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AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

D 2.3: Current status and market opportunities for SSS

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List of Acronyms

Abbreviation / acronym	Description
BRI	Belt and Road Initiative
CEF	Connecting Europe Facility
CETMO	Centre for Transportation Studies for the Western Mediterranean
CNC	Core Network Corridors
COP21	The 2015 United Nations Climate Change Conference
D2.3	Deliverable number 3 belonging to WP 2
DCS	Data Collection System
DIP	Detailed Implementation Plan
DSS	Deep Sea Shipping
EC	European Commission
EGD	European Green Deal
EU	European Union
GHG	Greenhouse gas
GTMO 5+5	Group of Transport Ministers of the Western Mediterranean
ICT	Information and Communications Technology
IMO	International Maritime Organization
Lo-Lo	Lift-on/lift-off ships
MARPOL	The International Convention for the Prevention of Pollution from Ships
MOSES	AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping
Med	Mediterranean
MoS	Motorways of Sea
Ro-Ro	Roll-on/roll-off ships
SSS	Short Sea Shipping
TEN-T	Trans-European Transport Network
UK	United Kingdom
UN	United Nations
WP	Work Package

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Executive Summary

Ports play a decisive role in the EU's external and internal trade. Although ports and especially Deep Sea Shipping (DSS) ports are integral nodes within multimodal logistic flows, Short Sea Shipping (SSS) and inland waterways are not so well integrated. As the European Union (EU) has aimed for a modal shift from road transport to other more sustainable transport modes, such as rail or waterborne transport, Short sea shipping (SSS) has gained more attention. After liquid bulk, containers have been the dominant type of cargo in EU Short Sea Shipping. Mediterranean is one of the Europe's major sea basins. The perspectives of container shipping in the western Mediterranean side reveals a trend of expansion of major infrastructure in the main ports while in the Eastern side of the Mediteranean sea, Black sea and Suez Canal offer a significant opportunity in the container transportation to Eastern European trade areas.

The aim of the MOSES project is to enhance the SSS component of the European supply chain by addressing the vulnerabilities and strains related to the operation of large containerships. A two-fold strategy has been followed from the begining, in order to reduce the total time to berth for TEN-T Hub Ports and to stimulate the use of SSS feeder services to small ports that have limited or no infrastructure. In this respect, this Deliverable is focused on the identification of the market opportunities and business cases. The main objective of this task is to identify market opportunities for the MOSES innovations in the context of the SSS part of the container supply chain and develop the MOSES Business Cases 1 (Western MED-Spain) and 2 (Easter MED-Greece), while exploring other promising business cases (in view of the MOSES Transferability Business Case).

The study has been focused on the logistical aspects of the container supply chain to map the current status and problems. Initially, information has been collected through desktop research and analysis on the current container traffic flows in Europe, including container traffic flows between major European container Hub Ports and connected small ports nearby, and also the intermodal interfaces in Hub ports and connected small ports. Subsequently, the identified market opportunities are made more specific by elaborating two different viable business cases though extensive contacts with external stakeholders. The development of the MOSES Business Cases includes a preliminary evaluation of the related business models using the triple layer Business Canvass model that includes preliminary indications on benefits of implementing the MOSES innovations for the specific cases, as well as an assessment of the required costs and the technical and operational limitations that may act as a barrier for implementation. The information provided in D2.3 will also be used as input for the technical development of the MOSES innovations, in particular to the

innovative feeder. These are to be considered first input for the cost-benefit analysis that will be conducted after the MOSES pilot demonstrations (Task 7.5) and for the MOSES exploitation activities (Task 8.3). It should be noted that due to its timeline (between M12-M18) and the fact that the full content about the MOSES matchmaking platform shall be ready later, the transferability business case will be managed and executed in the context of Task 6.3.

1. Introduction

1.1 Purpose of the document

This deliverable has been focused on the identification of market opportunities and business cases (as mentioned M1-M6 in the grant agreement). The main objective of this deliverable is to identify market opportunities for the MOSES innovations in the context of the SSS part of the container supply chain and develop the MOSES Business Cases 1 (Western MED-Spain) and 2 (Eastern MED-Greece), while exploring other promising business cases (in view of the MOSES Transferability Business Case).

In this respect, this study is focused on the logistical aspects of the container supply chain to map the status and problems. Initially, information and data have been collected through desktop studies and research analysis from various sources such as the EU Transport publications, Peer reviewed academic articles, doctoral thesis, etc, on the current container traffic flows in Europe. Particular attention was dedicated to two aspects of the container traffic flows between major European container Hub Ports and connected small ports, and also to the intermodal interfaces in Hub ports and connected small ports. Later, the identified market opportunities were made more specific by elaborating two different viable business cases though extensive contacts with external stakeholders in the Mediterranean area.

1.2 Intended readership

The development of the MOSES Business Cases will include a preliminary evaluation of the benefits of implementing the MOSES innovations for the specific cases, as well as an assessment of the required costs and the technical and operational limitations that may act as a barrier for implementation. This task will provide the information that will also be used as input for the technical development of the MOSES innovations in particular to the innovative feeder, input for the cost-benefit analysis that will be conducted after the MOSES pilot demonstrations (Task 7.5), and also for the MOSES exploitation activities (Task 8.3). It should be noted that due its timeline (between M12-M18) and the fact that the dissemination material advertising of the MOSES matchmaking platform shall be ready in M12, the transferability business case will be managed and executed in the context of Task 6.3.

1.3 Document Structure

The methodology for providing this deliverable is based on desktop analysis from a wide scope of reviewing the current European motorways of the sea, and the Short Sea Shipping around Europe at the beginning, then narrowing down the discussion to the container cargo traffic in the Mediterranean basin with its opportunities and barriers. For this part, the main references are the OnTheMosWay of the Sea project and the Eurostat publications on the EU Maritime Transport. However, other references such as peer review articles, European official reports, and books are referred to and listed in the Reference chapter. Following up, the deliverable is focused on describing and developing the MOSES Business Cases, where port typologies, i.e., the classes of ports that are of interest to the MOSES innovations, are identified. Twenty EU container ports in the Mediterranean Sea are targeted, based on their container traffic from a European database, and suggested as examples of port typologies for each of MOSES innovations. Later, the deliverable is followed by two specific business case analyses in detail on feeder vessels, first for the case of the port of Piraeus and second for the port of Valencia. In the end, the Canvas business model which intends to better understand and visualize the relationships between the economic, environmental, and social aspects, is introduced and discussed for each of the MOSES innovations. The document consists of ten chapters. The methodology is to review the current status of EU Motorways of the Seas in a wide scope, then to narrow it down to analyse the current status of Short Sea Shipping in the Mediterranean Sea, and finally conducting two specific business cases analysis for feeder vessels, as described in detail below:

- **Chapter 2 to Chapter 3**:

This part provides some information and data on the current traffic flow of motorways of the sea in European waters and continues with a focus on the Short sea shipping (SSS) around Europe. This information helps to understand better the status of SSS in Europe which is addressed more in detail in following chapters. Furthermore, European legislative drivers and the related challenges are discussed with references mostly from the European publications.

- **Chapter 5 to Chapter 8**:

Following the first part, this part is reviews the evolution of the container traffic in the Mediterranean Sea, with the focus on the status of the container transports in Mediterranean Sea, the opportunities that Med ports has had, and also some related problems discussed. It reviews more in detail the container traffic flow in two areas of Eastern Mediterranean and Western Mediterranean areas with a focus on feeder ships, transhipment, and future perspectives. It also contributes to developing the two specific business cases analysis for feeder vessels in Chapter 9.

- **Chapter 9 to Chapter 10**:

Finally, the last part on MOSES Business Cases starts with the MOSES overall concept on its strategic vision to enhance the Short Sea Shipping (SSS) component of the European supply chain, and followed by identifying port typologies, i.e., the classes of ports that are of interest to the MOSES project and their characteristics. In this respect, the proposed target ports for the MOSES innovations of Innovative Feeder Vessel, Robotic Container-Handling System, Autonomous Tugboats, and Matchmaking

Logistics Platform are discussed. Then, two specific business cases analysis for feeder vessels are conducted: 1-Analysis of the potential traffic for a container feeder line (Lo-Lo): the case of the port of Piraeus and 2- Analysis of the potential traffic for a container feeder line (Lo-Lo): the case of the port of Valencia. Subsequently, the Canvas business model which intends to better understand and visualize the relationships between the economic, environmental, and social aspects, is introduced and discussed for each of the MOSES innovations, keeping in mind that these models are the preliminary versions, and they will be addressed and discussed more in detail in WP6 and WP8.

2. The European Motorways of the Sea

In 2018, the 335 ports of the TEN-T core and comprehensive networks handled 3.8 billion tonnes of cargo (Figure 1). According to this project, six major sea basins can be grouped in Europe : the Baltic Sea, the North Sea, the Atlantic, the Western and the Eastern Mediterranean, and the Black Sea [1]. These sea areas have a more intensive exchange within rather than between basins, even though they are interconnected among each other. Furthermore, there are maritime ports in the European's outermost regions (e.g. the Canary Islands). In 2018, out of the total 3.8 billion tonnes handled, around two thirds were related to Short Sea Shipping (see Appendix 1). Short sea traffic (including feeder traffic) has had in particular a high share in some basins such as the Baltic Sea, the Eastern Mediterranean and the Black Sea [1].

