Seminar on Intermodal Autonomous Green Terminal in medium ports

Deliverable D10.6 - Version Final – 2023-05-31

Advanced, Efficient and Green Intermodal Systems

http://aegis.autonomous-ship.org/

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Final	OEM	2023.05.31	Final revision to be submitted to EC

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Executive Summary

This document reports the seminar on “Intermodal Autonomous Green terminal in medium ports”, which was held on April 18th, 2023, in Aalborg, Denmark.

The seminar in Aalborg was attended by 60 participants including 16 from the AEGIS consortium and summarized the general findings from the AEGIS logistical system and those related directly to WP10 and the Port of Aalborg use case. The seminar was organised under the following Agenda:

Port of Aalborg:	Presentation of the results on cargo-volumes with emphasis on Port of Aalborg.
SINTEF Ocean:	Introduction to the more general findings regarding the AEGIS logistical system.
AAU:	Presentation Presentation of the regulatory challenges for Short Sea Shipping in Denmark and around the Limfjord.
ISE:	Presentation of vessel designs that are applicable to the Aalborg Case
Kalmar:	Presentation of the concept of an automatic Green Intermodal Container terminal with interface to Rail and Ro-ro in Port of Aalborg.

DFDS, NCL and SINTEF: Short Q&A “How do we make it happen” – Moderated by Port of Aalborg.

It should be noted that this report only summarizes the seminar in Aalborg. Therefore, more specific details concerning the presented findings and material should be found in the public deliverables, which can be found the on the project webpage: https://aegis.autonomous-ship.org/

Definitions and abbreviations

IMO: International Maritime Organization

HGV: Heavy Good Vehicle

LoLo: Load on Load off

RoRo: Roll on Roll off

SSS: Short-Sea Shipping

TEU: Twenty-foot Equivalent Unit

1 Seminar on Intermodal Autonomous Green Terminal in medium ports

The seminar in Aalborg on Intermodal Autonomous Green Terminal was held in Port of Aalborg's (AHL) R&D facilities at Langerak 15, 9220 Aalborg Øst Denmark the 18th of April 2023. The seminar was organised as the main seminar in a two-day event, where the seminar D10.5 "Seminar on multipurpose terminals in small ports" was held the subsequent day, April 19th, 2023, in Vordingborg, Denmark. Acting as the main seminar for the WP10 use-case, the seminar also presented the AEGIS project as a concept and the general findings from the project relevant to the participating audience.

The seminars denoted "D10.5" [3] and "D10.6" had a combined attendance of 63 different participants (incl. 17 members of the AEGIS consortium) representing many different stakeholders and organisations within the transport and production industry. The participants were, besides AEGIS consortium members, e.g., local business and users of the port facilities and infrastructure, board members, municipalities, shipping companies, freight forwarders, the industry association Danish Ports and colleagues etc. The list of participating firms and organisations can be seen in this list in the annex: 1.7.1A.1. Participation firms & Organisations in the D10.6 seminar. Throughout this report, relevant slides from the presentations during the seminar will be inserted.

The seminar was organized as a series of presentations moderated by Jesper Raakjær (AHL) as the leader of WP10 and the Aalborg Use case more specific. The program had the following agenda:

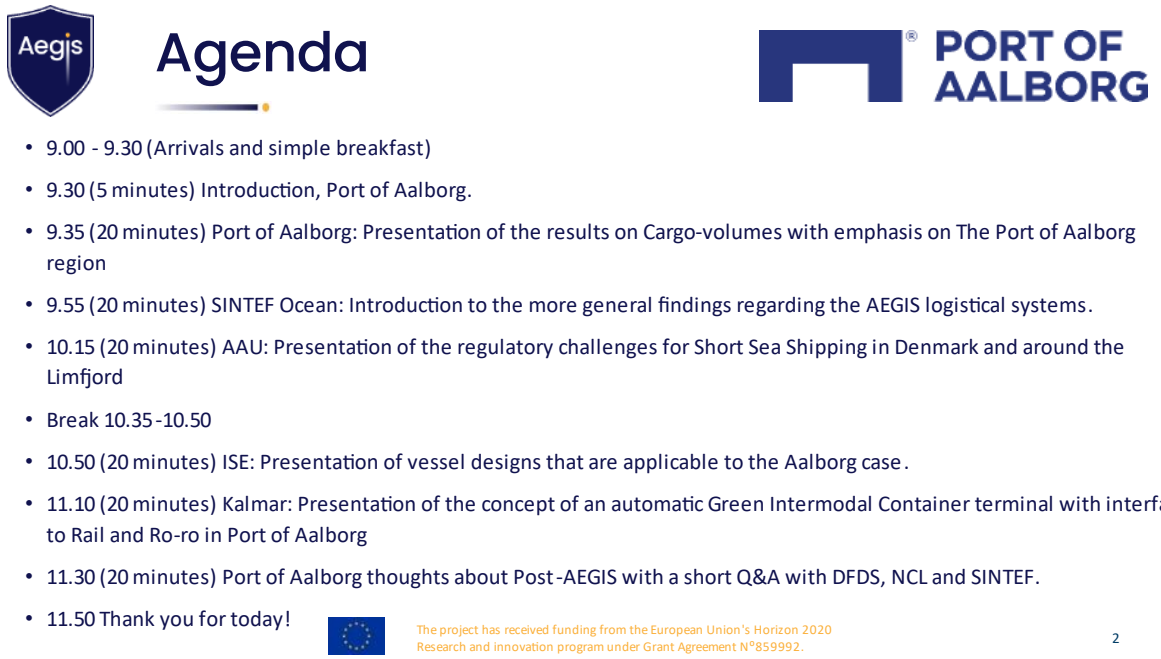

Figure 1 - Agenda

List of speakers:

