Revolutionizing short sea shipping

Positioning Report

Magnus Gustafsson
Tomi Nokelainen
Anastasia Tsvetkova
Kim Wikström

Åbo Akademi University

Åbo Akademi

PBI RESEARCH INSTITUTE

fimecc

Revolutionizing short sea shipping

Positioning Report

Åbo Akademi

PBI RESEARCH INSTITUTE

fimecc

Executive summary

Shipping in the Baltic Sea forms an essential part of Finnish industry. At present, the utilization rate of bulk and general cargo ships serving Finland is under 40%, and the old-fashioned routines in ports lead to ships sailing at non-optimal speeds and thereby to unnecessary fuel consumption. Lack of transparency and coordination between the large numbers of actors in logistical chains is the key reason for inefficiencies in sea transportation, operations in ports, and land transportation. Addressing these inefficiencies could increase the competitiveness of Finnish industry, and, at the same time, create a basis for significant exports.

By changing the business models and ways of working it would be possible to lower cargo transportation costs by 25-35% and emissions by 30-35% in the dry bulk and general cargo logistics in the Baltic Sea area. Moreover, it would be possible to transport cargo in smaller consignments and with greater scheduling flexibility without increasing overall transportation costs. With the introduction of this new logistical solution, a share of road transportation could be replaced with sea logistics. This can be achieved by carrying out the following measures:

- Establishing transparency in the short-sea freight market by introducing an electronic freight marketplace that would enable industrial cargo owners to transact directly with ship operators, bring visibility to the freight market, and enable both parties to adapt their operations to the supply and demand in the market.
- Establishing real-time integrated production and logistic planning to ensure optimized just-in-time freight throughout the logistic chain.
- Introducing a new cargo handling concept developed by MacGregor that reduces turnaround time in ports, maximizes cargo space utilization, and secures cargo handling quality.
- Employing a performance-driven shipbuilding and operation business model that ensures a highly competitive ship by keeping world-leading technology providers engaged throughout the lifecycle of vessels.
- Implementing new financing models that integrate institutional investors with a long-term investment perspective in order to reduce the cost of capital and put the focus on competitiveness.

These innovations would create significant added value throughout the system by increasing asset utilization and making sea logistics strategically more relevant, with industry as one of the primary beneficiaries. This would also lead to several opportunities, on which companies could capitalize by, for example, identifying the potential for cost savings, capitalizing on emission reductions, optimizing the logistic process, developing their offering or increasing sales. Municipalities and ports could increase the competitiveness of companies in their area by organizing the effort among local companies to coordinate cargo flow.

Acknowledgements

We would like to thank the European Maritime Safety Agency (EMSA) for providing the historical data on ship movements and port calls that was utilized to analyse inefficiencies in short sea shipping within the Sulphur Emission Control Area (SECA), including the Baltic Sea and North Sea. We also want to express gratitude to the Directorate-General for Mobility and Transport (DG MOVE), the Finnish Transport Agency and the Finnish Ministry of Transport and Communications for their assistance in obtaining this data.

We wish to cordially acknowledge the financing that was provided by FIMECC (Finnish Metals and Engineering Competence Cluster) within the REBUS ('Towards Relational Business Practices') program, Project 2 'Logistics Networks' and Tekes (Finnish Funding Agency for Innovation) within the RECO ('Redesigning Ecosystems') project.

This report is based on the results of on-going research being conducted in close collaboration with companies participating in the REBUS P2 project: Meriaura, MacGregor, Napa, Nordkalk, and Rauma Marine Constructions. We specifically acknowledge the significant input made by Napa Oy in analysing the data and working on the calculations utilized in this report and would like to thank Jouni Salo and his team. The analysis and visualization of calculation results made by Víctor Sifontes Herrera and Anu Keltaniemi from Åbo Akademi University is highly appreciated. We are also grateful to our collaborators from the Global Projects Center at Stanford University and from the Center for Research, Technology and Innovation at Kellogg School of Management, Northwestern University.

Table of Contents

Executive summary ... 2
Acknowledgements ... 3

1. Introduction: Über of the seas ... 6

2. Current inefficiencies in short sea shipping and their business impact ... 8

3. Competitiveness through a new short sea shipping solution ... 12
3.1. Increased freight market efficiency through transparency ... 12
3.2. Dynamic and integrated production and logistics planning ... 12
3.3. Efficient cargo handling ... 13
3.4. Performance-driven shipbuilding and operating ... 13
3.5. Sustainable financing and governance for system renewal ... 14

4. Key enabling innovations for the solution ... 16
4.1. Electronic freight marketplace ... 16
4.2. The MegaUnit ... 17
4.3. The ‘barebones’ port ... 18
4.4. Real-time voyage execution ... 18

5. Conclusions and actions for implementation ... 20
5.1. Conclusions ... 20
5.2. Actions for implementation ... 20

1 Introduction: Über of the seas

The new emission regulations within the shipping sector have created a need and an opportunity to renew the logistics chain in the Baltic Sea. Could an 'Über of the seas' type of a concept be the answer? Why is the Über transportation concept interesting to compare with? Über revolutionized the traditional taxi transportation concept by creating a new, more transparent marketplace, which is more efficient and provides a better service for a significantly lower price. It also, importantly, created a more relational approach that has a friction-free way of interacting. Moreover, by having a two-way feedback, it created a system that continuously strives to improve its performance. Another interesting factor learned from Über is the extensive resistance from existing structures and organizations, where many of the lock-ins have made the implementation troublesome yet successful from a global perspective.

On a global scale, logistics and energy are the largest sectors in terms of investment, and these sectors also play a vital role in improving the international competitiveness of Finland. The logistics and energy sectors are also the biggest producers of greenhouse gases, enabling new innovation opportunities for Finnish clean-tech companies.

In the European Union, Finland is considered a pioneer in marine engineering and an innovator in seaborne logistics. The arctic conditions during the winter months combined with Finland's need to ensure competitive logistics due to the geographical location of the country, create an ideal testing environment. Thus, the formula is simple: after creating a comprehensive new short sea shipping concept that works in the Baltic Sea, the same concept can be scaled up for the global market.

In this report we present how the 'überization' of short sea shipping can be done.

Our vision is to create the highest-performing, most environmentally friendly short sea logistics system in the world. For several years, we have researched and developed a system for short sea shipping and the related land logistics. The goal is ambitious, as the starting point is to modernize not only technical systems in complete logistical chains, but also organize and lead them in conjunction with managing the corresponding information flows. The result of the development work is a new industrial ecosystem with enhanced productivity and profitability, as a result of Finnish technical, organizational and financial innovations.

2 Current inefficiencies in short sea shipping and their business impact

Current logistics solutions in short sea shipping are not efficient. For example, low vessel utilization and long port call durations are unmistakable evidence of the fact that the current way of organizing the logistic chain is inevitably outdated and in need of reform.

These inefficiencies mean a direct waste of capacity that could have been used to generate economic value – a service for system customers. As a result, all the system stakeholders suffer. For example, in the end industrial customers have to pay for the unused capacity as well, while owners of the system assets such as ship owners earn unsatisfactory profits due to low asset utilization.

One of the central reasons for inefficiency is the high number of actors involved in the transportation chain. To be precise, at worst, more than 15 different organizations are involved in the export or import of a foreign trade cargo from the point of origin to the final destination. Such a multitude of actors in the transportation chain translates into an equally high number of profit margins, all of which are included in the freight rate paid by the system customers – either directly or indirectly. Briefly, such a lengthy series of involved actors means increased shipping costs due to a serialized margin on margin, and a multiplication of risks.