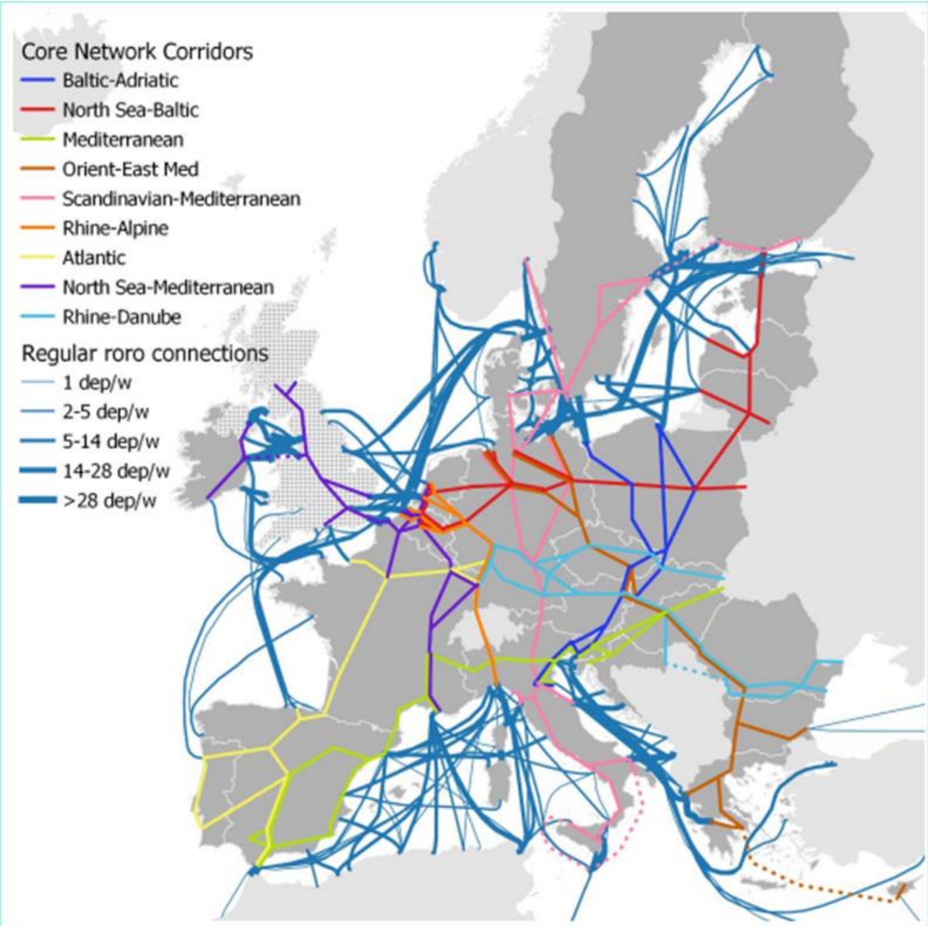


Figure 1: European Core Network Corridors and ro-ro shipping routes

Source: MoS study consortium [1]

Among these six major sea basins, the largest volume of cargo is handled in the North Sea basin followed by the Western Mediterranean and the Baltic Sea. In rank, liquid bulk is most cargo transported by these comprehensive network during 2018 followed by container and then dry bulk (Figure 2).

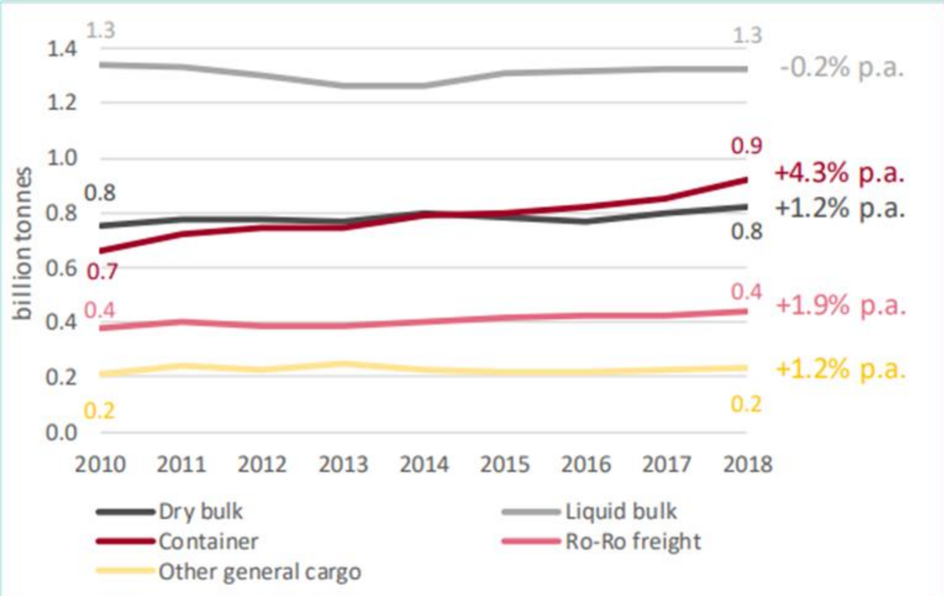


Figure 2: Cargo traffic of major European seaports by cargo type, 2010-2018

Source: ISL based on Eurostat [1], 2019

Regular short sea links are in large numbers between the different sea basins and therefore between different regions of the European TEN-T Network. In this context, two types of Short Sea Shipping can be highlighted: the ones bridging straits or connecting islands (e.g. the Strait of Gibraltar) and the other long-distance services along coastal lines. The former is sometimes part of a core network corridor (e.g. the connection between South Italy and Malta), while the second type of short sea sevices connect different corridors (e.g. services between Spain and Italy in the Western Mediterranean) [1]. Despite a relatively small number of direct deep-sea services, the Black Sea and the Baltic Sea strongly rely on short sea connections with the Mediterranean Sea and the North Sea, respectively. In the South, the Black Sea is connected to the Mediterranean with about twenty short sea container services and five ro-ro services (excluding car carriers). The relevant maritime traffic in each of these six sea basins are summarised below.

Western Mediterranean Sea

In the Western Mediterranean basin five core network corridors start/end. The various Ro-Ro connections in the Western Mediterranean Core Network Corridors (CNC) ports extend the North-South corridors to North Africa [1]. There is therefore a large exchange between the Motorways of the Sea and corridors. For example, the port of Algeciras provides the shortest sea distance and frequent services to/from Morocco. Barcelona, Valencia, Genoa, and Marseille provide a high number of long-distance services to north of Africa in Mediterranean Sea. Malta is also connected to the continent via Italian ports at the southernmost tip of the Scandinavian-Mediterranean Corridor (see Figure 3). Furthermore, there are East-West connections between Italy and Spain, an alternative to the land-based transport (see also Appendix 1).

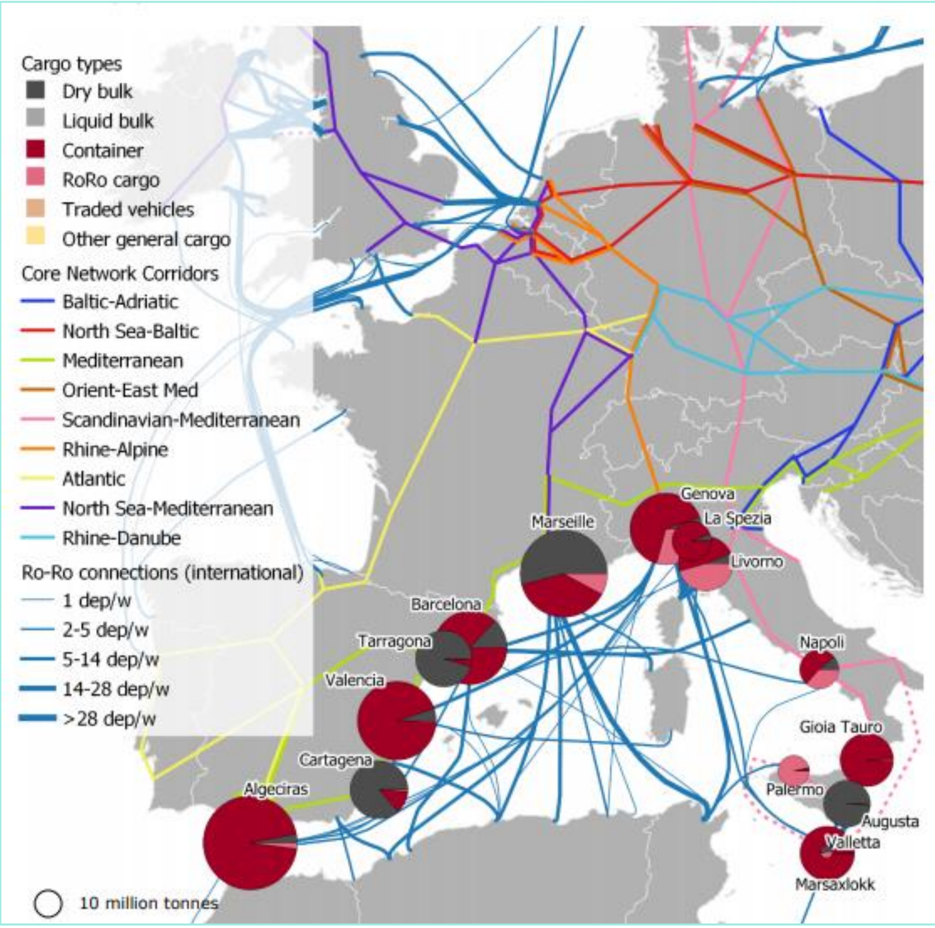


Figure 3: Core Network Corridor ports and ro-ro services in Western Mediterranean, 2018

Source: ISL [1]

Eastern Mediterranean and Black Sea

In the Eastern Mediterranean, the ports host five core network corridors, three of which concern ports in the Adriatic Sea : Scandinavian-Mediterranean, Baltic-Adriatic and Mediterranean. The Adriatic area has a high traffic network of ro-ro services, connecting the East coast of Italy with Croatia and with neighbouring Albania and Montenegro. Morever, there are various services connecting the Adriatic CNC ports with Greece. For cargo arriving from western Europe, they provide an alternative to the landbased Orient-East Med Corridor for cargo to Greece. The Orient-East Med Corridor itself connects Central Europe with Greece and on to Cyprus (connected to the EU with container services, among others to/from Piraeus and Thessaloniki).

Finally, the Rhine-Danube Corridor links the Romanian ports of Constanta and Galati with Central and Western Europe. In this basin, there are nine ports with an annual maritime traffic of more than ten million tonnes, the largest ones being Trieste, Piraeus and Constanta (see Figure 4). The port of Constanta is one of the largest player in this segment with around 25 million tonnes handled in 2018 [1]. Ro-Ro traffic is also slightly above average, Trieste and Piraeus being the major players and another eleven ports handling ro-ro traffic in the basin (see also Appendix 1).