- Jesper Raakjær, Port of Aalborg
- Jimmi Normann Kristiansen, Port of Aalborg
- Odd Erik Mørkrid, SINTEF Ocean
- Kay Fjørtoft, SINTEF Ocean

- Nelson F. Coelho, AAU
- Stefan Krause, ISE (Virtual, teams)
- Pia-Liisa Vuorela, Kalmar
- Christopher Saavedra, Kalmar
- Kenneth Johanson, NCL
- Kristoffer Kloch, DFDS

This document summarizes the most important points and arguments of each presentation from our viewpoint.

1.1 Introduction to the more general findings regarding the AEGIS logistical systems, SINTEF Ocean

Today, a significant challenge is the substantial contribution of transportation to the overall carbon footprint of supply chains. It is already possible to reduce this footprint considerably by using more maritime or rail transportation instead of roadgoing HGV transportation. However, the alternative transportation methods are hindered by an increased level of complexity when compared to point-to-point transport via HGV and require a different level of planning. The AEGIS projects aim to create new and more efficient solutions for this as well as improving the environmental performance of the intermodal transport solutions by introducing autonomous ships and highly automated ports.

To improve the intermodal transport system a series of action points are identified via the AEGIS project, all as part of a total solution to improve the general and the environmental competitiveness of the intermodal system.

1.2 Purpose built ships

Depending on the location of cargo and the amount present, different types of vessels are optimal for the specific context. Therefore, according to the use cases in this project a series of vessel concepts are defined in WP4.

Figure 2 – SINTEF Ocean key trends overview

Autonomy

Automation plays a crucial role in optimizing operations by introducing several benefits, some of which are the reduction of man hours and minimizing errors. This is particularly important in the maritime transport industry, where profitability is highly based on a margin-business model. In the context of this project, the focus is on automating terminal operations, crane operations, and ship operations. WP3 introduces a concept for terminal automation and a new design for onboard cranes, while WP4 discusses the automation of ship operations.

