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Executive summary

Short sea shipping is less complex than deep sea in that an unmanned ship calls at ports more often and salvage is much easier. Thus, some of the maintenance problems can be reduced or solved at lower cost. Also, close to shore operation is performed in emission control areas where also manned ships need to use cleaner fuels or exhaust cleaning systems. Thus, fuel costs are also less of a problem. Finally, coastal shipping will normally have access to much higher and lower cost communication infrastructure which also reduces cost of operation.

On the other hand, the ships operate in more congested waters which require other approaches to anti-collision and automated manoeuvres.

This report discusses these issues in some detail and proposes two different cases for unmanned short sea ships. Both address the "last mile" problem, i.e. from feeder or hub ports to final destination. One is a larger coastal carrier while the other is a small shuttle barge for shorter distances.

The report also briefly discusses inland waterway shipping and looks at the more specific properties of that. The shuttle barge could be a useful starting point for an inland ship design.

List of abbreviations

CBA	Cost-Benefit Assessment
ECA	Emission Control Area
GHG	Green-House Gas (CO_2 mainly)
HFO	Heavy Fuel Oil
LNG	Liquefied Natural Gas
MGO	Marine Gas Oil
ROPAX	RORO passenger ship (longer distance car ferries)
SSS	Short Sea Shipping

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1. Introduction

1.1 Scope

European short sea shipping (SSS) may be an interesting opportunity for unmanned shipping. On the societal side, it is desirable to make better use of the European waterways than today to reduce road congestion and greenhouse gas (GHG) emissions. Unfortunately, SSS is often more expensive or less convenient than truck transport and significantly increasing competitiveness by reducing costs is attractive. On the technical side, there are factors that both simplify and complicate unmanned shipping in a short sea context.

This report will briefly go into the technical possibilities and limitations of unmanned short sea shipping in Europe and compare it to some typical types of shipping. It will also outline a few examples of possible unmanned ship concepts for the short sea trade.

This report should be read in conjunction with D10.2 /1/ as that goes more into details on the general technical restrictions or constraints on unmanned vessels.

1.2 Structure of document

Section 2 outlines some typical SSS cases and the requirements these cases put on the ship. It is not an exhaustive analysis, but covers some of the main classes of SSS. A brief analysis of possibilities will be done.

Section 3 discusses the possibilities of unmanned shipping in SSS with basis in the general constraints described in D10.2 and in the most promising cases from section 2. This will basically be a list of arguments pro and contrary to unmanned SSS, when compared to deep sea shipping.

Section 4 will discuss inland waterway shipping as a special case of SSS.

Section 5 and 6 will then briefly outline two possible cases that may be worth further investigation. This is not a full CBA, but will outline the general arguments for and against these types of ships.

2. An overview of selected types of short sea shipping

The analysis presented in this chapter is fairly high level and mainly based on personal insight and opinions by the authors. After working with unmanned shipping for three years during the MUNIN project we believe that this may be of some use to the reader. Also, the arguments are presented and the reader is free to make up his or hers mind.

The conclusion in this section is that the "last mile" type of shipping may be the most interesting to look at in the context of unmanned shipping. This may apply to longer and shorter distance, including inland short distance transport and ship terminal shuttling.

2.1 Passenger ships and ROPAX

A significant part of European short sea shipping is high or lower speed passenger crafts as well as passenger carrying car ferries (ROPAX). It is close to inconceivable to see these ships as unmanned since an important task of the crew is to assist passengers in the case of emergencies. It may be possible to reduce crew size marginally by using technology of the type developed in MUNIN, but this will have marginal impact on overall operational costs. These ships are not likely cases for unmanned operation.

2.2 Highway ferries

Another case which could be interesting is the highway shuttle ferry which ferries cars and passengers over relatively short stretches where subsea tunnels or bridges are not cost-effective. The voyage duration is often on the order of 15 to 30 minutes and location and infrastructure seems to favour unmanned ship solutions. However, the same point as in the previous section applies: Crew are needed to help passengers in the case of emergencies and it is not trivial to device automated rescue systems that would allow these ships to sail without crew.