The high number of actors also obstructs the flow of information in the transportation chain for at least two reasons. First, every organizational interface means a delay and a possible obstacle – due to human or technical reasons – for information transmittal. Thus, a high number of organizational interfaces implies large delays and a high probability of a breakdown in the flow of information. Secondly, sometimes withholding information is in the best interests of some of the actors in the chain. Cargo brokers who earn their living through consolidating and withholding information constitute a good example. Moreover, sometimes not notifying about a delay, for example, may be economically advantageous for an individual actor such as a ship operator, even though the system as a whole suffers because of the lack of this piece of information.

In any event, incomplete information restricts the system stakeholders' and especially the cargo owners' possibilities of analyzing their actions after the actual shipment, and therefore prevents them from understanding the reasons behind any of the unpredicted additional costs and delays in the process.

More importantly, the lack of transparent and timely access to relevant information has led industrial customers to consider sea logistics as a 'black box', which is largely impossible to affect, and whose efficiency or inefficiency cannot be really ascertained. In other words, currently, sea logistics is by and large detached from operation planning in industrial organizations, and treated as an isolated function of its own. This, in turn, means that it is not possible to create optimized door-to-door logistical chains that would be tightly integrated with production processes.

Such lack of integration between sea logistics and production processes, and the corresponding unavailability of information also means that the ship operators, in turn, have a limited ability to plan their operations so that vessels would be maximally utilized. This leads to low vessel utilization which, in turn, translates into unnecessarily high freight rates and emissions. Both of these could be avoided if ships' routing is done with better advance information. As evidence of this, the bulk and general cargo vessels in the Baltic Sea sail on average 34% of their sailing time in ballast without a cargo[1]. As illustrated in Figure 1, more than half of the vessels sail empty at least 40% of their sailing time.

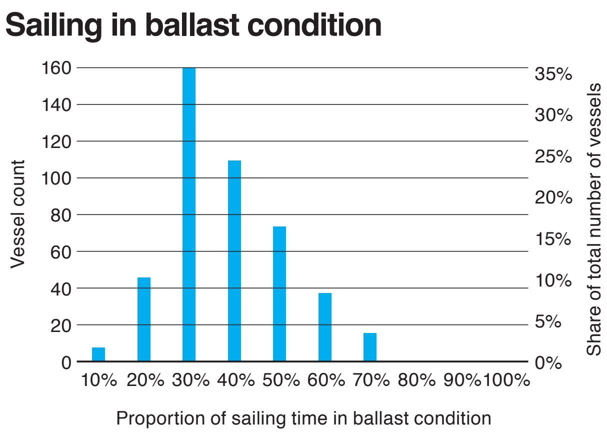


Figure 1. Distribution of dry bulk and general cargo vessels according to the share of ballast sailing time in total sailing time.

[1] The original data was provided by the European Maritime Safety Agency and is based on AIS and PortPlus notifications for the period 1.1.2013 to 31.12.2014, covering the Baltic Sea and the North Sea (including the English Channel). This data was further filtered to focus on 472 bulk cargo vessels under 10,000 DWT that called on a Finnish port at least once during the specified period, and calling, at least, 80% of the times at a SECA port. This sample constitutes the basis for sea voyage and port time related figures in this report.

Furthermore, about half of the vessels in dry bulk and general cargo segment operating in the Baltic Sea currently spend at least 40% of their time in ports (see Figure 2 below) – and most of this is time not spent creating economic value and earning revenue. This is also evidence of informational failure. Namely, in many Baltic ports, there is no clear slot system that would allow booking in advance a certain time for the vessel to arrive, load or unload, even if the arrival of a vessel is known days before and could be targeted with accuracy during sailing.

Time spent in ports

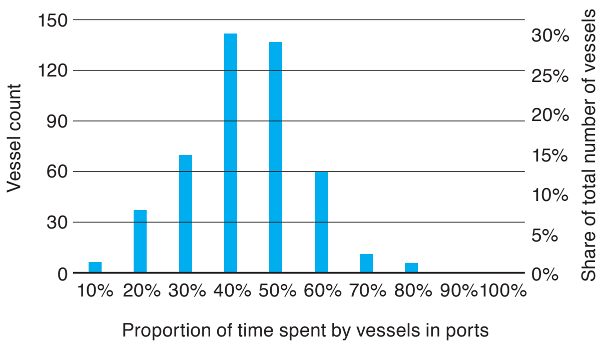


Figure 2. Distribution of dry bulk and general cargo vessels according to the share of time spent in ports.

Instead, vessels often rush because of the 'first come, first served' slot allocation system, wait in the resulting queues, and then idle while waiting for permission to enter port, stevedoring and other shore side services. As it can be seen in Figure 3, in the example voyage, the speed is increased from 8 knots to around 11 knots when the vessel ends its voyage and approaches a port, and then the vessel waits for around 31 hours in anchorage area to enter the port.

Speed profile of an example voyage

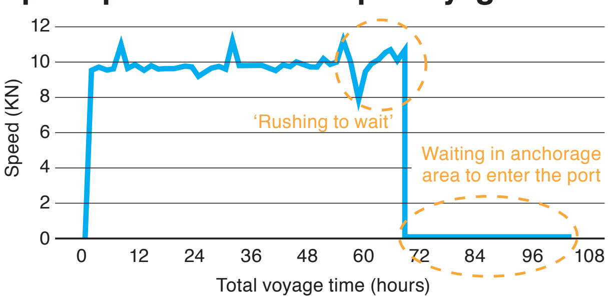


Figure 3. A typical 'rush to wait' sailing speed profile in the Baltic Sea[2].

Inevitably, such practices result in suboptimal sailing and excessive fuel consumption with the consequent emissions ('rushing to wait') as well as an underutilization of the system capacity.

Another contributing factor to the high proportion of time vessels spend in ports is the slow cargo loading and unloading process, during which the vessel must currently remain present. Indeed, it is not uncommon that unloading, cleaning, and loading – i.e. the port turn-around – of a typical bulk and general cargo vessel takes two days or more. This is by and large a result of using outdated technology.

A central reason for the lack of technological innovation is the decision-making process in shipbuilding, which is biased towards minimizing the initial capital expenditure instead of a more holistic consideration. Such a holistic consideration would see the ship as a business case, where both the initial investment and the earning during the life cycle of the ship are given equal emphases. Deficiency of information when predicting vessels' operating profiles and the impediments to their full utilization during operations are the major reasons for the reluctance of ship-owners to invest in more technologically advanced ships.

Another problem caused by the disconnectedness of activities during ship design and construction from the operations can be seen in suboptimal design of vessels. For example, most vessels operating in the Baltic Sea are designed for higher power output and optimal speed than they normally need for sailing. Figure 4 illustrates this divergence between design speed and actual average sailing speed. As it can be seen from the figure, around 70% of vessels on average sail at speed that is 15–25% below their design speed. This can be partly explained by the need to sail in ice conditions. In such a case, a bigger engine is usually installed. However, there is a number of power and propulsion solutions that allow complying with ice class regulations while installing the main engine suitable for the actual sailing speeds.

[2] The figure is based on historical data obtained from the European Maritime Safety Agency for a voyage between Sillamäe, Estonia and Lübeck, Germany.