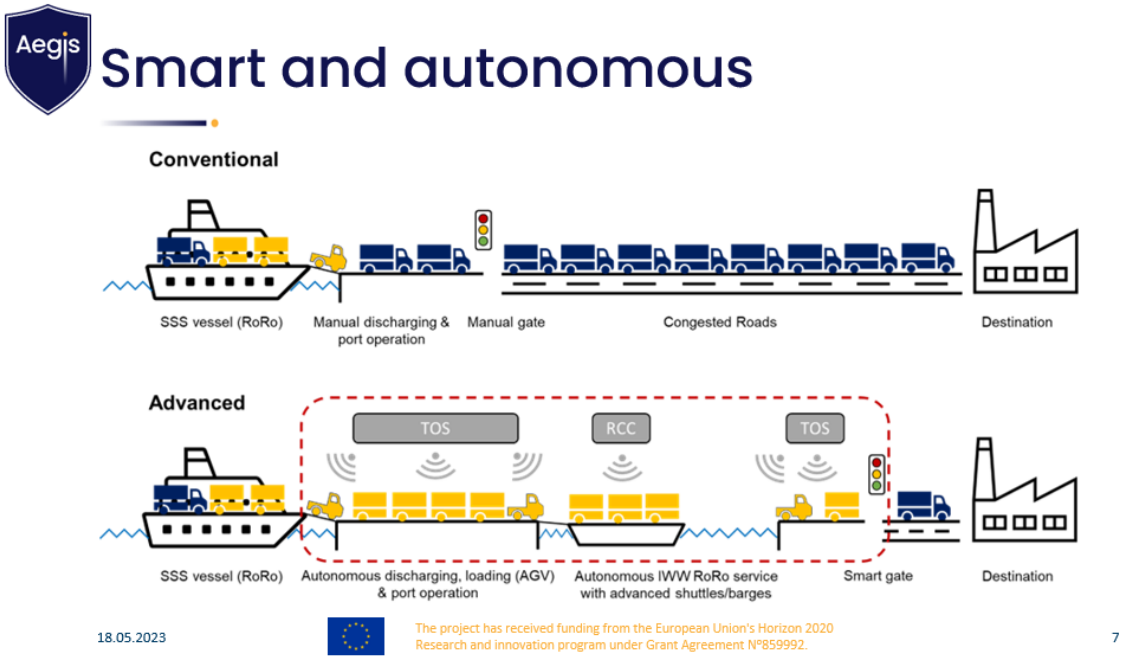

Figure 3 – Autonomous vessel concept illustration

- Digitalization of information flows and physical objects and activities
    - One of the major challenges of any supply chain is timely and correct information to plan and prepare operations. The need for effective information sharing increases as the complexity of systems increases as errors can multiply with each process step. WP5 aims at defining a series of standards, both technologies and communication protocols. One focus is the Maritime Single Window (MSW) as point of reference for what data should be exchanged, however it is very ship focused, and perhaps needs to be expanded with landside operations requirements.
- RoRo as an option for more flexible, less dense transport
    - In AEGIS RoRo is viewed as an alternative to container transport, as it requires less port side handling, and the number of cargo units for economical transportation is lower. AEGIS deliverables 10.1 *Potential transfer from road transport to short-sea-shipping in Denmark* [1] and 10.3 *Potential for calling the two Danish ports by DFDS* [2] have made extensive analysis on the feasibility of goods conversion as well as potential RoRo calls as part of AEGIS. In cases WP10 and WP8 RoRo solutions are designed.
- LoLo more handling of cargo
    - LoLo is better suited for high density consolidated cargo, as the transport cost are brought down by economies of scale.
- From congested roads and congested truck terminals to advanced optimized maritime transport
    - By combining the different concepts in the AEGIS project, it is possible to create a new more advanced, efficient, and environmental intermodal transport solution.

1.3 Presentation of cargo volumes with emphasis on the Port of Aalborg region, Port of Aalborg

One of the objectives of AEGIS is to shift mode of transport for cargo currently being transported by road, to more sustainable options. Therefore, road transport in and out of Denmark has been analyzed, as part of the use case, to determine how much cargo could potentially be shifted from road to sea in the region.

This has been conducted through detailed analysis of goods flows in European regions to/from Denmark.

It is found that the gross volume of goods that can be shifted in Denmark is approximately **5.000.000 tonnes/year**, after considering that:

- Price for Short-Sea Shipping should be on-par or lower than competing road solutions. SSS can be competitive with road on price, when the distance between load and unload region is higher than 150 km. This is due to the “starting cost” of the Short-Sea Shipping solution as well as last mile delivery; making road more competitive on shorter distances.
- For low-time-value goods, longer transport times are acceptable, and can be planned. Many customers are merely accustomed to very fast and flexible shipments, but do not necessarily see these as crucial parameters in their supply chains.
- High-time-value-goods (such as machinery and machine equipment) are unlikely to be shifted, as longer transport times are not acceptable.

The presentation included a comprehensive cost-structure analysis of short-sea-shipping vs. road transport solutions. This included different baseline scenarios, including analyses of different break-evens of solutions.

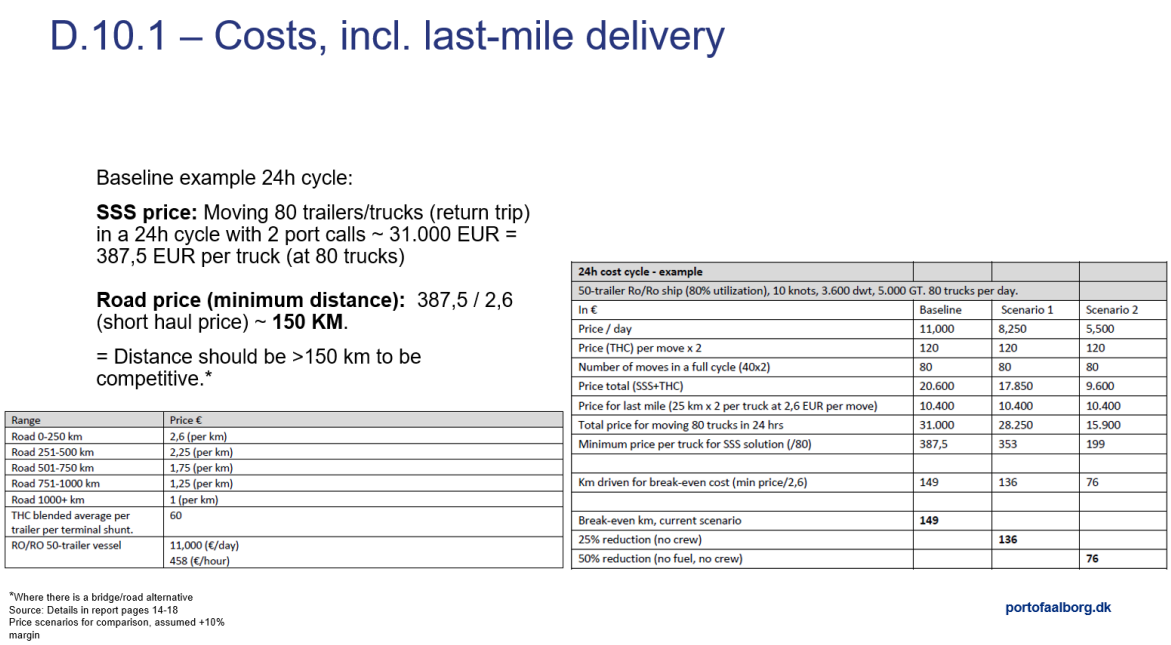

Figure 4 – Baseline Scenario for cargo volume conversion (economic considerations)

Similarly, the presentation also reported on the thresholds economics in developing a RoRo call to the port of Aalborg, concluding that a RoRo vessel concept as discussed in AEGIS would need 2 weekly calls in order to be financially viable (for all parties). The confidential deliverable in D10.3 [2] had carefully analyzed the business models and revenue models of the terminal operator, the vessel operator as well as the port authority to reach this conclusion. In extension, the calculations show that autonomous vessel and port call concepts become more financially viable at scale, due to higher capital expenditure (investments) for autonomous solutions.

