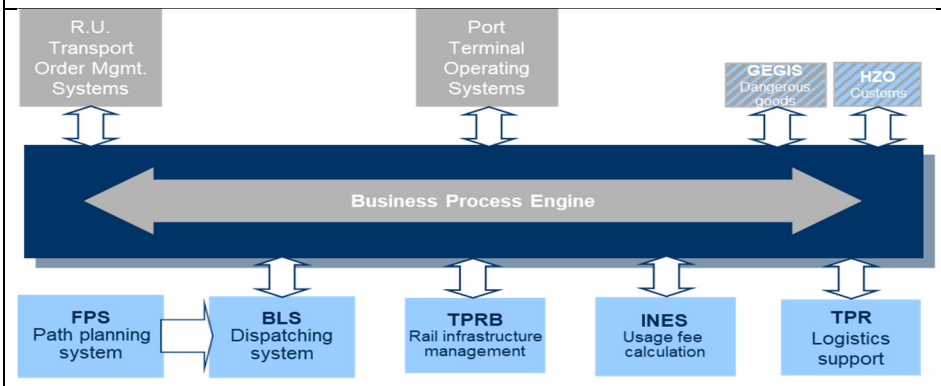
The Hamburg rail port community recognized this need and already sought for IT support about 30 years ago. As conclusion a central Rail Port Community System was established as an IT system and access made available to all stakeholders. The public port administrator (currently HPA) operates and maintains the system as a neutral organization.

The current generation has been operational since 2014 under the brand name “transPORT rail” (tPr). Even though the overall system relies mostly on data exchange via electronic data interfaces, it also offers a web interface for convenient access without technical access hurdles.



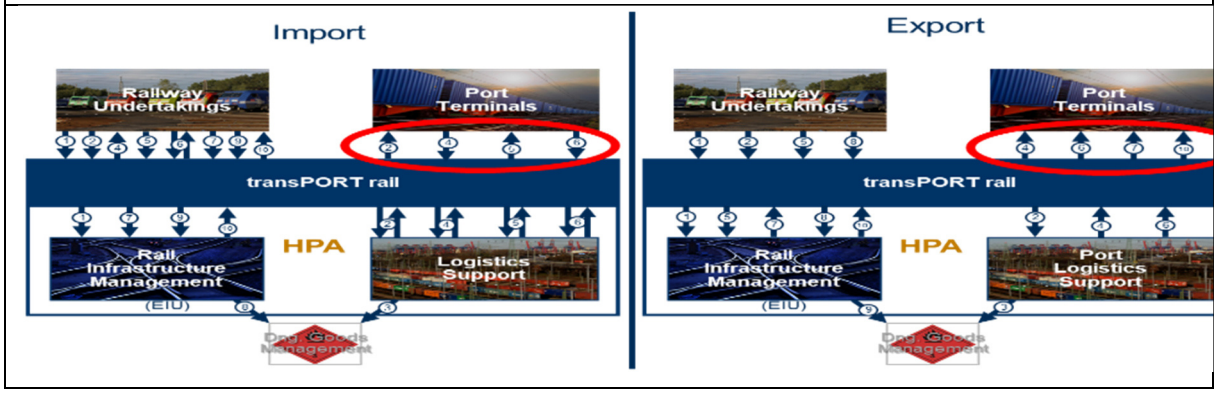
One of the core features is its modular design so that new stakeholders or systems can be connected without entirely rebuilding the system.

Figure 5: Modular IT concept



The success and efficiency of the system depends on a careful analysis of both the rail freight and the data exchange process.

Figure 6: Analysis of exchanged data (caption omitted)



Focus

The data exchange analysis is an ever-ongoing task which requires continuous observation of new logistical and technological trends. During such observation it became obvious that the data exchange between the rail operation and the intermodal terminal operation parts of tPr is not very detailed. It was concluded that further integration would lead to significant efficiency gains in overall rail freight transportation.

It became obvious that a standalone implementation would be far less efficient than expanding the already existing rail port community system tPr:

Firstly, many business objects relevant in rail terminal slot operations are already present.

Secondly, the technical data exchange with all stakeholders within the rail port is already established.

And thirdly, tPr usage is already implemented in the operational processes of all rail port stakeholders.

The scope of this pilot to integrate the slot plan data structure of multiple intermodal seaport terminals into the common rail port community system. Each terminal can still maintain their individual scheduling concept. Also, the slot process gets fully covered from initial application to final exact usage.

Beyond the addition of a new slot plan module to tPr, the pilot will also demonstrate connecting the slot business object with existing tPr business objects to leverage the efficiency gain from interlinking information.