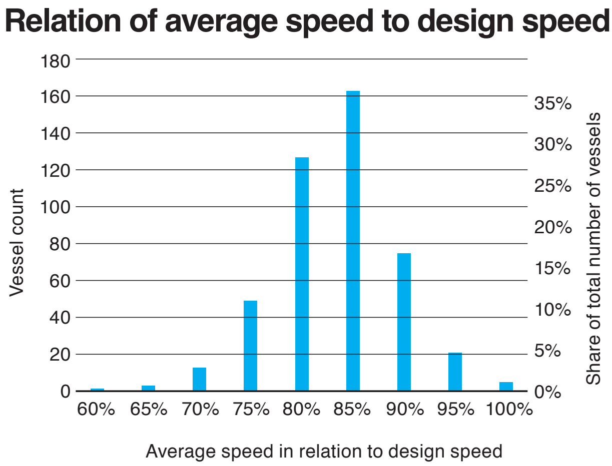


Figure 4. The divergence between vessels' design speed and actual sailing speed in the Baltic Sea area (based on sailing speeds during 2013–2014).

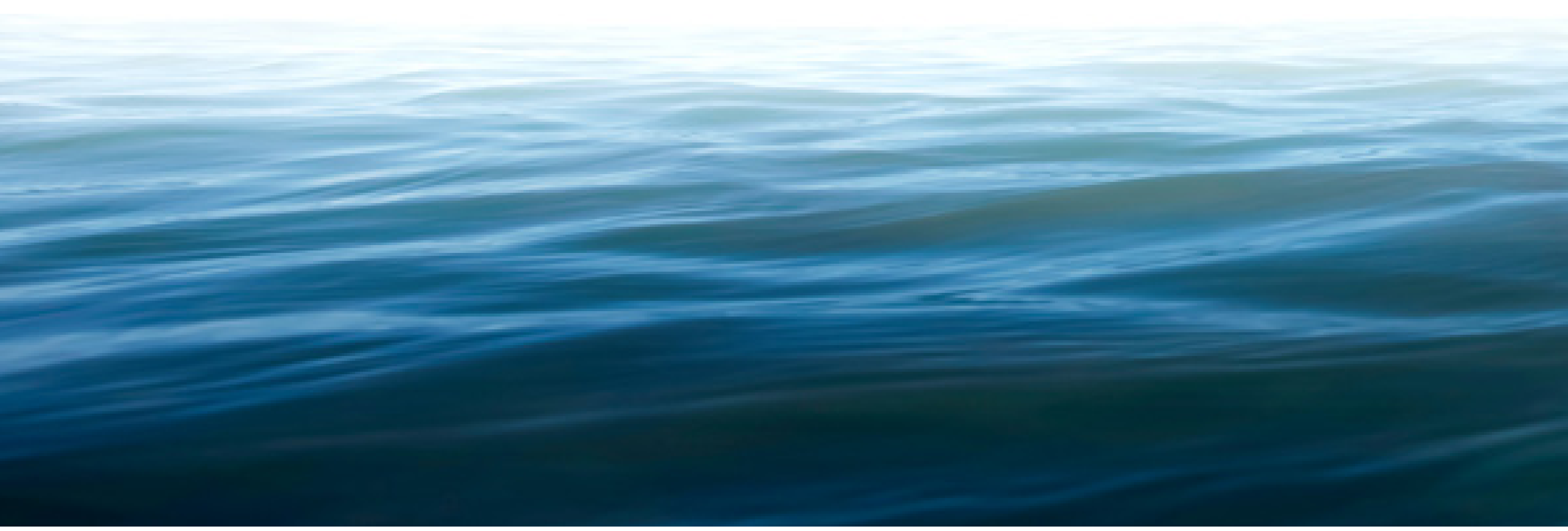
As shown in the figure above, the average speed for most vessels in the dry bulk and general cargo segment in the Baltic Sea has been below their design speed. Because design speed is the optimal speed in terms of fuel consumption, systematic sailing at speeds different from optimal leads to excessive fuel consumption and emissions.

The reason for such a discrepancy is the current disconnection between shipbuilding and operating as discussed above: operational performance is not sufficiently prioritized during ship design and subsequent construction. Moreover, historical data about realized driving profiles in intended service are currently largely unavailable to be used as a basis for ship design, since such data are not systematically recorded and analyzed.

To summarize, there is a number of inefficiencies in the organization of short sea shipping that together lead to excessive freight costs, emissions as well as low competitiveness of logistics in general. The effect of these factors is schematically represented in Figure 5. Ultimately, this affects many parties:

1. The inefficiency of the current sea shipping system implies wasted capacity that could have generated economic value for the system stakeholders

2. In particular, industrial customers are adversely affected because they, directly and indirectly, pay for the unused capacity and unnecessary fuel consumption as well.



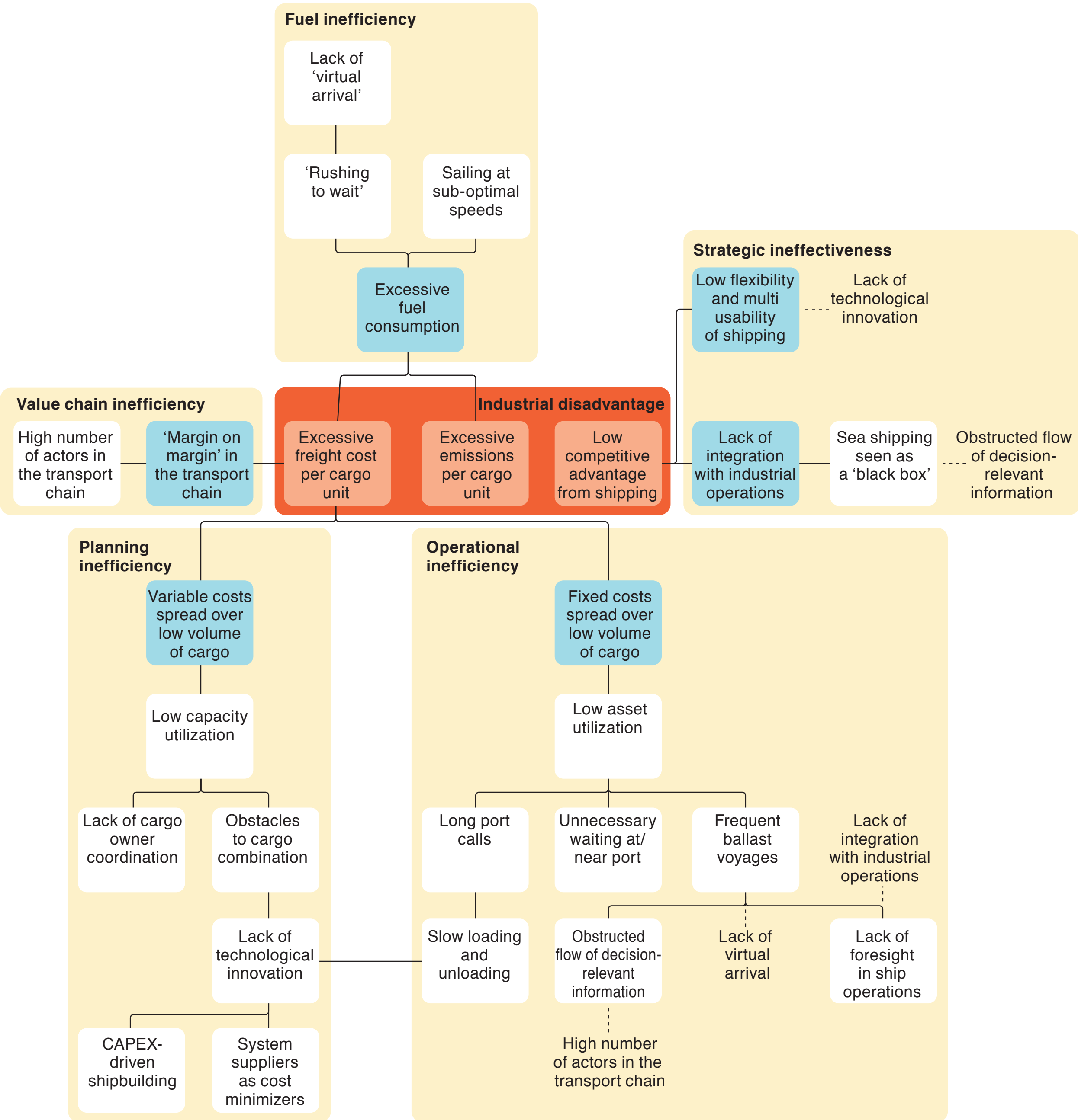


Figure 5. Inefficiencies in short sea shipping and their effect on industry.