1.3.1 Goods in the Port of Aalborg Region

The Port of Aalborg case has also analyzed the goods flows to/from the Region of North Jutland (the Danish region in which Port of Aalborg is Located). The analysis included a detailed regional analysis of the goods flows and referred to the findings made in D10.1 [1] and D10.3 [2].

The reports included a filtering (reduction) model to identify the goods types with the highest likelihood of conversion from road to Short-Sea Shipping (based on speed, flexibility, the time-value of the goods) and concluded that national goods (between North Jutland and Zealand (where Copenhagen is located) was equivalent to roughly 117.540 tonnes per year. The international goods to/from Northern Jutland and the total conversion potential was roughly 550.000 tonnes per year. This was built on previous findings in the reports which can be seen in the illustrations below.

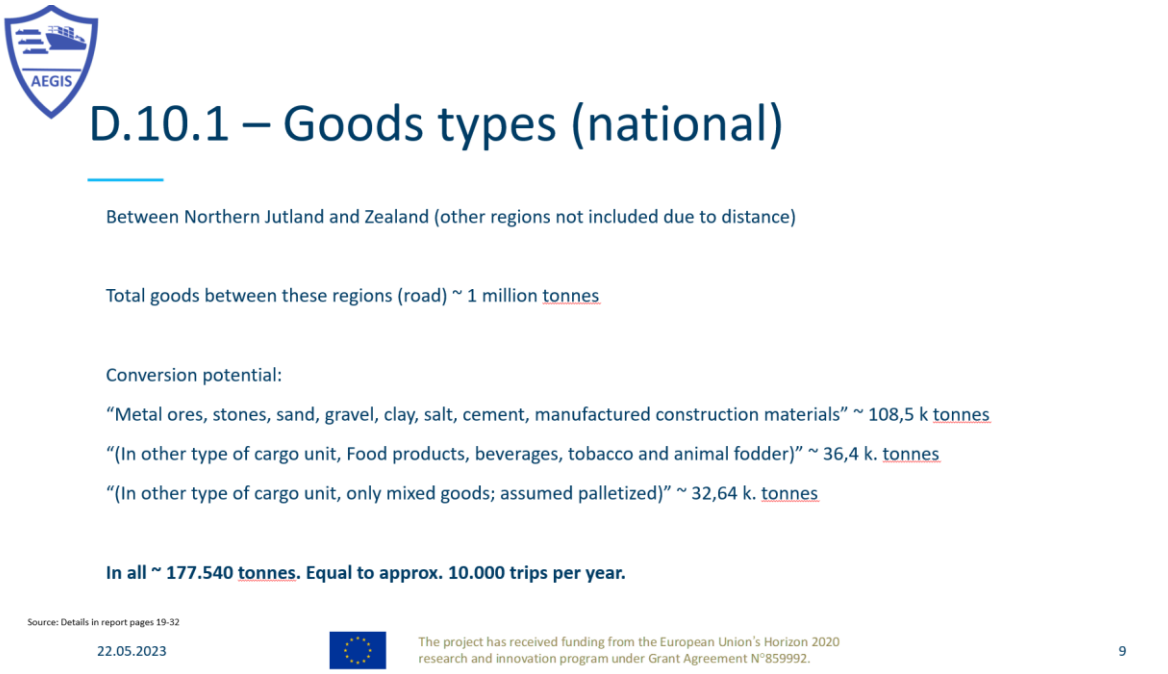

Figure 5 – National Goods Conversion Potential to Northern Jutland

From DK050 to ALL	tonnes	movements
DE	284.849	13.929
SE	256.712	11.036
PL	145.373	9.619
NO	140.949	7.414
NL	33.596	1.630
Other	82.697	3.871
Total	**944.176**	**47.499**
20%	188.835	9.500
30%	**283.253**	**14.250**
40%	377.670	19.000
(Movements at 30% /day)		**39**
From ALL to DK050	**tonnes**	**movements**
DE	311.811	17.116
SE	170.260	8.839
PL	261.896	15.369
NO	56.224	2.387
NL	41.113	2.645
Other	47.822	2.705
Total	**889.126**	**49.061**
20%	177.825	9.812
30%	**266.738**	**14.718**
40%	355.650	19.624
(Movements at 30% /day)		**40**
Grand Total (in-out)	1.833.302	96.560
20%	366.660	19.312
30%	**549.991**	**28.968**
40%	927.661	38.624
(Movements at 30% /day)		**79**

Figure 6 – International Goods Conversion Potential to Northern Jutland

In all, the goods flow and economic analysis of the potential gross transfer of goods from road to short sea shipping in Denmark concluded that there is good potential for goods conversion in terms of volume, as well as finding a competitive financial model for securing competition between the two transport modes.