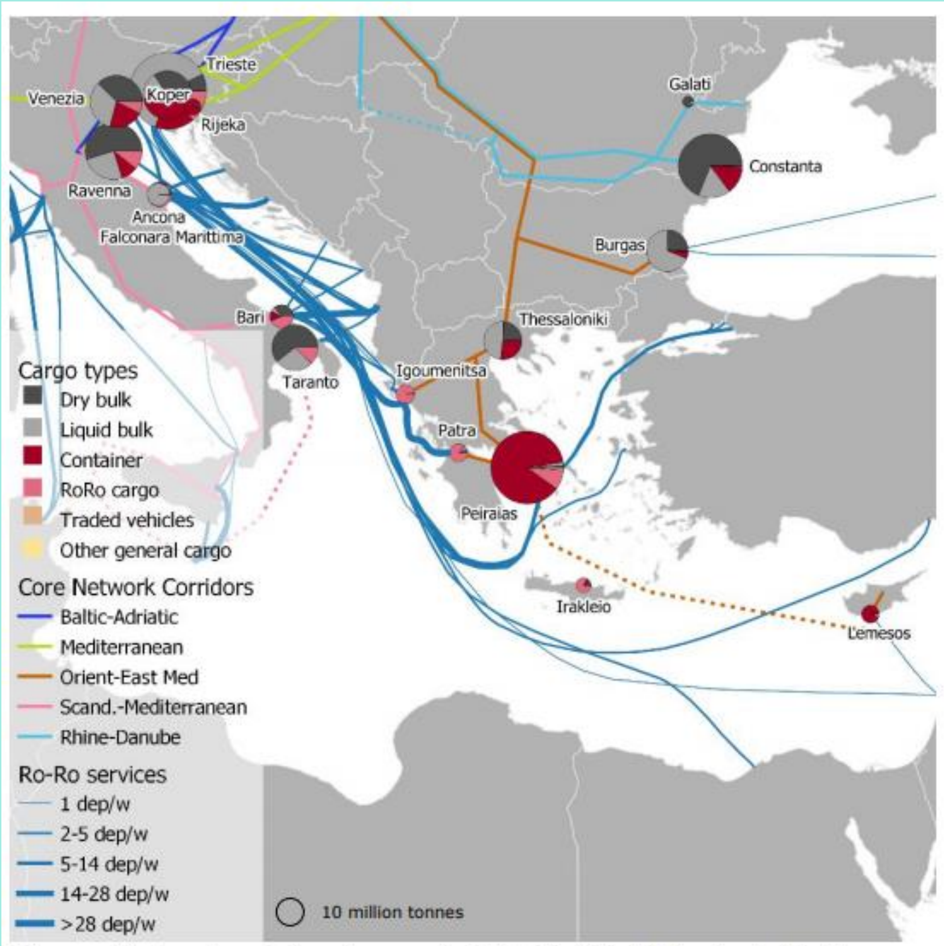


Figure 4: Core Network Corridor ports and regular ro-ro services in the Eastern Mediterranean and Black Sea, 2018

Source: ISL [1]

Baltic Sea

There are four core network corridors that connect the Baltic Sea with the EU hinterland. Two corridors start in ports of the southern coast (Northeast Germany and North Poland) and move southwards (Orient-East Med and Baltic-Adriatic). The Baltic Sea ports connect them with Sweden and Denmark through a dense network of ro-ro services and with other Baltic Sea countries through ro-ro and container services, including the non-EU countries Norway and Russia. Further to the West, the

Scandinavian-Mediterranean Corridor connects to the ports of Rostock and Lübeck with the continental European hinterland. For transport between Finland and Sweden, the Scandinavian-Mediterranean Corridor includes a Short Sea Shipping link (see Figure 5).

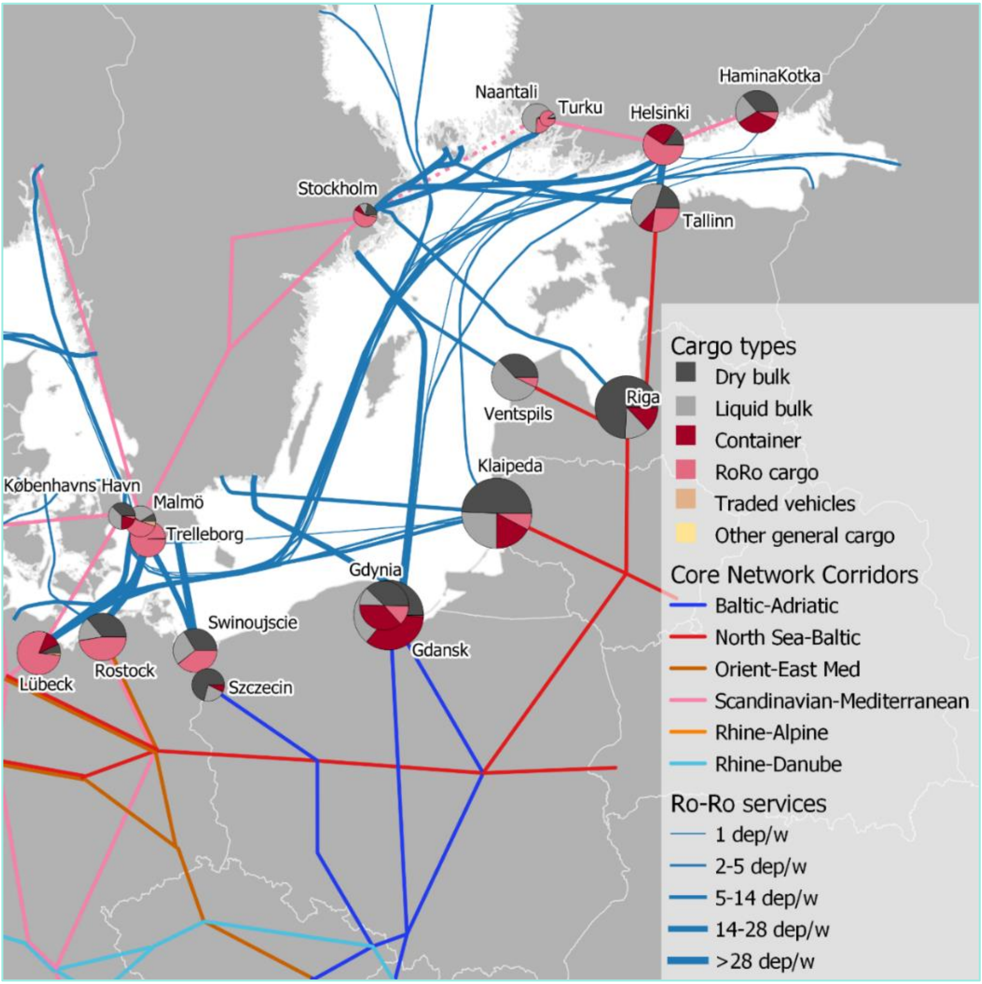


Figure 5: Core network Corridor ports and regular ro-ro services in Baltic Sea basin,2018

Source: ISL [1]

In addition, there is a strong interchange between the North Sea and the Baltic Sea (see Appendix 1).

North Sea

North Sea core network corridor ports are by far the busiest group among the six sea basins (Figure 6). Six core network corridors connect the North Sea ports with their hinterland. Most of them are North-South corridors and therefore the important role of the hinterland connections of the North Sea ports. The Scandinavian-Mediterranean Corridor marks the eastern end of the North Sea and is the only one connecting Sweden (and also Norway) with the main continent [1]. The North Sea-

Mediterranean Corridor includes Europe's busiest ro-ro route, namely Dover-Calais, and also Dover-Dunkerque (see Appendix 1).

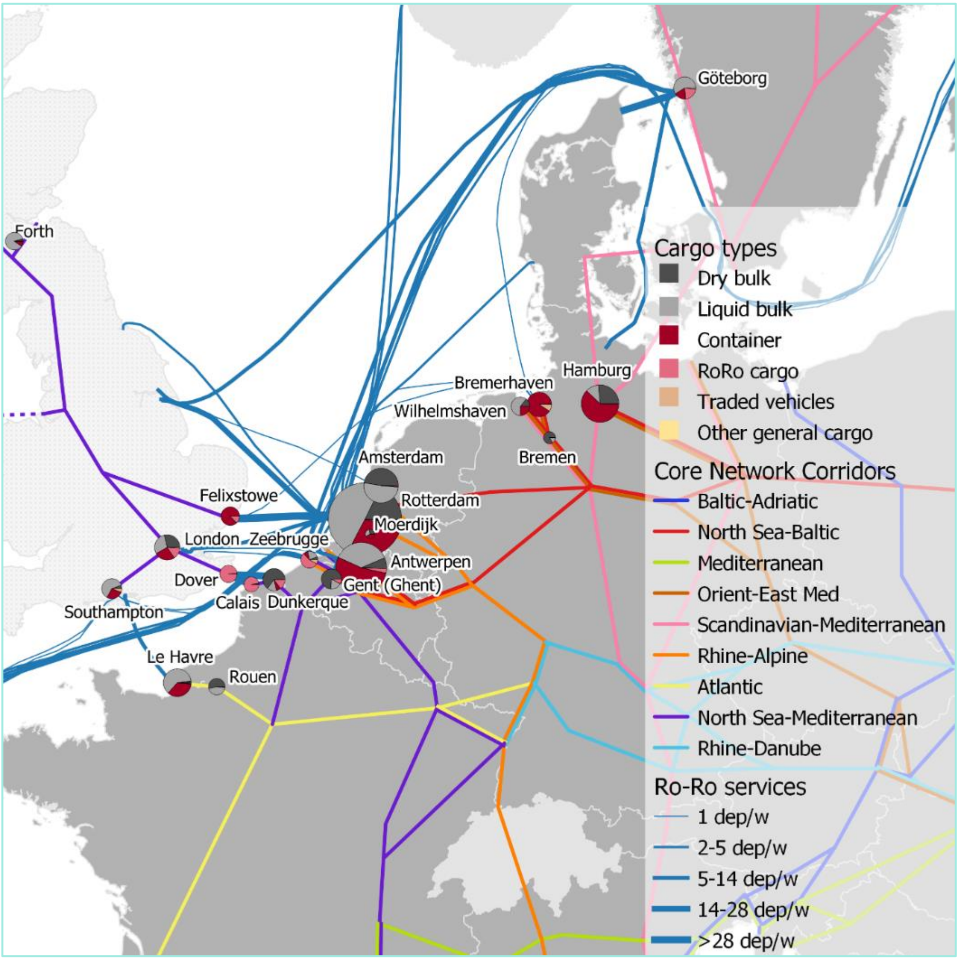


Figure 6: Core Network Corridor ports and regular ro-ro services in North Sea basin,2018

Source: ISL [1]

Atlantic Sea

The European Atlantic Basin includes Portugal, Ireland, France, Spain, and the western coasts of Great Britain (see Figure 7). The most important core network corridors connecting the basin's ports with the hinterland are the Atlantic and the North Sea-Mediterranean Corridors. The former corridor includes Rouen and Le Havre as the two North Sea ports and Algeciras in the strait of Gibraltar. The second important corridor for the Atlantic Basin is the North Sea-Mediterranean Corridor, more specifically its northern part connecting Ireland and Great Britain with the European motherland (see Appendix 1).