3 Competitiveness through a new short sea shipping solution

Short sea shipping needs a solution that improves the competitiveness of the key system actors. For system customers, i.e. the industrial companies, this implies a system which offers additional economic value produced in relation to the costs incurred. Correspondingly, for system asset owners this means more productive – i.e. revenue-generating – use of their assets through increased utilization and higher-value services. As a result, the competitiveness of the system as a whole increases in terms of both the economic and environmental aspects.

Next, this solution is presented in outline. The key enabling innovations of the system are discussed in more detail in the subsequent Chapter 4.

3.1. Increased freight market efficiency through transparency

The solution to increasing the systemic efficiency and commercial effectiveness of the short sea shipping ecosystem is premised on increasing the amount, quality, transparency, and speed of information transmittal in the system. The underlying rationale here is to improve the operation of the market process – the 'invisible hand' – so that self-interested system actors can utilize the value-generating potential of the system to the fullest.

In other words, short sea shipping must undergo a transition similar to those brought about by Über in taxi services, Airbnb in accommodation, and Amazon.com in retailing.

This transition calls for a marketplace where a transparent exchange of information on cargo shipment needs, on the one hand, and available capacity for shipping, on the other hand, can take place. This can be done with a web-based freight marketplace, which is the key enabling technology in the renewal of short sea shipping.

Such a marketplace serves as the market-clearing platform, and with the enhanced information availability the self-optimization of the sea logistics system as the pricing mechanism is improved and can more efficiently guide actors' decision-making. For example, industrial customers – the cargo owners – can better incorporate sea logistics into their operation planning when the system status can be transparently and comprehensively studied (e.g. historical freight rates, and currently vacant capacities) and predicted (e.g. vessels' planned future routing). Moreover, the system-wide bidding and contracting mechanism can match supply and demand directly on a systemic scale without intermediaries, instead of within the current clientele of a given cargo broker.

However, in order to facilitate the market process, such a marketplace needs to offer, as a distinguishing feature, advanced optimization and simulation capabilities for the users. In other words, with such capabilities, the users would be able to simulate different scenarios (e.g. which combination of available shipping options would yield the best operational and economic result for an industrial customer, or which ship routing would maximize the ship's revenues).

In addition to the increased transparency in the freight market, the renewal of the short sea shipping ecosystem requires four additional elements: (1) dynamic and integrated production and logistics planning, (2) efficient cargo handling, (3) performance-driven shipbuilding and operation, and (4) sustainable investment and governance models for bringing about the system-wide transition.

3.2. Dynamic and integrated production and logistics planning

Dynamic and integrated production and logistic planning means a two-way transparent interface between industry and logistic operators, which includes early sharing of transportation needs, on one side, and transportation opportunities, on the other. Furthermore, such an interface would also enable rapid adjustments to any changes, for example, in industrial production scheduling following changes in demand.

To put it concisely, dynamic and integrated production and logistic planning is an agile and planned matching of supply and demand. This is enabled by and relies on the electronic freight marketplace as the central information and interaction platform.

The benefits of such production and logistics planning for the industry include more effective production and warehousing planning, lower freight rates, and better control over the quality and cost accumulation throughout the logistical chain. The economic impacts are significant, especially for industrial companies producing steel coils, cement, quick lime, paper and pulp. In addition, the resulting more efficient operations due to higher vessel utilization would also lead to a decrease in carbon dioxide emissions by 30–35% per ton shipped.

Correspondingly, the direct benefit for logistical operators, specifically ship operators, is the enhanced ability to plan and optimize transportation services (e.g., route planning) so that asset utilization is maximized. The required flexibility in operations can be ensured through constant dialogue with the industry. For instance, industrial customers should indicate which shipments have a strict delivery time requirement and which can allow delivery within a less rigid delivery time window. The freight rates, in turn, should reflect these less strict requirements, as they allow more flexible operations.

3.3. Efficient cargo handling

More efficient information transmittal can go a long way towards more competitive sea logistics. However, the technical system must be equally competent to enable a fully efficient and effective system. Here, cargo handling technology has a central role.

The two constraints to overcome are (1) loading and unloading cargo while a ship sits in a port, and (2) a mindset of 'shipment=shipful=ship'.

Addressing the first means detaching ship (un)loading and cargo (un)loading from each other so that the ship does not have to wait while the cargo is being processed. The second means enabling efficient transportation of multiple cargoes at the same time by modularizing the cargo hold into rapidly handled cargo-containing enclosures.

In this manner, system efficiency is increased both in terms of vessel utilization (less time spent idling in ports) and cargo capacity utilization (fuller ships through carrying multiple cargoes). Total effective vessel capacity utilization is the product of these two.

Such a solution brings about slot-based shipping, where the vessel merely serves as a carrying platform for a number of cargo-carrying modules. As a result, the logistics service is more agile, because the basic unit of shipping is smaller (a cargo-carrying module instead of a ship), and because the modules can be flexibly picked up and delivered along a vessel's route.

Thus, the electronic freight marketplace is basically a slot-trading platform, to match the supply and the demand of transportation slots.

The enabling innovation for bringing about such efficiency gains is the MegaUnit, an ultra-large multi-purpose bulk and general cargo container, described in more detail in the next chapter.

3.4. Performance-driven shipbuilding and operating

To bring about technically advanced cargo handling technology, and ships that better match the needs of the system customers, incentives in shipbuilding must be aligned accordingly. Currently this is not case, because incentives in ship construction are geared towards minimizing upfront investment costs instead of improving overall value creation.

The solution for this prevailing incentive misalignment problem is a reorganization of role and task divisions in shipbuilding and operation. The reorganization must result in a setup where both shipbuilding and operating consistently aim at ships that are maximally capable of turning a profit, and operations which can realize this capability. In other words, the actors' incentives throughout the life cycle of a ship, from the drawing board onwards, must be aligned towards in-use performance.

Alliance-based shipbuilding and operating is an organizational model for achieving this goal. In this model, an alliance is established between all the key ship system suppliers, with the shipyard and ship operator as members. In other words, all relevant expertise about ships and shipping is brought together from the very beginning.

Incentive alignment is based on an alliance model according to which the alliance constructs ships, sells the ships to a non-operating owner and/or leases the ships for its own operation. Moreover, the business model of the alliance is set up so that the alliance members predominantly earn profits only through ship operating, not construction. Thus, the ships are constructed at or near cost.