1.4 Legal challenges to implement AEGIS in Denmark: a focus on the Limfjord, AAU

The project has introduced autonomous vessel concepts as part of the AEGIS logistical system. Legal challenges exist at the international level for autonomous ships, as the IMO regulates ship specifications, and the IMO is currently working on identifying different obstacles depending on autonomy levels. A key aspect for applying AEGIS vessels and take part in the European transportation system in the future is, therefore, the legalization of the concepts by the IMO.

Hence, challenges for introducing advanced autonomous vessels exists at a global level and is not something member states of the IMO can solve alone. However, there are two possible "transit" solutions:

- In national waters, member states can establish official waterways, e.g. coastal or inland waterways, where local bodies can govern by a different framework and ships can navigate under different and more flexible conditions. In these locally governed waterways, new technology such as autonomous vessels can be introduced on test-based conditions. Denmark currently doesn't have official waterways. The Limfjord, where the Port of Aalborg is located, contains the geographical conditions to be categorized as an inland waterway.
- In regional waters, coastal and port states can establish a bilateral agreement, that can facilitate navigation under different conditions than those regulated by the IMO.

Figure 7 – Legal challenges overview

1.5 Vessel Design for the Aalborg Case, ISE

ISE has developed several concepts for low-emission autonomous vessels, suitable for the AEGIS use cases. In the Port of Aalborg use case, the following routes are being considered:

- RoRo route between Aalborg and Gothenburg (approximately 90 nm)
- Ro-Ro connection from Aalborg to Copenhagen (approximately 135 nm)
- Aalborg to Brevik (approximately 150 nm)

Two different Ro-Ro concepts have been developed; one for the short connection to Gothenburg, powered by swappable battery units, and one for the longer connections to Brevik and Copenhagen, with a propulsion system based on (bio)-methanol. Both concepts have a capacity of 55 trailers and a medium autonomy level (Degree 2-3 on IMO's scale for autonomous shipping), which includes a route optimization system and automated mooring systems. These ship concepts align with the scenarios analyzed and discussed as part of D10.1 [1] and D10.3 [2] (with a 50-unit baseline, with different utilization rates). The characteristics of these concepts can be seen in the following figures.

Figure 8 – RoRo vessel concept 1

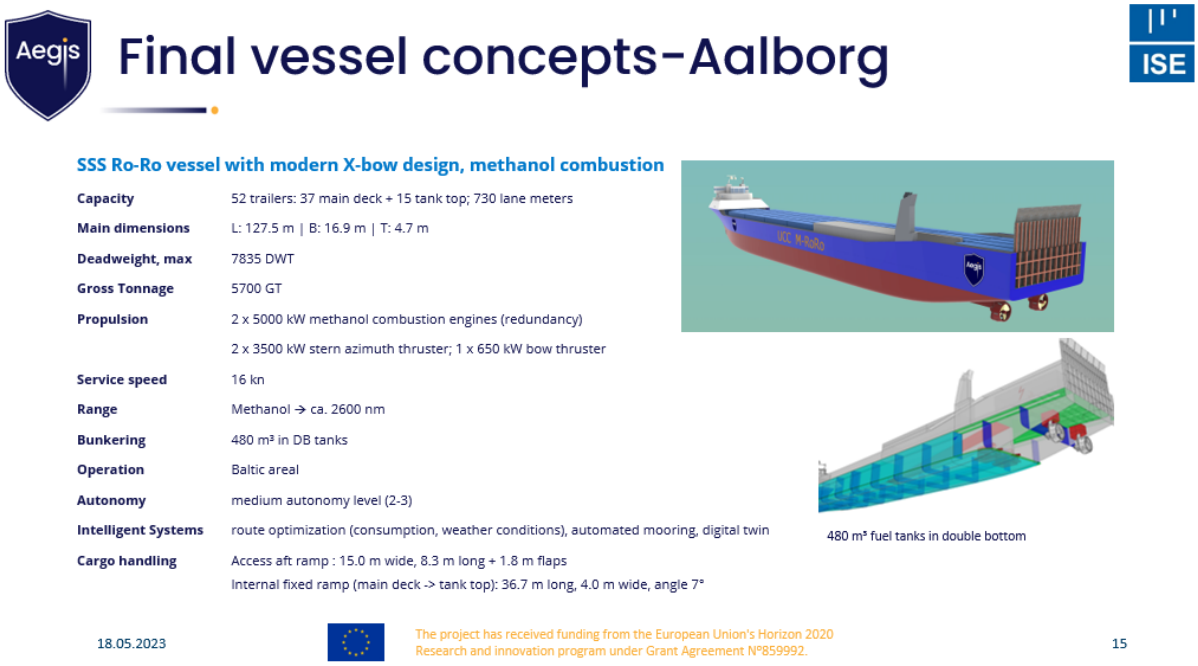

Figure 9 – RoRo vessel concept 2

Besides the Ro-Ro concepts, ISE has also developed a concept for a methanol powered SSS container vessel with a capacity of 1.100 TEU, on board cargo handling equipment, and an autonomy level of 2, which could potentially be used for the routes. Furthermore, a concept for a fully electric, highly autonomous self-propelled shuttle with a capacity of 100 TEU has been investigated, to handle last-mile delivery of cargo from, and to, terminals on the Limfjord.