On the other hand, it should not be impossible to find technical solutions to the rescue problem so it is not as unlikely as the general passenger ship.

2.3 Coastal tankers and dry bulkers

Chemical and oil tankers will probably upset public opinion if they were operating without crew. Technically and from a safety perspective, one could argue that this is a reasonable proposition, but one may assume that the general public would be very sceptical.

Dry bulkers, transporting sand, gravel or other bulk material, could be a good case, but many of these ships are more or less operating on very low freight rates and there is likely not capital in the business to do the necessary technical innovations. It is also unlikely that the business would be able to recover the additional costs.

An exception may occur if the society decided to offer some form of subsidies to remove very old and presumably more dangerous ships from this trade. However, even in this case, unmanned ships would probably not be the first choice.

2.4 Container feeders

The special purpose feeder ships without cranes and optimized for hub to larger feeder port traffic could be case, but the economic incentive may not be that strong. This type of traffic seems to be operating on a fairly sound commercial basis although there is arguably a tendency that the feeder ports get fewer and larger.

It is questionable if the necessary increased investments would represent a good business case.

2.5 Inland waterways boats

Inland waterway boats could be a good case for unmanned shipping. However, introduction of unmanned barges or boats would require a fairly large change in the infrastructure and how the business was conducted. The impression is that there are perhaps too few large actors that could undertake to spearhead the necessary changes.

Otherwise, the technical issues of unmanned shipping are significantly easier to overcome in the inland waterways and it remains attractive if a good business model could be found. Furthermore, unmanned convoy systems could also provide a cheap alternative to increase freight volumes while not increasing the water depth by dredging.

2.6 Last mile

Last mile shipping is the transport of goods from hubs to smaller destinations that are not served by large feeder ships. Normally and today, this is often done with trucks or in some cases trains.

However, in some areas there are also ship routes with general cargo ships that handle part of the last mile transport. These ships may also handle cargo between feeder ports. They do not generally call on the large international hubs.

This type of traffic has a great potential in reducing road traffic. They will not completely replace trucks as there will still be the need to move cargo from the ports where these ships call and locations outside the maritime network.

If such ships were to become more automated and more competitive, they may also compete with some of the feeder traffic, although this is more speculative. There is also an extension the other way into very small shuttle barges that may directly compete with trucks on certain destinations.

3. Differences between short sea and deep sea shipping

Report D10.2 identifies a number of constraints that apply to deep sea shipping. This section will go through these constraints and modify the list with respect to short sea operations. The solution column will, where applicable, give a reference to the sub-section in which the issue is discussed.

The table does not contain an entry on the legal issues. Briefly, it can be mentioned that the short sea or inland waterways unmanned ship usually will be a simpler case legally than the deep sea ship. This is because one will often be able to avoid operating in international waters and can make do with general agreements between the flag state and the afflicted coastal states. This does not mean the legal issue is straight forward as many complicated issues remain as is documented in other deliverables, e.g. D9.3 /3/.

Table 1 – Comparison between short and deep sea shipping constraints

Constraint	Solution
1. No crew	Similar with respect to economy of solutions (3.1)
2. No passengers	Same.
3. Quality SCC	Same.
4. Simple design	Less of an issue (3.2)
5. Automated cargo	May be more important (3.3)
6. Fire protection	Same
7. Fuel issues	Less of an issue (3.4)
8. Maintenance	Less of an issue (3.5)
9. Redundancy	Same, see item 8 however.
10. Secure ICT	Same.
11. Heavy traffic	More severe (3.6)
12. Direct control	More often (3.6)
13. Heavy weather	Less severe, more protected waters.
14. Documented safety	Same.
15. Dangerous cargo	Same.

While short sea in many respects is fundamentally different than deep sea, it is likely that good solutions can be found also here. One may also assume that short sea shipping may be a better starting point for unmanned ship as it is shorter distances between maintenance possibilities, involving fewer authorities and probably offers better economic possibilities in the short run.