According to this model, the incentives of the key actors become aligned as follows:

- The alliance members have an incentive to make the ship as capable as possible of earning a profit in operation, instead of merely trying to construct as cheap a ship as possible.
- The non-operative owner (e.g., a financier consortium) has an incentive to invest, because the ship is constructed below market prices (at or near cost) and because there already is a committed long-term leaser for the ship.
- The alliance members have a joint interest in making the ship capable of earning a profit, and therefore have an incentive to co-operatively bring their best knowledge to bear on the project, instead of trying to meet pre-determined individual supply scope specifications with the lowest costs possible.
- The alliance members have a joint incentive to improve the earning capability – i.e. the meeting of customer's needs for the ship over its lifetime (e.g. responding to changing market conditions, or as a result of new knowledge and innovations), and are in an optimal position to carry out such improvements.
- The non-operative owner has an incentive to invest in a ship whose constructor-leaser has an incentive to actively improve the ship over its lifetime, thereby increasing the resell value of the ship.

To summarize, the alliance-based model of shipbuilding and operating results in ships optimized for revenue earning – i.e. serving customer needs – throughout their life cycle.

3.5. Sustainable financing and governance for system renewal

System-wide renewal requires significant investments, especially in infrastructures such as ports and the ships themselves. Therefore, an innovative financing model is a major contributor to bringing the systemic investment together, managing and allocating risks, and lowering the cost of capital.

Moreover, such innovative financing models are first and foremost a way to create governance structures that are more sustainable. Involving financiers that have a genuine interest in the actual outcome and benefit from the project is the primary target. The interplay between public and private financing can also play a crucial role in gaining public and political support for the system-wide transition.

Public-private partnership (PPP) models offer an array of suitable financing and governance models that involve public and private partners in projects for various periods over the life cycle of the project. The competencies that the various financiers bring to the investment are one essential element, while another key feature of PPP arrangements are the risk sharing schemes to equitably share risks in a manner which reflects investors' incentives. The public part should also provide a long-term commitment or guarantee that enables the involvement of private entities into the financing schemes.

PPPs are especially suited to systemic large investments where national interests are strong. The renewal of short sea shipping in Finland is exactly this kind of a case.

We have developed a specific model for financing vessel construction, which goes in line with the alliance-based shipbuilding and operating arrangement described above. From a financing perspective, this model helps to lower the risk involved in both the building and the operating phases. This is achieved through having the technology providers already take an equity part during the building phase – with or without the intention of exiting during the operations phase. Instead of trying to maximize the interest from the equity invested, the technology providers should see this as an opportunity to create business cases. The margins, in this case, come from the building and operation phases rather than from direct interest in the invested capital. Moreover, if the capital structure of the company owning the assets is optimized through such "smart" equity, then the total capital expenditure can be lowered.

A lower risk means a lower cost of capital through lower interest. This is because when receiving external financing, risk is the aspect that influences the interest rate the most. A secondary issue is the maturity of the external capital. To ensure the liquidity of the owning company, long-term loans are essential. Through the PPP model, long-term government financing can be accessed. This also increases the possibility to attract long-term financing from e.g. insurance companies and pension funds.

To summarize, the overall solution is premised on transparent information sharing and transmittal, integrated logistics and production planning, more efficient cargo handling, performance-driven shipbuilding and operating, and sustainable financing and governance. These aspects together create a short sea logistics system that offers a more effective logistics service for the industrial customers, and does so with lower costs and emissions through higher efficiency; thereby resulting in economic gains for all key system stakeholders.

In the next chapter, the key enabling innovations for the solution are described in more detail.

4 Key enabling innovations for the solution

The solution for renewing the short sea shipping ecosystem as discussed above is based on two key enabling innovations, which reinforce each other in enabling a more efficient and effective short sea logistics system. These innovations are (1) the web-based open freight marketplace, and (2) the MegaUnit, an ultra-large (400-ton) bulk and general cargo container. In addition to these, the enabling innovations include (3) MegaUnit-enabled lean 'barebones ports' and (4) real-time voyage execution optimization, enabled by enhanced transmission of information in the system.

Next, each of these four innovations is described in more detail.

4.1. Electronic freight marketplace

As noted above, an open web-based cargo marketplace goes a long way towards rectifying the lack of decision-relevant information within the system. The marketplace is a communicating, optimizing, and shipping slot-trading platform, with four specific purposes:

1. Make freight transportation supply and demand transparently visible to system actors in order to facilitate mindful integration of logistic decisions into corporate strategizing, both short- and long-term,
2. Serve as a market-clearing mechanism so that supply and demand conditions (e.g., crowding or temporal underutilization) become priced correctly, thereby allowing the market mechanism – the 'invisible hand' – to optimize system utilization,
3. Serve as an easy-to-use centralized communicating, booking, and contracting platform so that the system status is always up-to-date and visible in real time to system actors, and
4. Enable all system actors to optimize their own operations and simulate different scenarios (e.g. how an alternative ship routing would affect ship operator's overall profitability) to facilitate the actors' decision-making.

Accordingly, the freight marketplace itself does not set prices but instead the system actors – i.e. the marketplace users – negotiate these among themselves, on a case-by-case basis. Only in this manner can the market mechanism fully operate.

The primary user groups for the marketplace include ship operators, MegaUnit operators (i.e. the owners and renters of MegaUnit containers) and cargo owners (i.e. the industrial customers). The first two represent the freight service supply (transportation slots and transportation containers, respectively) whereas the third represents the freight service demand.

More specifically, the core functionalities of the marketplace for these three key user groups are as follows:

Cargo owners

- Reviewing the system status (e.g. the availability of free shipping slots and prevailing freight rate levels),
- Simulating own transportation scenarios and optimizing own operations,
- Indicating cargoes for delivery,
- Creating background alerts for lucrative shipping possibilities, and
- Bidding, negotiating, and contracting for deliveries.

Ship operators

- Reviewing the system status (e.g., the availability of cargoes indicated for delivery),
- Simulating their own ships' routing scenarios e.g., with different sets of indicated cargoes and optimizing own operations,
- Creating background alerts for lucrative cargo indications, and
- Bidding, negotiating, and contracting for deliveries.

MegaUnit operators

- Reviewing the system status (e.g., the availability of cargoes indicated for delivery),
- Simulating MegaUnit circulation scenarios e.g., with different sets of indicated cargoes, and optimizing MegaUnit circulation,
- Creating background alerts for lucrative cargo indications, and
- Bidding, negotiating, and contracting for MegaUnit rentals.

In other words, the marketplace makes the system status very visible for the key marketplace actors and facilitates information transmittal and direct action between them. Furthermore, the marketplace provides advanced simulation and optimization capabilities for the actors to facilitate their decision-making, and automatically provides alerts for opportunities that might be economically beneficial for them.

To facilitate adoption, the marketplace would be free to use upon registration, and the usage fees based on a commission on freight contracts entered into on the marketplace.

As noted above, the basic unit of trading on the freight marketplace is a freight transportation slot. This is enabled by the second key enabling innovation, the MegaUnit.

4.2. The MegaUnit

The MegaUnit is an ultra-large bulk and general cargo container, an innovation created by MacGregor, Finland. The MegaUnit resembles a standard shipping container, but is substantially larger and therefore not transportable on public roads. Instead, MegaUnits are moved using a multi-wheeler carrier platform.

The cargo capacity of a MegaUnit is 360 tons, with the gross weight of 400 tons and a footprint roughly equal to that of a badminton court. Volumetrically, a MegaUnit is equivalent to approximately eight standard 20-foot shipping containers. The MegaUnit is multi-purposed, capable of being used to transport bulk (e.g. powdery or grainy) materials and general cargo (e.g. steel coils or pulp bales). In addition, a MegaUnit can serve as a carrier housing for eight standard shipping containers. The following Figure 6 illustrates MegaUnits onboard a specific MegaUnit ship which, in turn, is discussed in more detail below.