1.6 Terminal yard automation study for Port of Aalborg, Kalmar

For a terminal to become more efficient both operationally and environmentally it is necessary to find new solutions and new equipment. The focus by Kalmar is on electrified equipment and autonomous processes. Because of the high congestion in larger ports a new focus area is on smaller ports, and how to create an economical and environmental solution here, as a method to bring down road-based congestion in Europe in general. According to Kalmar, there are several smaller terminals in the landscape, so there is potential for substantial growth in this segment.

- Terminal Layout
    - Kalmar has proposed a new terminal layout for the Port of Aalborg based on a future number of containers, derived from a Port of Aalborg growth plan. 75.000 TEU is the yearly capacity for the layout.

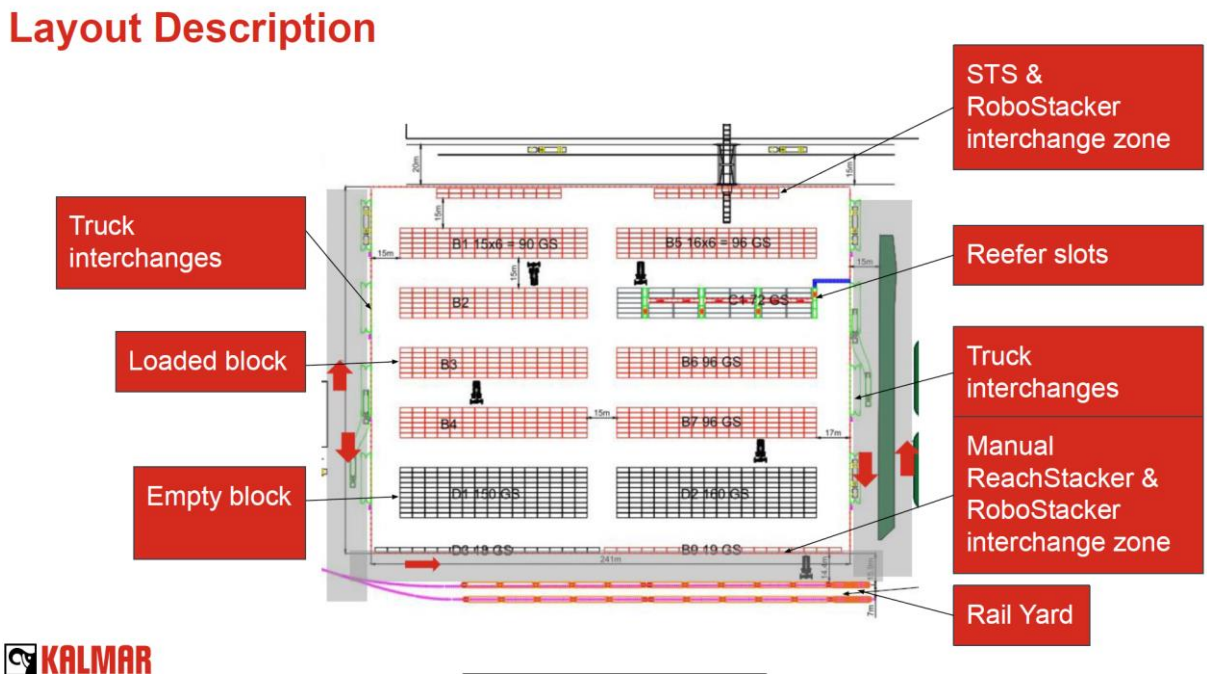

Figure 10 – Kalmar technical layout of Port of Aalborg Container Terminal

- The layout focuses on isolating the automated area from all other activity, this is to ensure that the autonomous control system is aware of all objects in the fenced area and is able to act accordingly.
- The interface between the terminal and the outside is based on booths for the trucks, where the chauffeur must exit the vehicle and green light the terminals control system for pickup.
- The physical dimension of the terminal is also optimized for autonomous operation and all corridors are at least 15 meters wide. Empty containers are placed in storage in the back of the terminals, reefers are placed near the front. The other container

stacks are for normal dry cargo, and placement in each of the stacks are based on priority parameters of each container.
    - The rail yard is operated manually, and the reach stacker here places and takes container from marked fields on the opposite side of the fenced area.
    - The crane is fed by the robo-stackers servicing the terminal.
- Equipment
    - Firstly, it is proposed to invest in electrically powered stackers, which will be upgradeable to autonomous driving as the technology matures. The launch of autonomous driving is expected to coincide with the fulfilment of the growth plan. For 75.000 TEU it proposed to invest in 6 robo-stackers, for serving gate, vessel, and terminal. In the leadup to the fulfilment of the growth plan a lower number of robo-stackers (3) will be commissioned when available.
    - Currently the STS crane is not in operation, and mobile cranes are used instead. This is because the current STS crane is old and requires a lot of maintenance. However, if the growth plan is met, there will be an investment in a new STS crane that lives up to the requirements proposed by Kalmar.