The economy is probably better because the use of distillates or other fuel as well as lower efficiency of redundant machinery is much less of an issue for short sea traffic that cannot utilize the long voyages on constant and near optimal speed on the main engine.

3.1 Unmanned operation

Short sea is in a sense more demanding that deep sea as port calls are much more frequent and the fairways generally more complex in terms of traffic. To make the unmanned short sea ship cost effective, one will probably have to go for a solution with full remote control during difficult passages and autonomous navigation elsewhere. This means no crew on board, even during berthing.

3.2 Complexity of ship

Short sea ships normally have lower capital investments and operate on more frequent port calls. This means that consequences of technical defects may be less as they can more readily be fixed and have less consequences in terms of off-hire. This will, however, vary very much with ship type and trade.

3.3 Automated cargo

Port costs are relatively much more significant for short sea shipping and the degree of automation in loading and discharge may have a great impact on operational costs. As discussed in the previous section, last mile logistics may be an interesting case for unmanned ships, but this type of ship will also be very sensitive to port costs.

In general, many short sea shipping segments are very much cost constrained and the main attractiveness of unmanned ships is if it can reduce costs sufficiently to increase competitiveness against road transport.

3.4 Fuel issues

Fuel costs are important for short sea as well as deep sea shipping. However, as short sea shipping mostly operates within ECA zones, both manned and unmanned ships have some of the same problems related to selection of fuels. In many cases this means that also manned ships will operate with clean fuels such as MGO or LNG in the ECA area. This removes this particular competitive advantage for manned ships in short sea trade.

3.5 Maintenance

Short sea shipping is also somewhat less sensitive to the maintenance issues as port calls are more frequent and consequences of system failures are less severe. Salvaging a short sea ship is much simpler than a ship on the high seas.

However, maintenance problems and system failures will easily increase costs of operations and reduce revenue through more off-hire, so it is still important.

3.6 Heavy traffic

Traffic on short sea routes will be a challenge. There will generally be more traffic, the fairways will be more constrained and there will be much more leisure and small boat traffic. Also, port calls will be much more frequent and one will in general need an alternative method from that used for deep sea ships. One may want to use a combination of two approaches:

1. Much more tight control via the SCC. It is probably necessary to use direct remote control during larger parts of the voyage. This will also require much more use of high definition video signals and other on-line sensor data.
2. One also needs to consider the need for specific traffic regulation rules and legislation, e.g. giving the unmanned ship right of the way or reserving certain lanes for unmanned ships.

The benefit of short sea shipping operating close to shore is that it will normally be able to utilize better communication infrastructure, either dedicated or general purpose, such as 4G mobile data nets. It is also easier to create local legislation or rules that give unmanned traffic improved protection against other ships and boats.

4. Inland waterway shipping

The following table outlines the differences between inland shipping and general short sea shipping. More detailed explanations can be found in following sub-sections.

Table 2 – Comparison between short sea and inland shipping constraints

Constraint	Solution
1. No crew	Same with respect to economy of solutions.
2. No passengers	Same.
3. Quality SCC	Same.
4. Simple design	Barge type (4.1)
5. Automated cargo	Most use equipment in port.
6. Fire protection	Same
7. Fuel issues	Less of an issue (4.1)
8. Maintenance	Less of an issue (3.5)
9. Redundancy	Should be less of an issue (4.1)
10. Secure ICT	Same.
11. Heavy traffic	Rivers and canals (4.2)
12. Direct control	Same as SSS
13. Heavy weather	Less severe, more protected waters.
14. Documented safety	Same.
15. Dangerous cargo	Same.

The barge concept presented in section 0 could also be used on inland waterways and it would be a possible concept to make larger for more general barge traffic. It would probably not be so suitable for battery operation.

4.1 Inland ship types

The ships operating on inland waterways are relatively narrow and long and with a small air draught. Some examples of typical barges are shown in Figure 1.