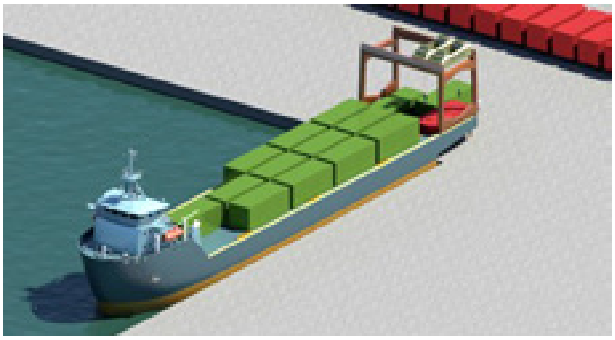


Figure 6. A rendering of MegaUnits onboard a MegaUnit ship.

The MegaUnit has four primary benefits:

1. Detaching (un)loading of a ship and (un)loading of the cargo from each other. Thus, a ship does not have to be present while the cargo itself is being loaded or unloaded. This significantly reduces ships' turn-around times in ports, since moving one MegaUnit to/from the ship only takes about 15–20 minutes.
2. Modularizing the cargo hold of a ship into interchangeable cargo hold modules, detached from the ship itself. This enables slot-based shipping (a ships' capacity is essentially a number of MegaUnit-carrying slots) and the transportation of several cargoes simultaneously without fear of cargo contamination, in the MegaUnits.
3. Enabling flexible ship routing, because at any given port along a ship's route one or more MegaUnits, instead of the whole of ship contents, can be loaded or unloaded. This, figuratively speaking, enables a service bus-type of routing and operations.
4. Making the ship independent of the port operations (e.g. the availability of port personnel or equipment), because the MegaUnit ship is self-sufficient in loading and unloading with its own equipment. This, in turn, enables new kinds of 'barebones' ports to emerge, as discussed below.

For the MegaUnit-based shipping, and especially port operations, to be optimally efficient, the ship carrying the MegaUnits must be specifically designed and equipped for this use.

The MegaUnit ship

The MegaUnit ship is premised on maximizing vessel utilization and profitability. The key for this is to minimize the time that the ship is not sailing and earning revenue. Thus, the MegaUnit ship needs to be able to ensure quick port turnaround times and minimize the risk of this being adversely affected by the quality of the port-side services.

Consequently, the MegaUnit ship is equipped with systems – a mobile multi-wheeler platform to transport MegaUnits to and from port storage positions and a high-speed gantry crane feeding and fed by the platform – enabling robust and quick port turnarounds. Figure 7 illustrates the loading/unloading equipment.

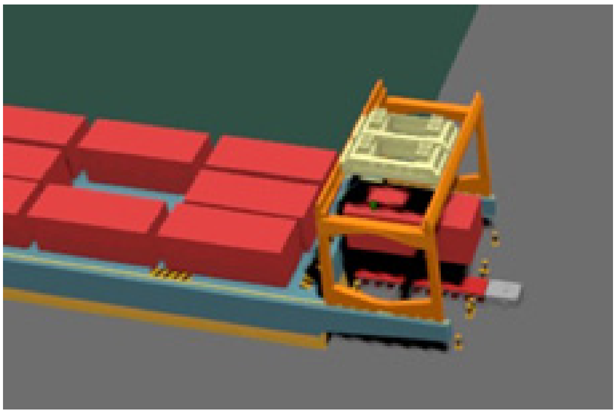


Figure 7. The loading and unloading equipment of a MegaUnit ship.

In addition, the MegaUnit ship is highly economical: a basic serially built deck cargo ship, geared towards low fuel consumption and emissions based on slow sailing speeds. Thus, the value of the ship – both in terms of initial investment and revenue-generating capability – to a large degree resides in the cargo handling functionality instead of the underlying basic ship itself. Furthermore, the basic cargo deck construction enables the ship to earn supplementary revenues by transporting other supplementary cargoes such as ship hull sub-assemblies, windmill components, or other large structures.

Thusly equipped, moving one MegaUnit to or from the ship takes about 15–20 minutes, as estimated by MacGregor, enabling the exchange of all the 15 MegaUnits of a fully-loaded ship in about 8 hours. This is a significant improvement over the corresponding two days of unloading, cleaning and loading, typical with a current-day basic bulk-carrying ship. This translates into an over 80% reduction in port turn-around time.

Since the MegaUnit ship is capable of loading and unloading without any equipment or service from the port, this gives rise to a wholly new kind of a port, a 'barebones' port.

4.3. The 'barebones' port

Because MegaUnit-based freight transportation does not require any particular port services or equipment, MegaUnit ships can utilize 'barebones' ports, which are basically structurally strong paved fields next to a navigable body of water. Figuratively speaking, 'barebones' ports are parking lots for MegaUnits, where the units can be filled and emptied by and for land transportation.

Such 'barebones' ports have two significant benefits:

1. Their investment and operating cost structure is very lean, because in addition to structurally strong paved field no other significant infrastructure is needed, and
2. They do not require traditional stevedoring personnel to run the operations.

As a consequence of deindustrialization in Europe and the United States, for example, appropriate vacant shore side sites are available to be adopted for or converted into this use.

4.4. Real-time voyage execution

Once vessel operations can be more predictable through better sharing of information between key system actors, real-time voyage execution solutions will play a key role in ensuring smooth and cost-efficient sailing.

Since dynamic and integrated production and logistical planning require reliable and regular information flow regarding sailing, control of voyage execution needs to be automatized. A system for voyage execution installed on a ship will serve two important functions:

1. Adjust sailing to dynamic conditions such as changing routes due to weather conditions or shifts in the voyage plan, while ensuring optimal fuel consumption, and
2. Record performance of the ship during sailing (including speed profiles, fuel consumption, time sailed on route, etc.), thereby enabling the gathering of knowledge and continuous improvement – both with regard to sailing itself and the optimization of the whole logistical chain.

The optimization feature of the voyage execution solution bears a significant potential for reducing fuel costs and associated emissions. As discussed in Chapter 2, current general inability to plan for 'just-in-time' vessel operations leads to sub-optimal sailing profiles with highly variable speed profiles (see Figure 3 for a typical vessel speed profile in the Baltic Sea).

Following better information sharing between system actors, especially industrial customers, as well as the ship operators and ports, cargo pick-up and delivery times can be known with precision and no rushing to or queuing in ports would be necessary. Hence, sailing can be executed at an appropriate even speed, which translates into reduced fuel consumption and resulting emissions. Figure 8 illustrates the impact on speed profiles and Table 1 translates this into fuel consumption and emissions.

Speed profiles sailed, optimized, ETA+6h and ETA+12h

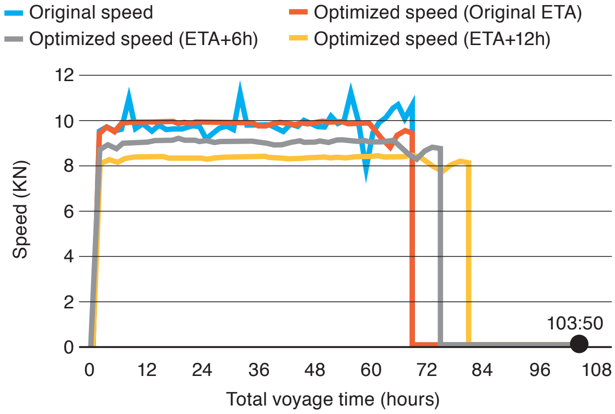


Figure 8. Retro-optimized sailing speed profile for navigation speeds for meeting the original ETA, ETA +6 hours and ETA +12 hours[3].