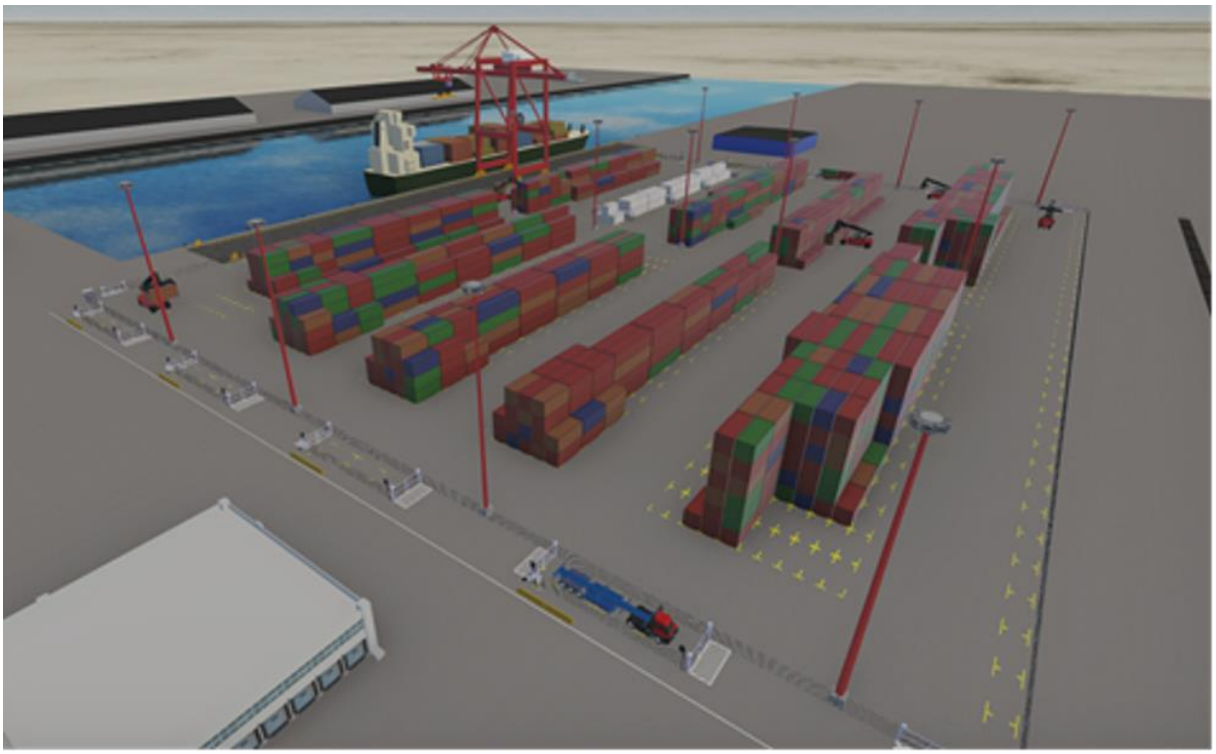

Figure 11 – Visual illustration of the terminal concept, courtesy of Kalmar

- Simulation
    - The terminal design and equipment configuration have been validated through a series of simulations of different scenarios, which have led to the recommendation of the presented setup. These simulations were performed by Kalmar, as a contribution to the AEGIS project, WP3 and WP10.

1.7 Conclusion: Intermodal Automatic Green Terminal in a medium port - Aalborg

Port of Aalborg are pursuing the findings from AEGIS (Convertible goods and the new terminal design/setup) in their strategy. The slides below summarize the ambitions and strategic goals for Port of Aalborg in the upcoming years.

Figure 12 – Visual overview of complete future terminal operations at Port of Aalborg