Many of these ships have a single engine with thrusters for increased manoeuvrability. However, diesel-electric systems are also here increasing and LNG is also considered as a suitable fuel.

Relatively complex operational characteristics should allow for more advanced propulsion systems without a very high additional cost penalty.

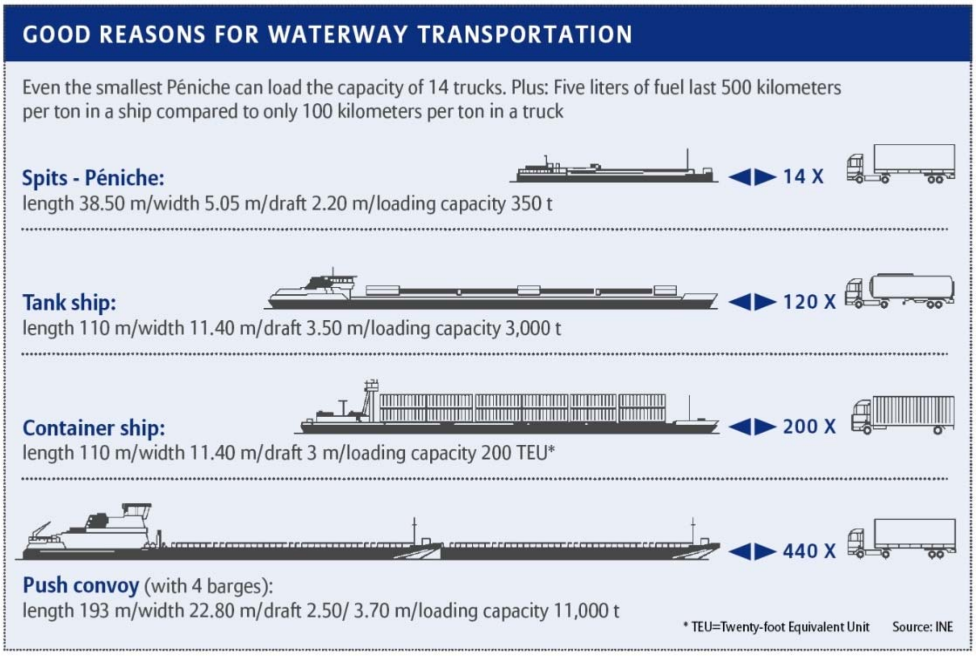

Figure 1 – Some inland barge types /2/

4.2 Traffic pattern

Inland waterways will be even more restrictive than general short sea shipping. These vessels sail mostly on channels and rivers with relatively limited flexibility in movements and often with heavy traffic.

However, traffic patterns are more regular due to the same restrictions and one may in some cases compare this type of traffic to truck driving on highways.

Also the legislative regime is very different from national shipping and there are more possibilities for adaption of rules locally than it is for areas where internationally flagged ships operate.

5. The unmanned short sea cargo ship

An interesting case for a short sea cargo ship was developed by the Godsfergen[1] project in Norway. It proposed a relatively small cargo ship for unit loads (45 feet containers) and with own cranes and no need for manned port operation as part of the concept.

Figure 2 – The proposed Godsfergen route[1]

The business model would be good, if one could manage to remove some of the port costs associated with cargo handling which basically means automated handling of the cargo in port. This could also be extended to fully or partly unmanned operation of the ship.

This is a form of last mile transport, where the ship is not directly a feeder, but rather calls on smaller ports to take the last part of the voyage that the feeders do not find economical or technically possible to pick up.

A brief comparison of this concept to the general constraints for unmanned ships has been made below.