	Original	Optimized (Original ETA)	ETA +6h	ETA +12h
Fuel consumption [t]	23.0	22.8	21.5	20.1
Bunker cost [€]	11,511	11,396	10,731	10,044
CO_2 emissions [t]	71.7	71.0	66.9	62.6
CO_2 emission savings	-	1%	6.8%	12.7%

Table 1. Fuel consumption and CO_2 emissions for the original and retro-optimized scenarios.

In this case, there is the potential for reduction in fuel consumption and emissions depending on the estimated time of arrival (ETA). That is, if schedule is planned carefully, a vessel can spend more time sailing instead of 'rushing to wait' and then idling in a port. With marine fuel price of 500 € per ton, this translates into savings in the range from 115€ to 1,500€ for a 30,000 dead weight tonnage and 180 meter long vessel travelling 670 nautical miles (Sillamäe – Lübeck). As in most cases industrial cargo owners directly pay for the bunker, there is a clear potential for freight cost savings.

[3] The figure is based on historical data obtained from the European Maritime Safety Agency for a voyage between Sillamäe, Estonia and Lübeck, Germany. The retro-optimization was carried out utilizing NAPA voyage optimization tools.

5 Conclusions and actions for implementation

5.1. Conclusions

The current short sea shipping system suffers from systemic inefficiencies that lead to excessively high freight prices for the industry. At the same time, other key system actors such as ship operators earn unsatisfactory profits. This is because of significant systemic waste, especially in ballast voyages and time spent in ports, i.e. low asset utilization.

The system outlined in this report will significantly reduce such systemic waste thereby allowing, at the same time, lower freight prices for the industry and increased profitability for other key system actors. This is because higher asset utilization leads to increased value creation throughout the system.

Furthermore, the slot-based shipping system and the electronic marketplace will enable more flexible and agile shipping with smaller and more frequent consignments, making shipping more strategically relevant, especially when tightly coupled with industrial companies' production planning and operations.

As an additional benefit, more efficient asset utilization means increased environmental friendliness, because the reduced waste includes the fact that less fuel will be consumed for non-productive purposes. In particular, ballast shipping can be reduced through the dynamic slot-based shipping. Table 2 shows the emissions reductions that can be achieved by reducing ballast sailing.

Ballast sailing reduction	Distance saved [nmi]	CO_2 emission savings [t]	CO_2 emissions savings
20%	1,224,821	190,729	7%
30%	1,837,232	286,094	10%
60%	3,674,464	572,188	21%
90%	5,511,696	858,281	31%

Table 2. CO_2 emissions reduction for various ballast sailing reduction scenarios.

Further emission reductions stem from optimal sailing speeds, slow-steaming, and avoiding 'rushing to wait', which leads to unnecessary waiting times when entering ports. Table 2 does not include these potential savings.

Finally, increased vessel capacity utilization with MegaUnit technology and the electronic marketplace can further reduce emissions per ton of cargo transported through the possibility of combining cargoes and achieving the maximum load for vessels on each voyage. This emission reduction potential refers only to the sea transportation leg, while replacement of road transportation with sea traffic is yet another source of decreasing the overall environmental impact of logistics in the Baltic Sea area. Last but not least, reduced fuel consumption, naturally, also translates into lower fuel costs.

5.2. Actions for implementation

In this section, we present a summary of the central benefits, and discuss what actions the key system stakeholders should undertake in order to implement the solution.

Industrial customers

The industrial customers of the system arguably stand to be the greatest beneficiaries from the renewed logistical solution. Their key benefits and opportunities include:

- Lower freight rates as a result of increased system utilization
- Lower emissions in their logistical chains as a result better fuel economy and increased system utilization
- Possibility to ship smaller consignments more frequently and flexibly with MegaUnits, which among other benefits enable serving new types of customers
- Reduced capital tied up in inventories as a result of MegaUnit-sized consignments and more frequent shipments
- Profitably and ecologically substituting land transportation with MegaUnit-based shipping in routes originating and terminating near a port
- Avoiding investments in fixed infrastructure such as silos by using MegaUnits as collection and/or distribution warehouses, and being able to ship from or to locations where such infrastructure investments are not economically justified
- Economically shipping refined (i.e. sensitive) goods instead of raw materials as a result of MegaUnits' cargo protection
- Taking a larger role in customers' value chain by, for example, managing customers' raw material and/or finished goods inventory function with MegaUnits as collection and/or distribution warehouses
- Leveraging production process flexibility by opportunistically capitalizing on vacant slots onboard MegaUnit ships (ship operators' willingness to accept low freight rates in order to ensure the ship is full)
- Flexibly adapting production processes to match the most economic operation of ships to enjoy reduced logistical costs (benefit sharing with ship operators)
- Ally with other industrial companies to jointly coordinate cargo flows to strengthen bargaining power towards other system actors

To achieve this, an industrial company needs to analyze its sales, operations, and logistic processes thoroughly. It does not suffice to compare the Über of the seas solution to the current logistical processes and cargo flows, because the current setup is a result of the current logistical system. For example, the current cargo flows do not include such cargo flows that would be possible and profitable with the Über of the seas. Moreover, the current routes, batch sizes, and even cargo types are as they are because of the nature of the current system, which cannot be seen as evidence of their general optimality.

More generally, the aim of this analysis must be in the generation of economic value from end to end, i.e., from the production process all the way to the customer. Consequently, merely focusing on shipping costs does not reveal the whole picture – an equal emphasis must be placed on the value components that logistics could create.

Furthermore, the company must not only consider its own cargo flows and logistical needs, but additionally study the system as a whole in order to learn, for example, how it could coordinate logistical processes jointly with other companies for mutual benefit.

Freight forwarders

In Über of the seas, freight forwarders would have an important role in arranging cargoes into vacant slots. This is both a lucrative opportunity (capitalizing on ship operators' willingness to accept low freight rates in order to fill their ships) and an important function in increasing the system efficiency.

Consequently, the key benefits to freight forwarders would include:

- Capitalizing on remaining vacant shipping slots by arranging for additional 'marginal' cargoes
- Capitalizing on project cargo shipments (e.g., shipments of large steel structures such as ship hull sub-assemblies delivered to shipyards) by arranging supplementary cargoes for those slots which are not occupied by the project cargo
- Leveraging the informational transparency of the electronic freight marketplace by capitalizing on cargo imbalances, i.e. arranging for cargo for those sea legs where at a given point of time there is capacity underutilization (and consequently low freight rates)

To do this, freight forwarders need to analyze the cargo flows and prevailing and foreseeable shipping capacity supply and demand. For this, the electronic freight marketplace with its transparent and real-time informational access is a perfect tool. In short, freight forwarders must coordinate the cargo flows of their customer base in such a way that they can flexibly act upon vacant capacity or more persistent imbalance in the logistical system.

Ports

The 'barebones' ports geared towards MegaUnit-based freight constitute a new type of port that is part of a highly competitive system for short distance shipping by sea – or by river or an inland waterway. Such ports can be likened to a storage area by the waterside.

Consequently, ports should explore the potential for establishing MegaUnit 'barebones' port operations alongside their existing operations to enable short-sea feeder functions. The opportunity is commercially gainful, because 'barebones' ports are very lean both in terms of their initial investments (a structurally rigid paved field next to a navigable body of water) and operating costs (no traditional stevedoring personnel required).