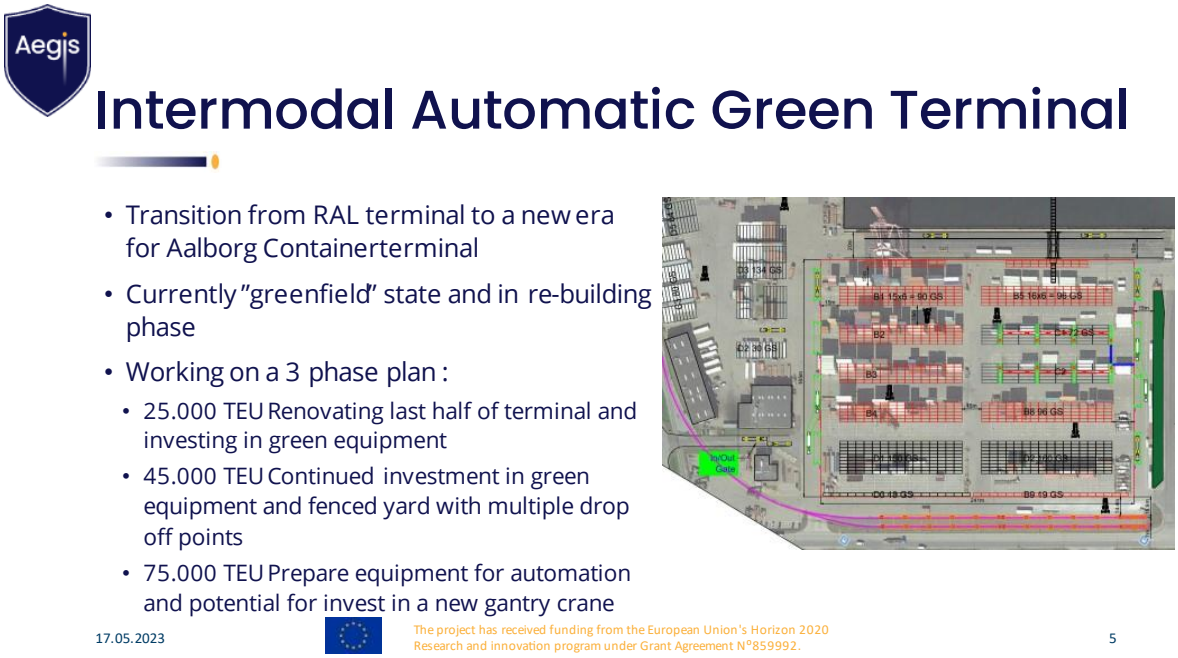

Figure 13 – Overview of Port of Aalborg core terminal layout and functional considerations

1.7.1 Remarks from the Q&A:

- When you want to substitute a truck, RoRo is a quite good reaction to it since, you do not necessarily need to change the freight mode as such. When you start doing containerized shipping, it requires a little more, the cost might go up in transshipment on and off vessels and then you have to move it on trucks. When looking into the operating expenditure of LoLo and RoRo, the RoRo looks like the immediate solution to move goods from road to SSS.
- If the container setup is already established as a form of transport between two regions, this is usually cheaper.
- The technology behind autonomy is becoming ready to initiate new transport solutions. Is reliant not only about the ports or vessels, but the transport system in general if we want to solve the problems that are facing us with sustainability, C02 emission goals and road congestions.
- A key finding in the project is that the stakeholders in the logistical system need to work together to develop solutions that could benefit the whole value chain in the transport system. To look into the individual needs and obstacles and figure out how new building blocks like autonomy, green fuels, new vessel types and moving more cargo by the sea can assemble the transport building blocks in a different way.
- The established routes today (RoRo and LoLo) would probably depend on the fuel supply in ports in the future, making today's routes potential exposed for changes in the future. If ports could provide fuels green-corridors, they could be very important as hubs in the future.
- Public funding needs to go ports and maritime development. Concurrently, the stakeholders need to address this to decision makers in order to push this development.
- New imposed tariffs on e.g., trucks may highly favour new short-sea-shipping solutions. The work group working on D10 and D9 has conducted sensitivity analyses demonstrating that roughly 10% increases in KM/€ pricing has a huge impact on the overall financial feasibility of the scenarios considered.

References

[1] AEGIS 859992 D10.1 Potential transfer from road transport to short-sea-shipping in Denmark, May 2021

[2] AEGIS 859992 D10.3 Potential for calling the two Danish ports by DFDS, November 2021

[3] AEGIS 859992 D10.5 Seminar on multipurpose terminals in small ports, May 2023

Annex A. Participants of the D10.6 seminar

This annex contains the list of participants of the D10.6 seminar.

A.1. Participation firms & Organisations in the D10.6 seminar

Port of Aalborg A/S	www.portofaalborg.dk
Danske Havne	www.danskehavne.dk
Loxam	www.loxam.dk
Royal Greenland	www.royalgreenland.com
Keflico	www.keflico.com
Unifeeder A/S	www.unifeeder.com
Protruck A/S	www.protruck.dk
Aalborg kommune. By & Land	www.aalborg.dk
Imerys Industrial Minerals Denmark A/S	www.imerys.com
Mollerup Mølle	www.mollerup.dk
Homerunner	www.homerunner.com
Eimskip Denmark A/S	www.eimskip.com
Blue Water Shipping A/S	www.bws.dk
Nordlux A/S	www.nordlux.com
Ancotrans	www.ancotrans.dk
DHL Global Forwarding	www.dhl.com
Hedegaard A/S	www.hedegard-as.dk
ITW Performance Polymers	www.itwpp.com
BMC Danmark	www.bmc-danmark.dk
Ocean Network Express	www.one.dk
DB Cargo Scandinavia	www.deautchebahn.com
Ambolt AI	www.ambolt.io
ShipCargo	www.shipcargo.dk
Dancontainer	www.dancontainer.dk
Nordjysk Transport Klub	www.nordjysktransportsklub.dk