Project Activity

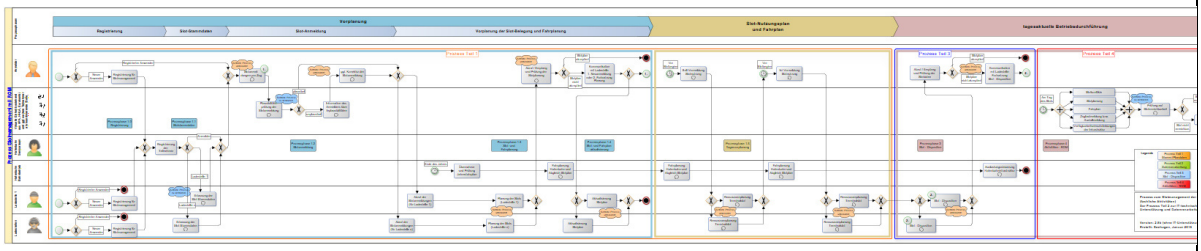
Analysis of the slot application process und slot plan structure of four major Hamburg intermodal terminals (also major seaport terminals) has been concluded. A combined data structure has been derived from this research. The slot plan below illustrates this as an example, see figure 7.

Figure 7: Slot plan structure - example

Terminal	Slot-ID	Weekday	Track	Start Time	End Time	ILU Type	#ILU Unload	#ILU Load

As all stakeholders are individual legal and commercial entities, it is important that the designed business process improves the overall rail freight process performance but also avoids negative impact by interference between roles. Thus, a combined business process has been designed which respects the key responsibilities and expertise of each involved role. It covers both yearly planning and day-to-day operations.

Figure 8: Combined business process for all roles



Afterwards a requirement description has been engineered for developing a new software module to be fully integrated with the existing tPr. This posed a special challenge as presently part of the technical tPr infrastructure in being rebuilt to address cyber security issues.

Additional care has been invested into the requirement scope to make sure that the pilot will be fully developed and reach software acceptance quality until March 2023.

Actual software development started in June 2022. During the programming phase, two technical previews were given to key experts from the tPr product management in order to achieve high practical relevance and usability. The software development company delivered both components of the software package in January 2023 for acceptance testing. This quality assurance activity is being carried out by HPA until end of February 2023.

8 FINDINGS AND EXPERIENCES ACROSS THE PILOTS

As the North Sea Connect project ran over a period that was heavily marked by covid-19 and a connected logistics challenges it became, during the project, clear that the connections between both small and large transport nodes are crucial to the wellbeing of the transport network. Despite this situation several findings and learnings can be drawn from the work that has been done in the five different pilots. The pilots shows that there is a richness of ideas and willingness to work with these initiatives in all the participating ports, companies, and organizations.

Themes of relevance for understanding the pilots and the ports' ability to interconnect in the North sea logistic structure are.

The size of operation:

There is a great variation in the size of the involved ports from Port of Hamburg and Port of Gothenburg that are large European ports to the medium and smaller ports of Oostende, Brussels and Vordingborg. However, despite the size difference there is an acknowledgement that a collaboration between parties is necessary and should be encouraged to achieve a smoother logistics in the NSR.

The level of optimization:

In the Port of Oostende, the Port of Brussels and the Port of Hamburg, the pilot initiatives are dealing with an optimization process that does not include new business areas or business ideas but rather utilizing the areas that are available in a more optimal way. In Brussels this is achieved through a consolidation process of building material that is forwarded by vessels all the way to where it should be used. In Oostende and Hamburg, the optimization processes are highly depending on digitalization and data sharing with the purpose of getting a better use of the railway in Hamburg and better utilization of a port area in Oostende.

The geographical position and interconnection of the port:

Among the five involved ports, the Port of Brussels is a dedicated inland port while the Port of Oostende, the Port of Hamburg and the Port of Gothenburg are mainly seaports but has connections to the hinterland through rivers and canals. While the Port of Vordingborg does not have inland waterway access it is an opportunity that could be reached.

The hinterland connection and its potential:

In the analyses made at the Port of Vordingborg and the Vordingborg area, there is a focus on how this port could include the companies in the port hinterland to initiate some initiatives that involve shipping opportunities in the European inland waterways. By doing this there may be some valuable insight that could be made by further knowledge sharing and interaction with the other pilots.

The pilot initiatives that have been done in the work package has all been focusing on strengthening the transport interconnection between different ports and between ports and their hinterland. This strengthening of interaction has proven to become of increased importance to external stresses to logistics networks, such as that caused by covid-19.