Table 3 – Comparison between short and deep sea shipping constraints

Constraint	Solution
1. No crew	Fully or partly unmanned (5.1)
2. No passengers	Ok.
3. Quality SCC	Ok. Need more direct control also for cargo handling.
4. Simple design	Will be somewhat more complex (5.2)
5. Automated cargo	Fully (5.2)
6. Fire protection	Same

1 http://www.godsfergen.no/SitePages/NyhetDetalj.aspx?nid=153&t=Competitive+coastal+transport+on+short+distance

Constraint	Solution
7. Fuel issues	LNG or other (5.2)
8. Maintenance	As generally for SSS ships (3.5).
9. Redundancy	Yes (5.2).
10. Secure ICT	Same.
11. Heavy traffic	As SSS (3.6)
12. Direct control	As SSS (3.6)
13. Heavy weather	Less severe, more protected waters.
14. Documented safety	Same.
15. Dangerous cargo	Same.

5.1 Reduced crew

The ship will operate on a 24/7 schedule where ports are called on at any time of day or night. Port side operations must be automatic and one could fairly easily extend this to automated crane operations from ship to quay side. The container would presumably be loaded directly onto a chassis for trucks to pick up later.

A problem with 24/7 operation is nighttime noise in ports close to residential areas. This may also have to be addressed.

A further extension to this would be to have a fully unmanned ship. This would reduce costs and would relieve crew of port operations at awkward times of the night. The ship would also be able to load more cargo or could be reduced in size.

5.2 Ship design

The current design is with LNG as fuel and with a single engine. This would probably have to be changed to diesel electric and perhaps podded propulsion to increase maneuverability in port. It would rely on automated berthing systems and cargo handling where cargo units were loaded on or off the ship directly from the quay side where trucks deposit or pick them up during day time. This may include forms of automated guided vehicles (AGV) in larger ports.

With generator sets on deck, running on LNG from tanks where superstructure would have been, these could later be exchanged with batteries or fuel cells, dependent on developments in technology.

6. The unmanned shuttle barge

Another concept that came up during discussion is a relatively small shuttle barge for transport of a few containers between a terminal and smaller destination ports. These could be sea or rail terminals and the voyage could cover distance up to about 200 km. The barge would be similar to the DNV-GL ReVolt concept, but smaller (Figure 3).

Figure 3 – DNV-GL ReVolt Concept ship[2]