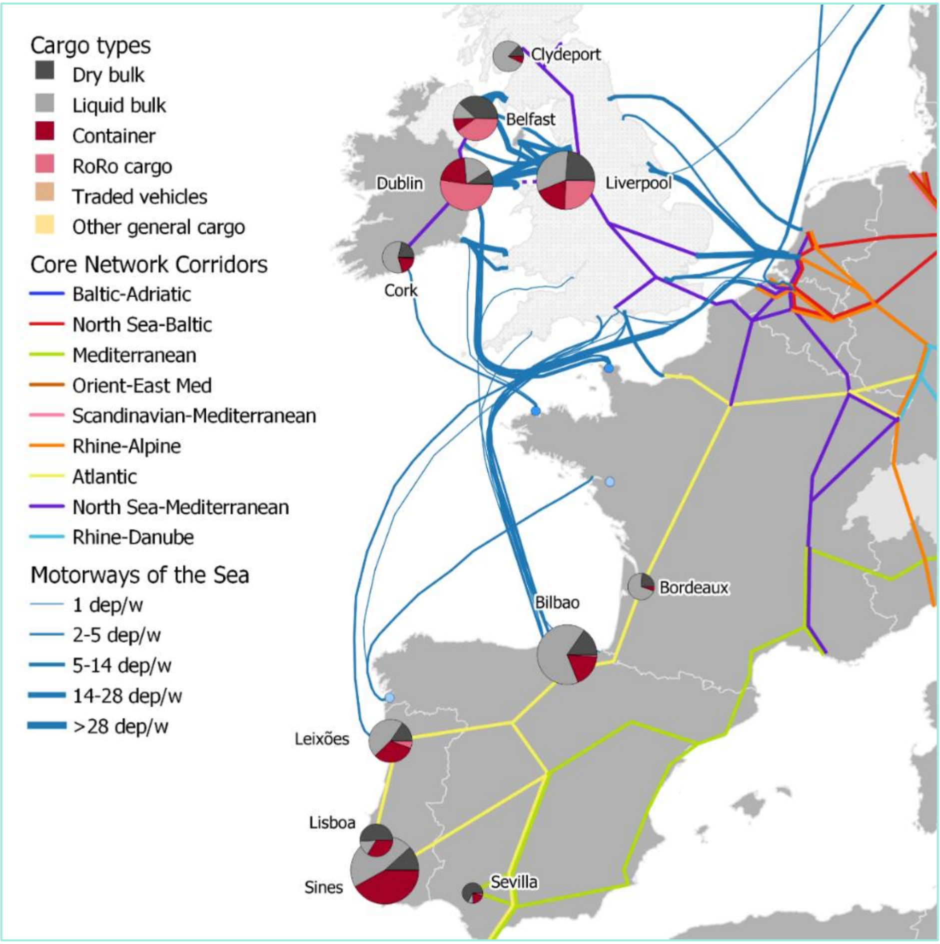


Figure 7: Core Network Corridor ports and regular ro-ro services of EU ports in the Atlantic basin, 2018

Source: ISL [1]

3. The European Short Sea Shipping (SSS) network

In recent years, the European Union (EU) has tackled the negative impacts of land transport such as road accidents and congestion, etc through setting goals for a competitive and also resource-efficient transport system. One of the main goals has been a modal shift from road transport to other transport modes which are more sustainable, such as waterborne transport. In this way, not only reduction in the emissions is achived but also Europe benefits from decreased congestion and accidents. Developing the Trans-European Network (TEN-T), the European Commission planned thirty priority axes and projects including land to sea transport networks and the implementation of Short Sea Shipping (SSS) lines and services. The European Commission also defined the Short Sea Shipping (SSS) as maritime transport of goods between ports across the EU. In terms of the freight quantity transported to/from the main European ports, in 2017, Short Sea Shipping (SSS) counted more than half [2]. However, the share of Short Sea Shipping (SSS) in total sea transport varies considerably between the reporting countries [3]. The predominance of Short Sea Shipping of goods over deep sea shipping was in particular noticeable in Denmark, Malta, Finland, Cyprus, Ireland, Sweden, Greece, Bulgaria, Italy, Latvia, Estonia, Romania, Poland, Lithuania, as well as in the United Kingdom, Norway, and in the candidate countries Montenegro and Turkey, all with Short Sea Shipping shares of 70 % or more in their main ports (see Figure 8).

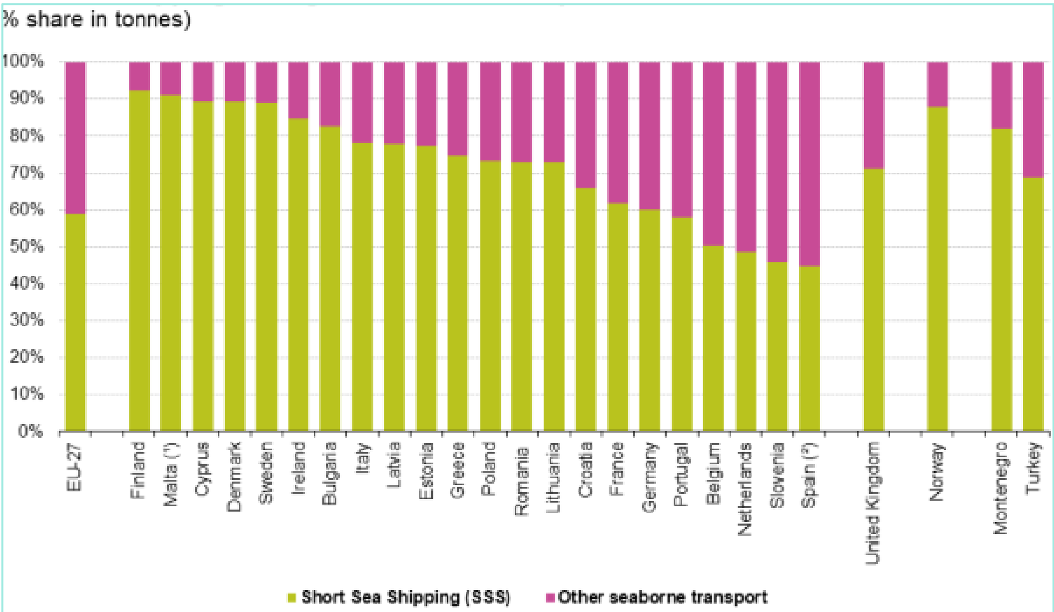


Figure 8: Short sea shipping of freight in total sea transport, 2018 (% share in tonnes)

Source: Eurostat [3], 2020

For Short Sea Shipping, one of the basins that has gained a significant attention in geographical Europe, is the Mediterranean. However, focusing on the Mediterranean basin, the proportion of freight transported by SSS in the same year was near to 33%, even allowing for the fact that some connections are only possible by sea (i.e., towards islands) therefore, the need to implement strategies and action to make SSS more competitive over road transport is there [2]. For majority of the EU Mediterranean countries, long coastlines and / or many settled islands, plays an important role in answering the high share of Short Sea Shipping. A large volume of feeder services to or from hub ports will also explain the high degree of Short Sea Shipping transport in countries which function as regional trans-shipment points.

3.1Short sea shipping by sea region and country

The Short Sea Shipping of goods between main EU ports and ports located in the Mediterranean Sea came to more than 601 million tonnes in 2018. This amounted to 31 % of the total EU Short Sea Shipping tonnages for all sea regions in 2018 (see Figure 9).

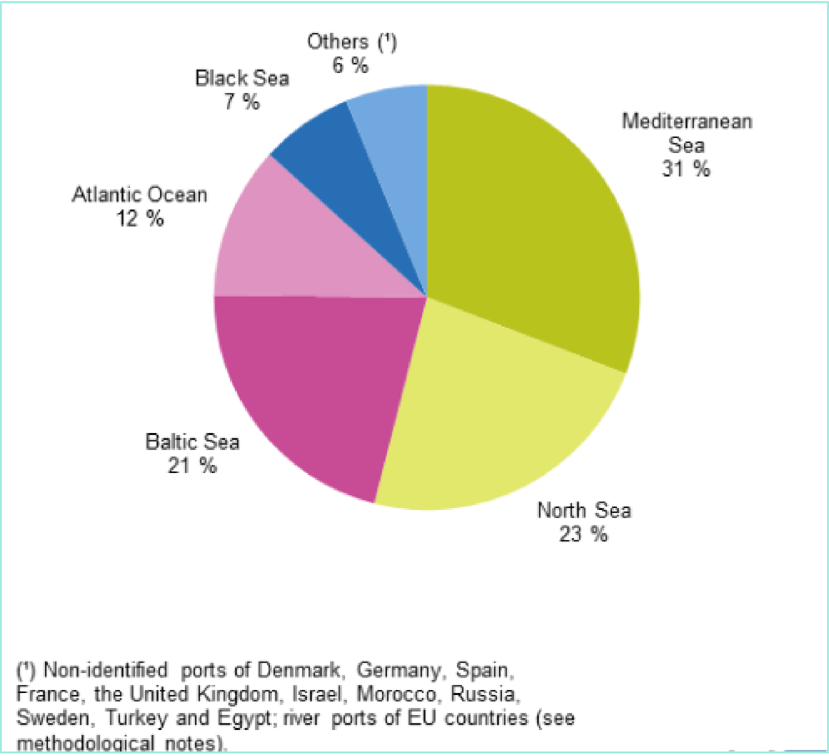


Figure 9: Short sea shipping of freight by sea region of partner ports, EU-27, 2018 (% share based on tonnes)

Source: Eurostat [3] ,2020

For the majority of the EU countries, the highest part of their goods was transported by Short Sea Shipping with the partner ports located in the same sea regions. However, the exception of countries like Latvia in the Baltic, where 39 % of the Short Sea Shipping of goods came from or was destined to ports located in the North Sea, should be considered. Romania and Bulgaria on the Black Sea were other more exceptions, with the largest share of Short Sea Shipping going to/from the Mediterranean Sea not in Black Sea. In comparison, countries with big ports that are called hub ports or transhipment points tends to have substantial Short Sea Shipping with ports in several sea regions.

3.2Short sea shipping by type of cargo, a focus on container traffic

As in 2017, liquid bulk remained the dominant type of cargo in EU Short Sea Shipping in 2018 with almost 41% of the total Short Sea Shipping of goods to and from main EU ports in 2018. Liquid bulk was followed by dry bulk with 21%, containers with 16% and roll on - roll off (Ro-Ro) units with 14% (see Figure 10 and Figure 11).