Local decision-makers

The Über of the seas system would bring significant potential in order for increasing cargo flows, production, and shipping of refined goods. To capitalize on this, municipalities can take a role in coordinating and facilitating the efforts of local companies and freight forwarders to establish local short-sea shipping hubs.

In particular, this involves bringing together local industrial companies to explore their joint logistical needs, interests and possibilities, and facilitating the establishment and running of lean ports such as the 'barebones' ports mentioned previously.

Financiers

The Über of the seas system provides an attractive investment opportunity, which encompasses the whole logistic chain over the entire lifecycle.

Moreover, the system investment includes various investment roles, incentive models, and risk profiles, which would allow different investors to participate in the system investment in accordance with their investment strategy.

First of all, technology providers would obtain an opportunity to partly finance vessel construction and receive the returns on investment throughout the lifecycle of the vessels. For the company owning the vessels this also means that the total capital expenditure would be minimized, because technology providers are interested in vessels generating maximum revenue, rather than in maximizing the interest from the equity invested.

Secondly, the financing structure described in section 3.5 makes the system investment attractive for long-term investors. Not only does this ultimately reduce the risk and thereby the interest rate, but also that the vessels built and operated through the proposed alliance model answer the main requirements of long-term financers for an investment: stable and long-term generation of income. Thus, novel types of long-term investors, such as insurance companies and pension funds, can be involved in financing sea logistics infrastructure.

Technology providers

For the technology providers, the Über of the seas solution is a prime possibility to leverage and capitalize on their best available technology and know-how instead of having to bid for fixed specifications based on price. This is because Über of the seas is geared towards generating maximum economic value for system stakeholders' benefit, instead of trying to force costs down within the existing system.

Therefore, technology providers should explore the potential for developing new functional solutions that increase the value generation potential and sustainability of the ecosystem. For example, rather than just focusing on providing a ship engine room with lifecycle services, an integrated solution of an engine room plus a locally produced renewable fuel could provide a low-emission propulsion solution. In this manner, by focusing on the use value, the technology provider can redefine the state of competition.

Moreover, the technology providers should seek collaborative business models with a combined functional solution that can generate more value than its component parts. The shipbuilding and operating alliance described above is an example of such collaboration.

Policymakers

Über of the seas provides an opportunity to increase the international competitiveness of Finnish industry by lowering the cost of seaborne logistics through increased efficiency, and by opening up new logistical opportunities with the MegaUnit and the slot-based way of shipping.

Furthermore, Über of the seas also provides an outstanding export opportunity for Finnish technology providers. This is because the inefficiencies described above are not peculiar to the Baltic Sea, but exist around the world in comparable short sea, coastal, river and inland waterway shipping. In other words, Über of the seas has global market potential.

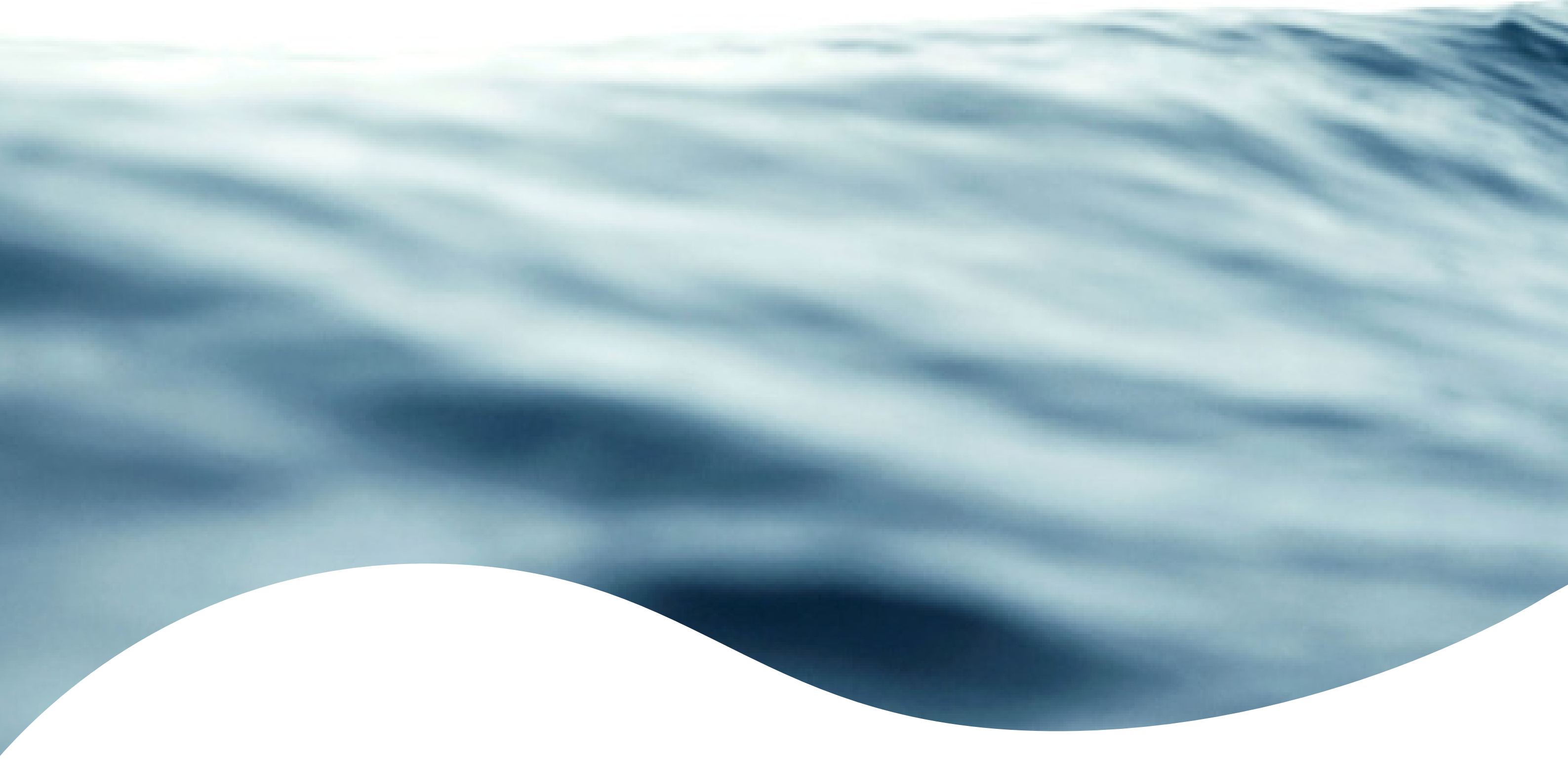
In addition, the system investment needed to bring about the solution with the PPP investment setup, represents an investment opportunity for Finnish institutional investors such as pension funds and state-owned investors.

Consequently, it is in the interests of the Finnish state and the policymakers to support the Über of the seas solution. This means, for example, the state taking the role of a lead investor to facilitate the convergence of the whole PPP investment, and making sure that there are no regulatory obstacles or subsidies that would hinder making this logistical system more efficient, effective, and sustainable.

Furthermore, the policymakers should, together with the technology providers, explore the possibilities of tightening the emission standards even further. By this means there would be a reduction in the relative competitiveness of the older wasteful solutions based on imported fossil fuels, in favor of sustainable solutions based on renewable domestically produced fuels.

Not only would this help in mitigating the climate change challenge and aid in fulfilling Finland's commitments to reducing greenhouse gas emissions, but additionally such concepts can be developed in Finland and then exported to other countries. If mindfully designed, such emission standards need not increase transportation costs.


NO SMOKING



ISBN 978-952-12-3356-2