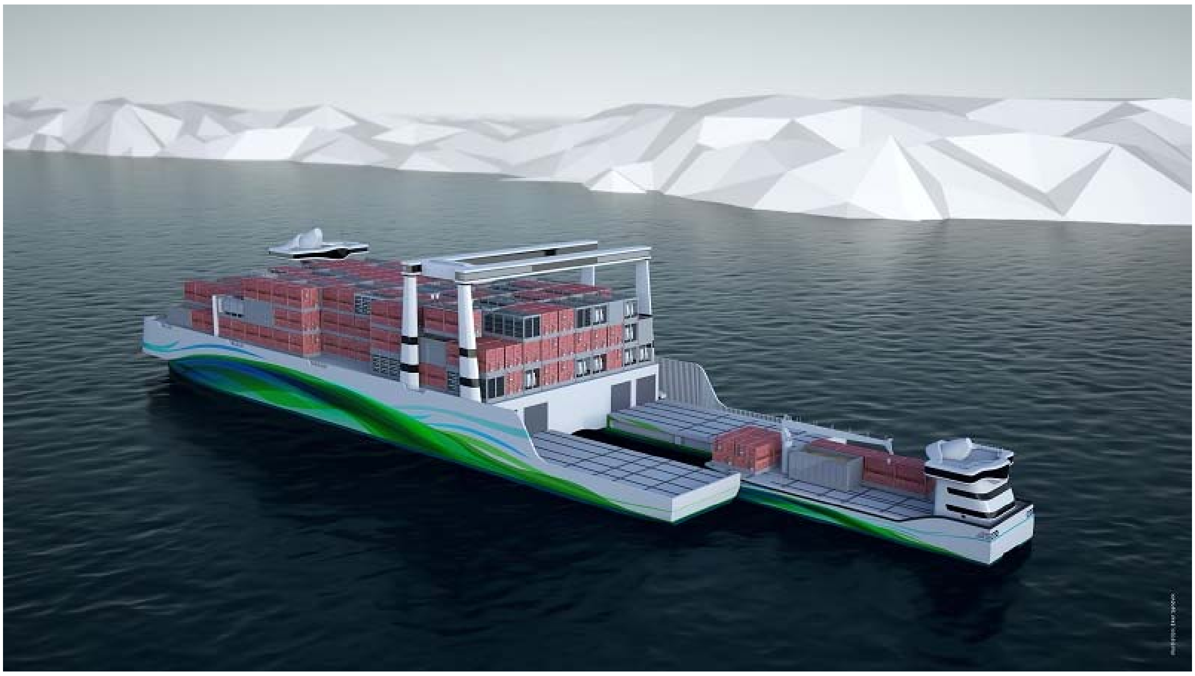

Figure 4 – Concept using a mother ship with barges[3]

[2] https://www.dnvgl.com/technology-innovation/revolt/index.html

It could also be used in a related concept, suggested by NCE Marine and NCL in Norway Figure 4). The concept includes a mother ship that can use this type of shuttles to reach smaller destinations along the route. In the original concept the shuttles were manned and had their own cranes, but unmanned units may also be attractive in such a configuration.

In both cases the same shuttle concept could be used. The general characteristics of the shuttle compared to the general unmanned SSS are summarized in the table.

Table 4 – Comparison between short and deep sea shipping constraints

Constraint	Solution
1. No crew	Fully unmanned.
2. No passengers	Ok.
3. Quality SCC	Ok. Need more direct control also for cargo handling.
4. Simple design	Fairly simple (6.1)
5. Automated cargo	None, dependent on shore support.
6. Fire protection	Ok
7. Fuel issues	Battery.
8. Maintenance	Very low.
9. Redundancy	Not critical, but probably an implicit effect of design (6.1)
10. Secure ICT	Ok
11. Heavy traffic	As SSS (3.6)
12. Direct control	As SSS (3.6), but controlled directly from mother ship
13. Heavy weather	Sheltered waters.
14. Documented safety	Same.
15. Dangerous cargo	Same.

6.1 Ship design

The ship should be based on battery power for propulsion and should be cheap enough to allow it to stay at port to recharge without compromising return on investments.

It only has cargo carrying capability and no cranes. It needs good manoeuvrability for remote control to berth.

Ballast system may be necessary, dependent on general design and carrying capacity.

It would be designed for operation in protected waters only.

[3] http://www.shortsea.tv/SitePages/News.aspx?t=Helt+ny+l%C3%B8sning+kan+l%C3%B8fte+last+fra+vei+til+sj%C3%B8

6.2 Application for inland waterways

The barge as described here could also be used in inland waterways, particularly in areas where depth may be a restriction for ordinary barges.

The general ideas could also be used in a larger design, replacing conventional barges. However, it is not clear if batteries would be a viable alternative as charging times and battery costs may be problematic. LNG or similar clean fuel could be a very good alternative.

7. Conclusions

The three cases described in sections 4 to 6 are all likely candidates for early tests of unmanned ships. Probably is the inland barge or the unmanned shuttle barge the simplest to implement in terms of technology and regulatory constraints. If the concept was used initially on a short range operations in waters restricted for other traffic and only within one jurisdiction, most constrains would be fairly straight forward to satisfy.

The short sea ship is also an interesting proposal, but requires more works as it operates in waters open for other traffic and often also in several jurisdictions. The larger short sea ship would also be more demanding in terms of port infrastructure and operators' business model.

Short sea is in general a more accommodating area for unmanned ship than deep sea as investments generally will be lower and operational and economical risks correspondingly smaller.

References

/1/ MUNIN Deliverable D10.2, New ship designs for autonomous vessels, 2015-08-31.

/2/ Watery assets, Global Risk Dialogue Autumn 2008, Allianz Global Corporate & Speciality (http://www.agcs.allianz.com/assets/PDFs/GRD/GRD-2008-02-en.pdf).

/3/ MUNIN Deliverable D9.3, D9.3: Quantitative assessment, 2015-08-31.