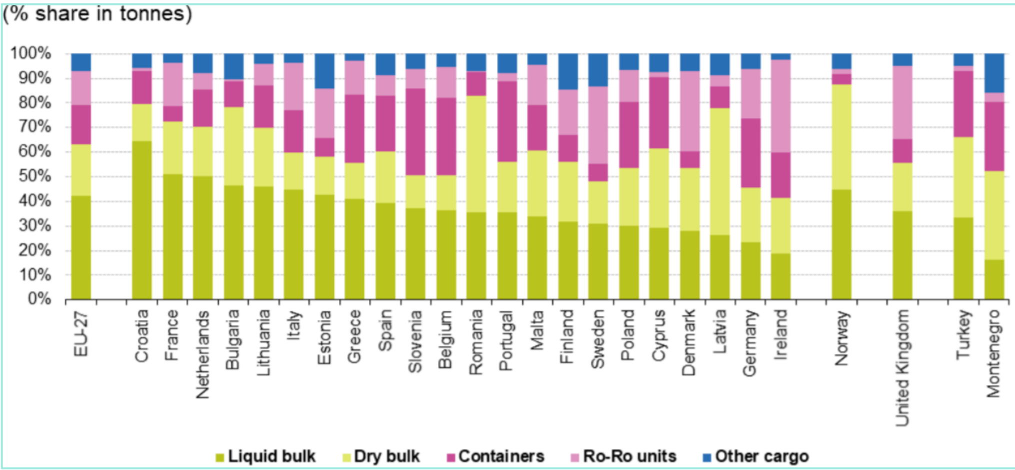


Figure 10: Short sea shipping of freight by type of cargo, 2019 (% share in tonnes)

Source: Eurostat [25]

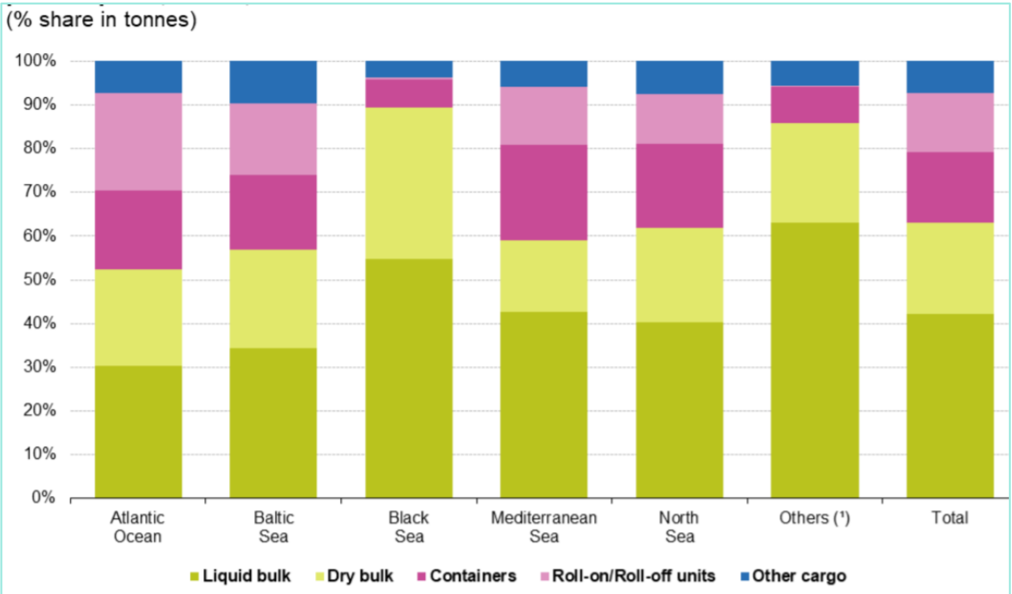


Figure 11: Short sea shipping of freight by type of cargo for each sea region of partner ports, EU-27, 2019 (% share in tonnes)

Source: Eurostat [25]

Unsimilar to the dry bulk goods in Short Sea Shipping, container transport for Short Sea Shipping is concentrated around a limited number of main hub ports. In 2018, the top 5 ports for containers handled almost 38 % of the total short sea shipped containers across the main EU ports (Table 1).

Table 1: Short sea shipping of containers, 2008-2018 (thousand TEUs)

Short sea shipping of containers, 2008-2018
(thousand TEUs)

	2008		2009	2010	2011	2012	2013	2014	2015	2015	2017		2018		Change 2018/2017 (%)		Change 2018/2008 (%)	
	Total	of which empty	Total	Total	Total	Total	Total	Total	Total	Total	Total	of which empty	Total	of which empty	Total	of which empty	Total	of which empty
EU-27	**24 609**	**5 153**	**21 130**	**23 507**	**25 411**	**26 326**	**27 293**	**29 236**	**28 535**	**31 365**	**30 592**	**6 828**	**33 515**	**7 016**	**+9.6**	**+2.8**	**+36.2**	**+36.2**
Belgium	3 973	649	3 860	4 440	4 011	3 843	3 949	4 288	3 988	4 501	3 480	661	**4 038**	**708**	**+16.0**	**+7.1**	**+1.6**	**+9.1**
Bulgaria	184	52	132	140	119	164	174	194	200	203	223	46	**234**	**51**	**+4.9**	**+9.3**	**+26.7**	**-2.4**
Denmark	664	171	571	665	625	590	593	630	609	606	625	178	**640**	**201**	**+2.4**	**+12.9**	**-3.6**	**+17.6**
Germany	5 863	1 277	4 218	4 421	5 401	5 632	5 905	5 921	5 744	5 653	5 418	1 092	**5 486**	**956**	**+1.2**	**-12.4**	**-6.4**	**-25.2**
Estonia	180	50	129	152	198	228	254	261	209	204	230	50	**240**	**53**	**+4.2**	**+6.8**	**+33.4**	**+7.0**
Ireland	1 037	235	806	752	713	705	701	758	854	896	942	225	**976**	**231**	**+3.6**	**+2.9**	**-5.9**	**-1.6**
Greece	655	167	771	801	1 257	1 961	2 225	2 478	2 545	2 728	2 965	564	**3 391**	**704**	**+14.4**	**+25.0**	**+417.5**	**+322.7**
Spain (¹)	4 050	939	3 582	3 975	4 391	4 599	4 513	5 124	5 183	5 527	5 679	1 418	**5 181**	**1 329**	**-8.8**	**-6.3**	**+27.9**	**+41.5**
France (²)	1 485	461	1 241	1 205	1 258	1 128	1 164	1 346	1 434	1 397	1 475	446	**1 451**	**401**	**-1.7**	**-10.0**	**-2.3**	**-12.9**
Croatia	138	51	129	109	111	103	85	95	123	119	145	44	**145**	**38**	**-0.3**	**-14.0**	**+4.6**	**-25.9**
Italy	4 533	427	3 992	4 205	4 202	4 811	4 793	5 396	5 487	6 827	6 236	286	**8 148**	**407**	**+30.7**	**+42.3**	**+79.8**	**-4.6**
Cyprus (¹)	120	38	99	103	245	267	243	273	290	348	354	133	**383**	**154**	**+8.1**	**+15.6**	**+218.3**	**+308.5**
Latvia	231	58	181	256	306	366	385	392	358	390	453	113	**479**	**119**	**+5.6**	**+5.4**	**+107.0**	**+104.5**
Lithuania	372	122	248	295	382	381	403	449	350	442	474	99	**749**	**221**	**+58.0**	**+122.9**	**+101.2**	**+81.1**
Malta (²)	70	20	74	79	83	82	86	77	67	82	89	28	**94**	**27**	**+5.7**	**-5.0**	**+34.1**	**+37.4**
Netherlands (¹)	3 736	895	3 227	4 090	3 256	2 811	2 720	2 569	2 603	2 626	2 961	1 114	**3 024**	**1 129**	**+2.1**	**+1.3**	**-19.0**	**+26.1**
Poland	856	221	660	850	1 047	1 256	1 494	1 676	1 311	1 801	1 631	331	**1 964**	**436**	**+20.4**	**+31.4**	**+129.6**	**+97.1**
Portugal	960	233	919	953	1 110	1 056	1 206	1 252	1 289	1 383	1 556	271	**1 656**	**287**	**+6.4**	**+6.2**	**+72.4**	**+23.4**
Romania (¹)	390	84	166	158	197	208	241	460	492	561	508	168	**473**	**133**	**-7.0**	**-20.6**	**+21.3**	**+59.2**
Slovenia	225	51	234	308	339	346	397	437	535	557	465	88	**385**	**83**	**-17.2**	**-5.4**	**+71.0**	**+63.7**
Finland	1 599	375	1 120	1 229	1 110	1 189	1 227	1 220	1 223	1 321	1 435	480	**1 411**	**464**	**-1.7**	**-3.3**	**-11.7**	**+23.8**
Sweden	1 129	251	1 056	1 203	1 336	1 277	1 243	1 284	1 148	1 181	1 245	332	**1 289**	**343**	**+3.6**	**+3.3**	**+14.1**	**+36.8**
United Kingdom	3 172	961	2 694	2 875	3 029	3 320	3 445	3 803	4 219	4 535	4 565	1 627	**4 462**	**1 491**	**-2.3**	**-8.3**	**+40.7**	**+55.2**
Norway	563	160	531	601	625	650	664	704	699	697	741	247	**778**	**244**	**+4.9**	**-1.1**	**+38.2**	**+52.7**
Montenegro	:	:	:	:	:	:	:	:	:	:	:	:	**28**	**1**	**:**	**:**	**:**	**:**
Turkey	:	:	:	4 897	5 445	5 976	6 514	6 835	6 673	6 924	7 710	1 797	**8 442**	**2 016**	**+9.5**	**+12.2**	**:**	**:**

Source : Eurostat 2018 [5]

4. Legislative drivers for European Short Sea Shipping (SSS)

The legal framework of maritime transport with regards to the safety of operations and environmental issues, is mainly drived at international level by the International Maritime Organisation (IMO) of the UN. These regulations are also applicable to European-related international shipping, which includes intra-EU voyages, and also many are implemented at EU level by means of EU Directives or Regulations (see Figure 12). Below, some of the mai EU regulations that are legilative drivers for shor sea shipping are briefly discussed.

Decarbonisation, Greenhouse Gas (GHG) Emissions, Alternative Fuels

The European Green Deal (EGD) with ambitious emissions reduction targets to protecting Europe's environment. In this respect, the European Emissions Trading System (EU ETS) is expected to be extended to the maritime sector. Furthermore, the Energy Efficiency Directive 2018/2002/EC has also set a binding goal on energy efficiency target by 2030. There is also an important EU Directive of deployment of Alternative Fuels Infrastructure (2014/94/EU) that requires Member States to draft and notify their national policy frameworks on alternative fuel infrastructure. As regards to maritime, there is a requirement that by the end of 2025 core network ports shall provide Onshore Power Supply (unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits) and LNG bunkering facilities [1].

Air pollution

Air pollution has been the main environmental of the European ports since 2013, according to the The European Sea Ports Organisation (ESPO) annual surveys [31]. At international level, among air pollutants, the sulphur emission has been addressed by the IMO in the MARPOL Convention-Annex VI while at EU by the Marine Sulphur Directive 2016/802/EU. IMO in MARPOL convention also sets international regulations regarding NOx emissions and designated the Baltic Sea and the North Sea as NOx Emission Control Areas (NECAs) [11] requiring all vessels built after 2021 to demonstrate their compliance with NOx emissions reductions of 80% compared to the emission level of 2016 [12].

Infrastructure and Marine Environment

The Environmental Impact Assessment Directive 2014/52/EU provides the rules for assessing the potential effects of projects on the environment, including projects involving coastal zones and the marine environment. Furthermore, there is the Marine

Strategy Framework Directive 2008/56/EC that can also be mentioned aiming at achieving good environmental status of the EU marine waters by addressing i.e., marine litter and underwater noise.

Digital Single Market

The transition towards digitalization and automation is speeding up in the maritime industry. Digital technologies and solutions are being used to increase competitiveness and enhance decarbonization in the international shipping. In this respect, the Europe first addressed in 2010 by the Directive on Ship Reporting Formalities that digitalised the reporting obligations and banned the use of paper forms. In 2019, a new Regulation 2019/1239 for the European Maritime Single Window environment ('EMSWe') was also adopted to to ensure competitiveness and efficiency of European maritime transport sector it is necessary to reduce the administrative burden on ships and to facilitate the use of digital information with the aim of improving the efficiency, attractiveness and environmental sustainability of the maritime transport and contribute to the integration of the sector to the digital multimodal logistic chain. It establishes harmonised interfaces for exchanging information related to ship reporting obligations between public authorities and the maritime industry to facilitate maritime transport and trade. In addition, a proposal for a Regulation on Electronic Freight Transport Information (eFTI) was also introduced by the European Commission in 2018 to simplify and optimize communication between transport operators and authorities by putting in place a uniform legal framework on goods transporting within the EU hinterland.

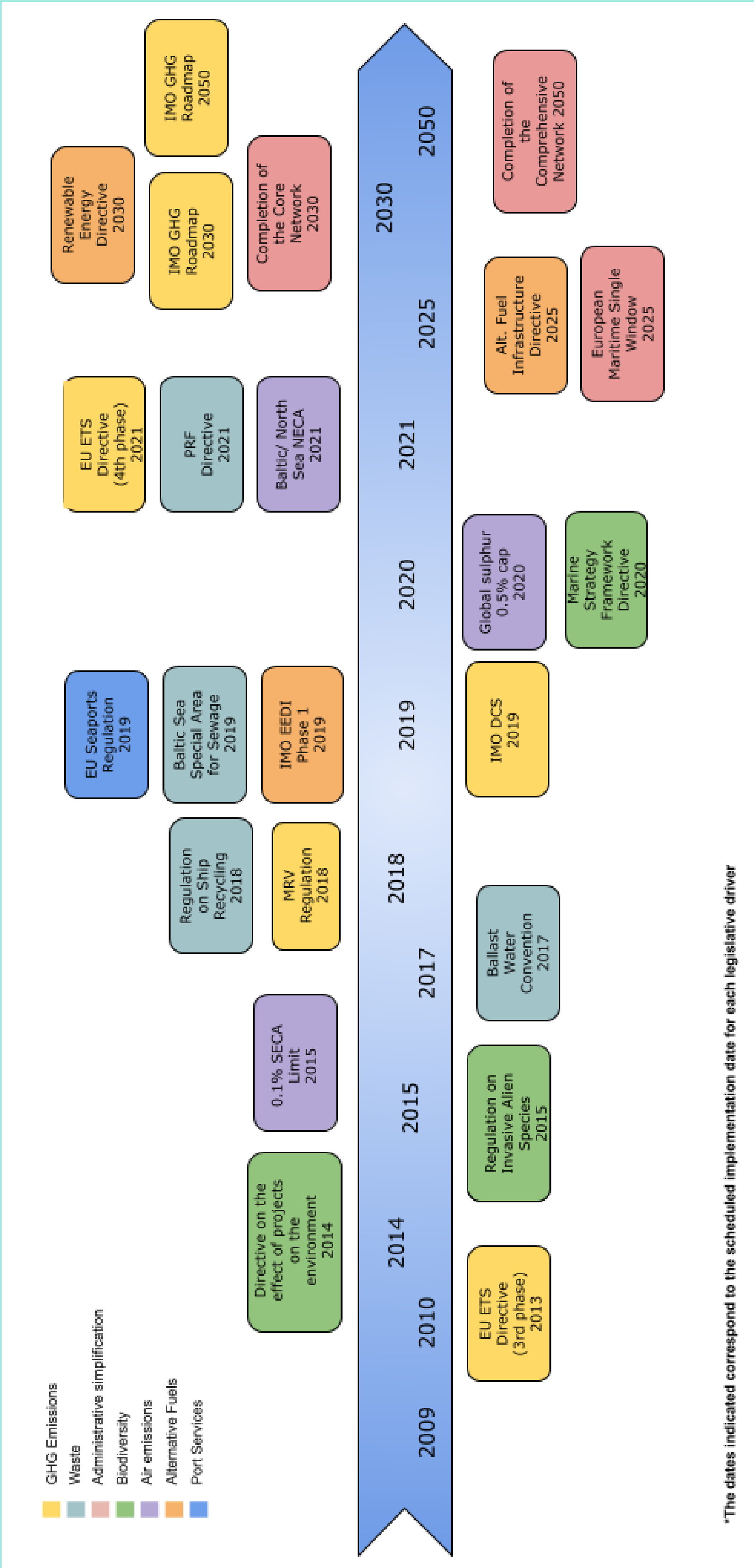


Figure 12: Timeline of Legislative Drivers

Source: Motorways of the Sea Detailed Implementation Plan [1]

5. The Mediterranean Sea and Maritime Networks

The dynamics of Mediterranean activities during centuries became even more evident during the last twenty years due to their high acceleration process related to the concept of globalization. Maritime networks in the Mediterranean have their own hierarchy with a pronounced distinction between hub and gateway ports. European hub ports in Mediterranean Sea mostly have a low distance from the Mediterranean's maritime trunk line, the optimal shipping route between the Strait of Gibraltar and the Suez Canal (see Figure 13).

Figure 13: Maritime traffic of Mediterranean region showing transiting shipping routes

Source: PortEconomics [26]

There is an intense competition for transhipment cargo among transhipment hubs. While ports in Africa are closest to the main shipping route from Suez to Giblatar, most transhipment ports are in Europe, with an exception of African Tanger Med (in Morocco) and Port Said East (in Egypt). It points out that there is also major transhipment opportunities and potentials along the North Africa shore [13]. Gateway ports in the Mediterranean serve as the maritime trade gateways to their hinterlands. Maritime networks in the Mediterranean area, particularly those in the Western Mediterranean, also significantly use roll-on/roll-off vessels to transport much the same mix of products which is moved by container ships. Transportation by roll-on/roll-off ships is especially important for trade between Europe and Africa.

Multimodal connectivity is important for gateway ports but is very limited in reality, except for the port city of Marseilles. Container-terminal productivity differs widely across the Mediterranean ports (Figure 14). It improves with throughput volume because it rises with ship size (more cranes to be in service at the same time on larger ships) and with call size (the number of containers loaded /unloaded per vessel), allowing more-efficient operations.

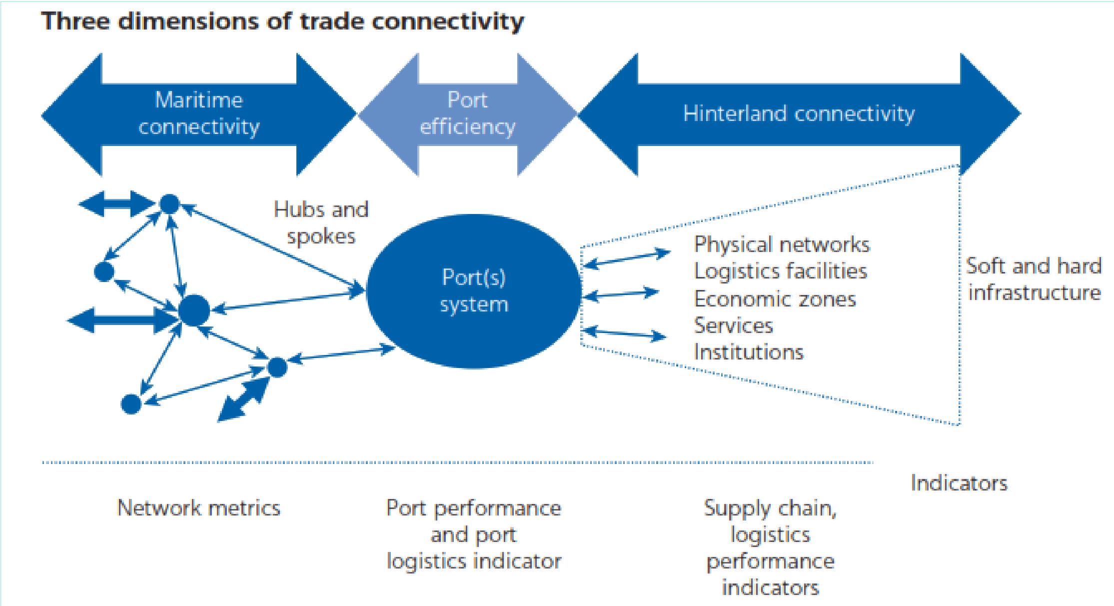


Figure 14: Three dimensions of thee Trade connectivity

Source: Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean [13]

The three dimensions of trade connectivity have complementary drivers of port growth and efficiency (see Figure 14). The main drivers of maritime networks are industry strategies by the shipping lines. In Mediterranean container shipping, major actors such as Mediterranean Shipping Company, Maersk, and CMA CGM (along with Asian companies, especially Chinese ones), have been uniting their operations and are pushing for a hub-and-spoke port system. Such a system also includes regionally focused shipping lines that feed secondary ports in the Mediterranean basin. The Mediterranean has polycentric but increasingly centralized maritime networks that reflects a strong east–west divide, with port connectivity [13]. Traffic from major shipping alliances appears to be an important driver for maritime connectivities and ports efficiency. In this regard, it is to be noted that maritime networks have a global and local scale.

Mediterranean global networks

For direct/adjacent vessel movements between ports, a port's proximity to the trunk line is a strong determinant of extra-Mediterranean traffic (that is, to ports outside the Mediterranean) for transhipment hubs and a few gateways. When all routes and services are included, the diversion distance to the trunk line is compensated for by the gateway effect, which is the ability to connect a port's hinterland, as with Western Mediterranean ports. The connectivity of the Mediterranean's transhipment ports is geographically more diversified than that of its gateway ports in the distribution of traffic to and from extra-Mediterranean regions. Some ports specialize—for example, Piraeus (Greece) focuses on East Asia. Shipping alliance traffic is concentrated along the trunk line, while the largest shipping companies and ports are more diversified.

Mediterranean local networks

As Mediterranean shipping centralizes services, it is becoming more uniform and offering fewer alternatives for main port calls. The share of intra-Mediterranean traffic in total Mediterranean traffic is increasing, with the majority of traffic going between European ports (mainly east–west). Subnetworks also show a strong east–west divide, with Piraeus–Ambarli (Turkey) and Marsaxlokk (Malta)–Valencia (Spain) the respective central nodes [13].

A typology of ports by connectivity and development strategy

Port development is also both place-dependent and path dependent. The preferred strategy for a container port depends on its location on two axes of development—hinterland connectivity, and maritime connectivity. Growth of one and/or both dimensions will increase traffic (indicated by size of the circle in the center) [13].

In Figure 15, cell A represents a typical cargo-based port, with a short hinterland connection (indicated by the dotted line in the left of the cell) and only secondary maritime services to other ports, some of which are feeder services to hub ports (indicated by the dotted line in the right of the cell). This type of port represents many ports that have long history based on serving just the city and metropolitan area in which they are located [13]. Path A→B2→C3 in below figure shows a development strategy focused exclusively on transhipment with maritime services evolving from direct and feeder services (A) to one with some transhipment (B2) to one with transhipment and its own feeder services (C3). Path A→B1→C1 shows a development path focused exclusively on hinterland connectivity (including the cargo base), with the hinterland evolving from (A) to an expanded cargo base (B1, with a heavier land connectivity line) to expansion in the hinterland beyond the cargo base (C1).

A port that already has a cargo base (B1 in Figure 15) and aims to develop transhipment service would add some transhipment services (C2) and ultimately have a stronger cargo base and more balanced demand (D2) than a pure transhipment port. A pure transhipment port (C3 in Figure 15) that focused on hinterland development would evolve towards (D2) and then (E), while the most balanced profile (C2) could follow the same path but from a different initial configuration.

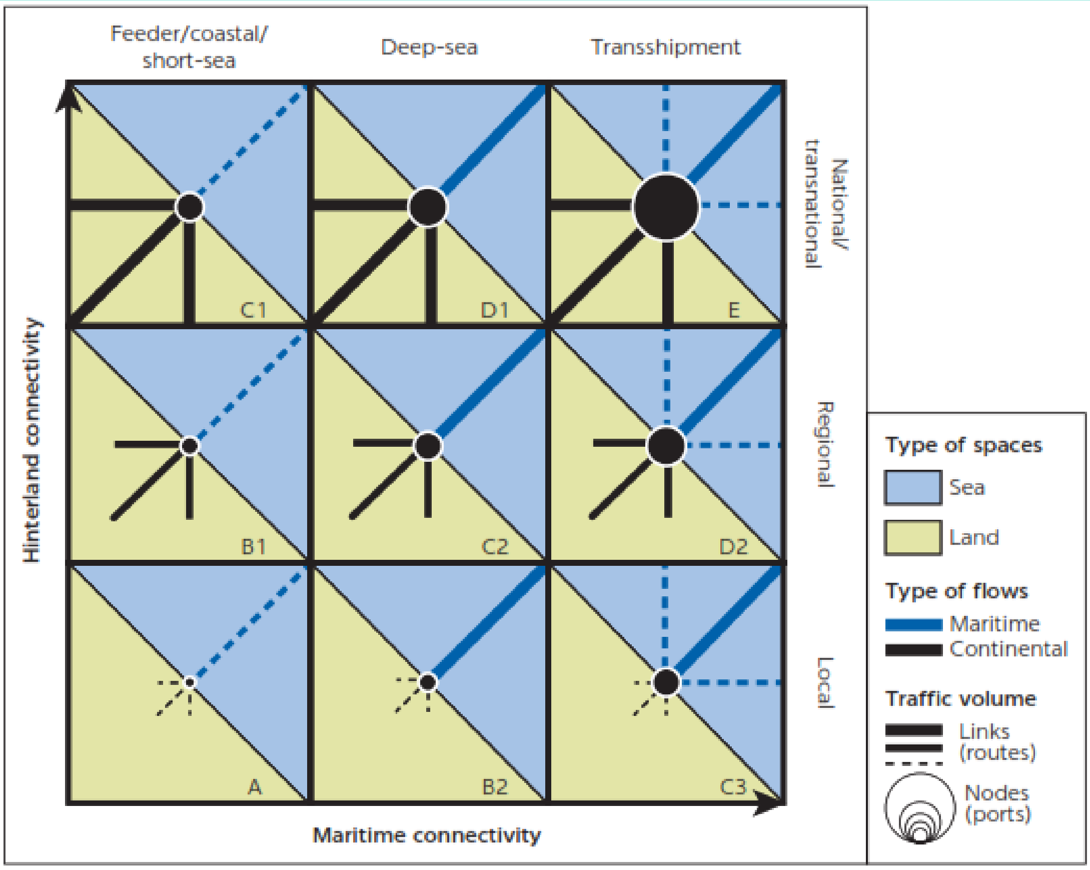


Figure 15: Typology of port connectivity

Source: [13]

6. The Mediterranean Sea and evolution of the Container shipping

Shipping containers are all built to ISO regulations. For shipping purposes, containers must conform to the same width of 8ft to be locked together on board a cargo vessel for safety reasons. There are two dominant lengths and heights of either 20ft long or 40ft long, but the width of all shipping containers is the same. There are different types of containers that have been handled in European Port (Figure 16).

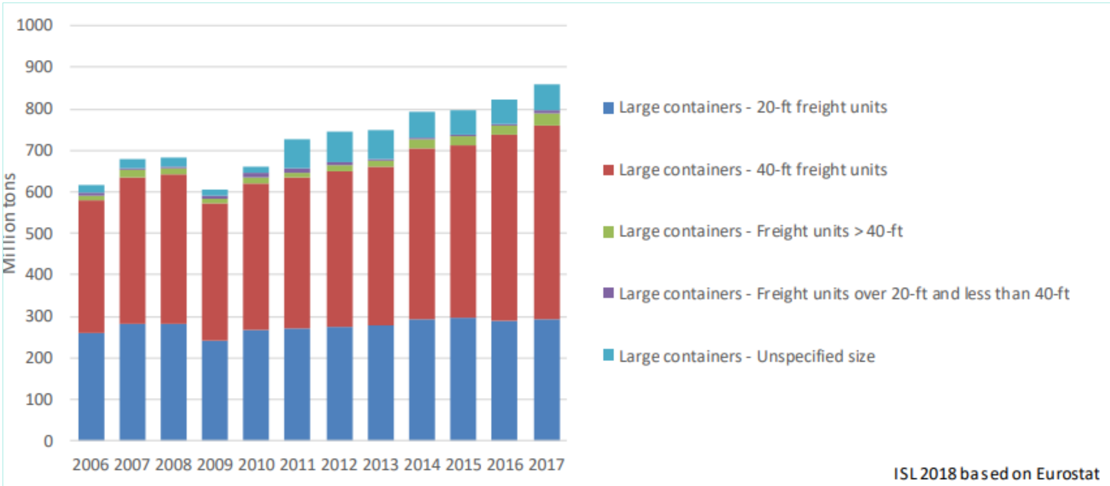


Figure 16: Container Handling in European Ports 2006-2017

Source: DocksTheFuture project, 2018 [15]

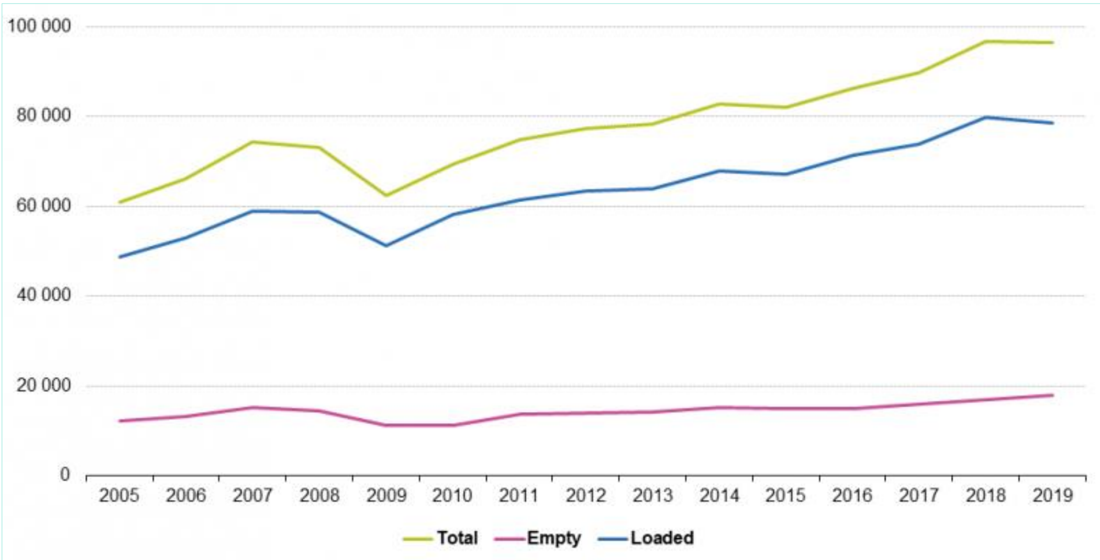


Figure 17: Volume of containers handled in main ports, EU-27, 2005-2019 (thousand TEUs)

Source: Eurostat [27]

In 2019 (Figure 17), 97 million twenty-foot equivalent units (TEUs) were handled in the main European ports. Spain reported the largest volumes of containers handled in Europe in 2019, at 17 million TEUs, represented 18.0% of the EU total in 2019 (Figure 18). Spain was followed by Germany (15.6% of the EU total), the Netherlands (14.4%), Belgium (12.6%) and Italy (11.5%). All together, these five countries had more than 70 % of the containers handled in main EU ports during 2019 [27].

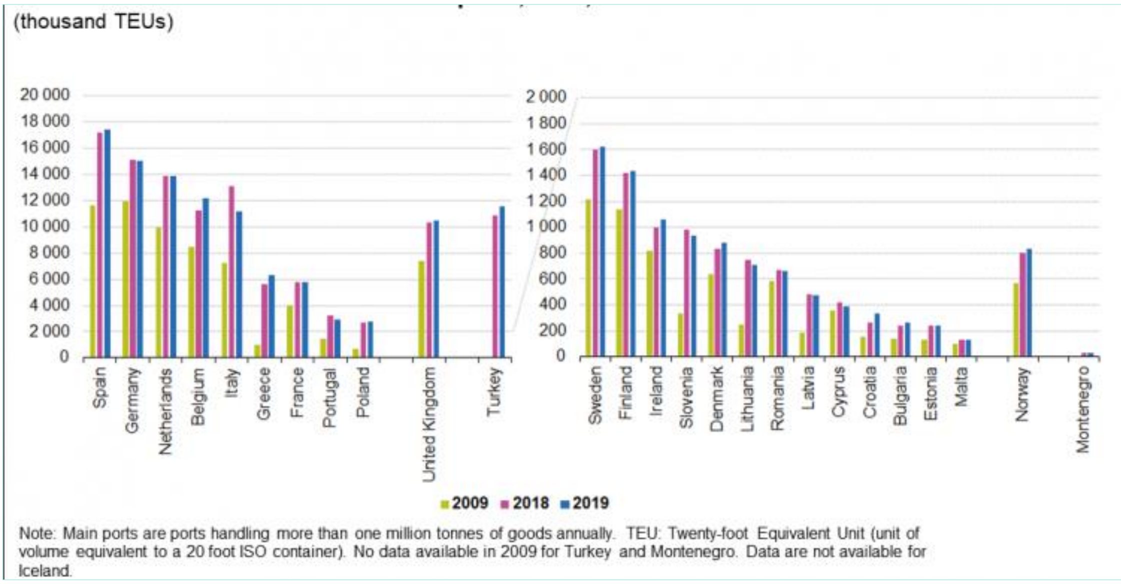


Figure 18: Volume of containers handled in main ports, 2009, 2018 and 2019 (thousand TEUs)

Source: Eurostat [27]

All European countries informed more loaded containers than empty containers. The share of empty containers handled was the lowest in Italy, and the highest in Cyprus and Finland (both 35%).

The Mediterranean region is an attractive sea that acts both as a transhipment region, and also as a destination of Europe and Far East trade route which is very critical for the Europe economy nowadays. During the last two decades, the Mediterranean container throughput increased from almost 20M TEU in 2000 to around 51M TEU in 2015 consistent, with the expansion and maturity of the containerization in the global context of the trade evolution (see Figure 19 and Figure 20). During 1990's, some Mediterranean ports increased their container throughput considerably because of increase in transhipment flows. For instance, currently, pure transhipment hubs in the Med are Marsaxlokk, Algeciras, and Gioia Tauro among others. However, from a historical point of view, in the European Med region, the main ports have been Marseille, Genoa, La Spezia, Valencia, Marsaxlokk, and Piraeus [14].

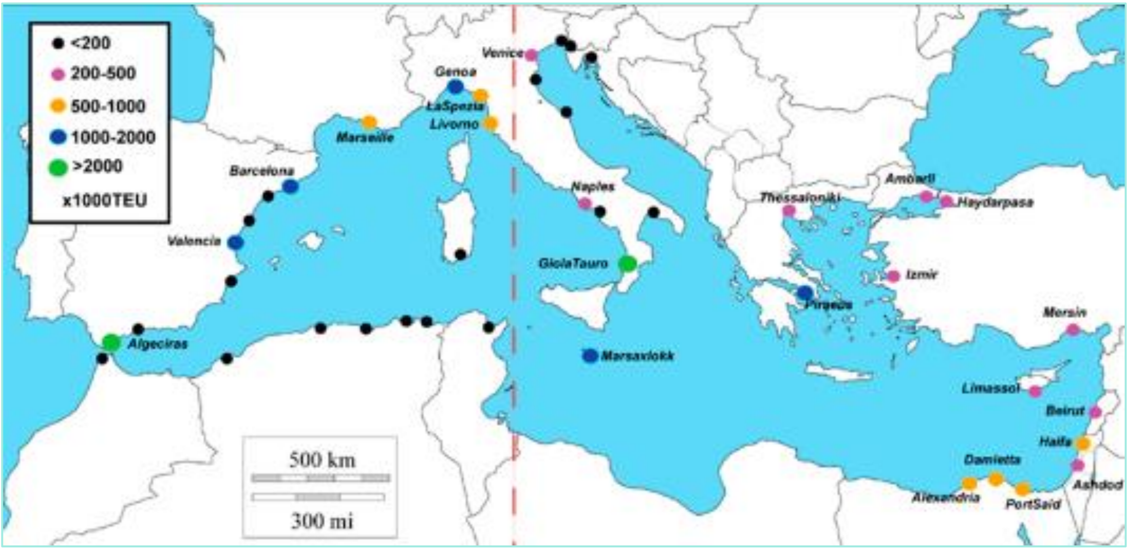


Figure 19: Container throughput in the main Mediterranean Ports for 2000

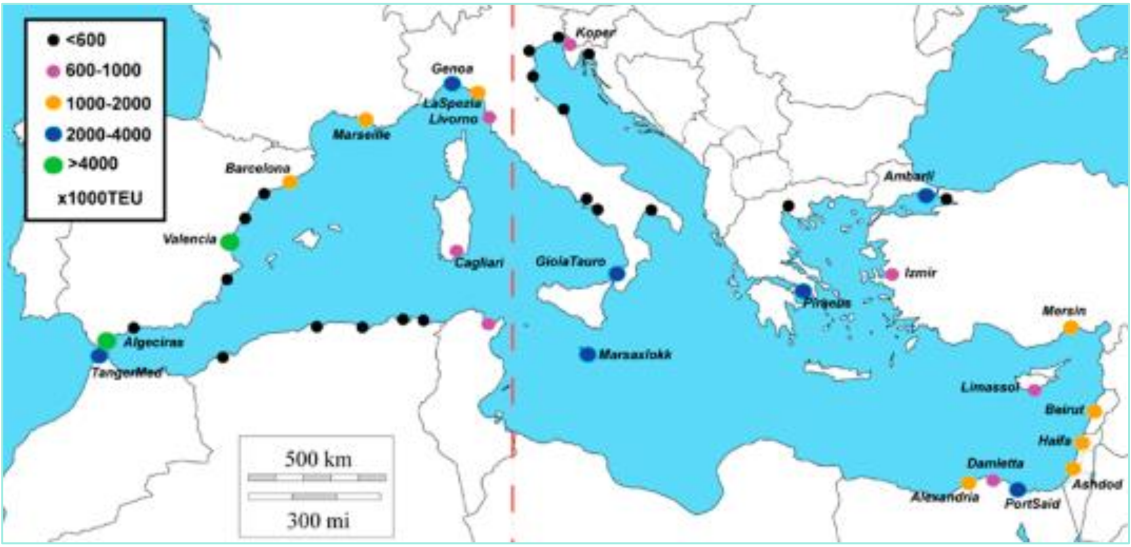


Figure 20: Container throughput in the main Mediterranean Ports for 2015

Source: [14]

As previously mentioned, during the period between 2000 and 2015, the Med region presented a port system dominated by transhipment hubs as result of the huge growth of transhipment. The consideration of two geographical regions of East Med and West Med is also helpful to analyse more in detail the container throughput evolution (see Table 2).

Table 2: Ports defined in two regions of West and East of Mediterranean

West	East
Annaba, Algeciras, Algier, Alicante, Barcelona, Bejaia, Cagliari, Castellon, Genoa, Malaga, Marseille, La Spezia, Livorno, Oran, Skikda, Tanger-Med, Tarragona, Tunisia, Valencia.	Ancona, Alexandria, Ambarli, Ashdod, Beirut, Damietta, Goia Tauro, Haifa, Haydarpasa, Izmir, Koper, Limasol, Marsaxlokk, Mersin, Naples, Piraeus, Port Said, Ravenna, Rijeka, Salerno, Taranto, Trieste, Venice.

Source: [14]

Ports such as La Spezia, or Castellón have increased significantly their traffic share in the recent years as alternatives to big gateway ports. Similarly, this was defined as "the challenge of the periphery" leading to a multi-port gateway region instead of a single gateway port. The substantial traffic increase at medium size ports and the emergence of new hubs with transhipment traffic (such as TangerMed in Morocco) corroborate the increase of the number of market players. The emergence of new transhipment hubs in Mediterranean region is also connected to the flexible labour market and tax policies, liberalization development (for instance in Piraeus a berth was put under concession to China Ocean Shipping Company (COSCO)), or as a positive result of rising emerging economies such as Turkey. Other Med hubs, such as Gioia Tauro in Italy, are in a relative gradual falling from the 5 top Med ports [14].

In both considered areas of West Mediterranean and East Mediterranean, the container throughput concentration has faced a gradual decline during the first decade of the 2000's followed by a period with fluctuations in the volumes and shares. The inconsistency of the traffic share is larger in the East side compared to the western Mediterranean ports in the second half of the decade of the 2000's, principally due to the traffic fluctuation in Piraeus, Gioia Tauro, and Port-Said (See Appendix 2).

7. Container Shipping in the Western Mediterranean

The western European Mediterranean area includes the ports in Malta, as well as the western part of Italy, the eastern part of Spain and the southern France. According to the On the Motorways of the Sea project [1], there are 59 core and comprehensive maritime ports, in this basin. Analysis of the container flows in the western Mediterranean basin requires a knowledge of how foreign trade has evolved in the area. From the late nineties up until 2008, trade between the countries of the North and South of the GTMO 5+5 [1]experienced a marked upward trend, both in volume and economic value. However, after the economic crisis, there was a downturn in this trend and, after several years of sharp fluctuations, in 2017, flows were significantly lower than their peak in 2008. Between 2008 and 2017, the flow of containers between the two shores of the Mediterranean increased [16]. The apparent loss of importance of European ports in the western Mediterranean should be considered the lack of a detailed measure of container flows, since it is not currently possible to distinguish transit flows from the existing statistics, which do not strictly reflect Euro-Mediterranean cargo trade.

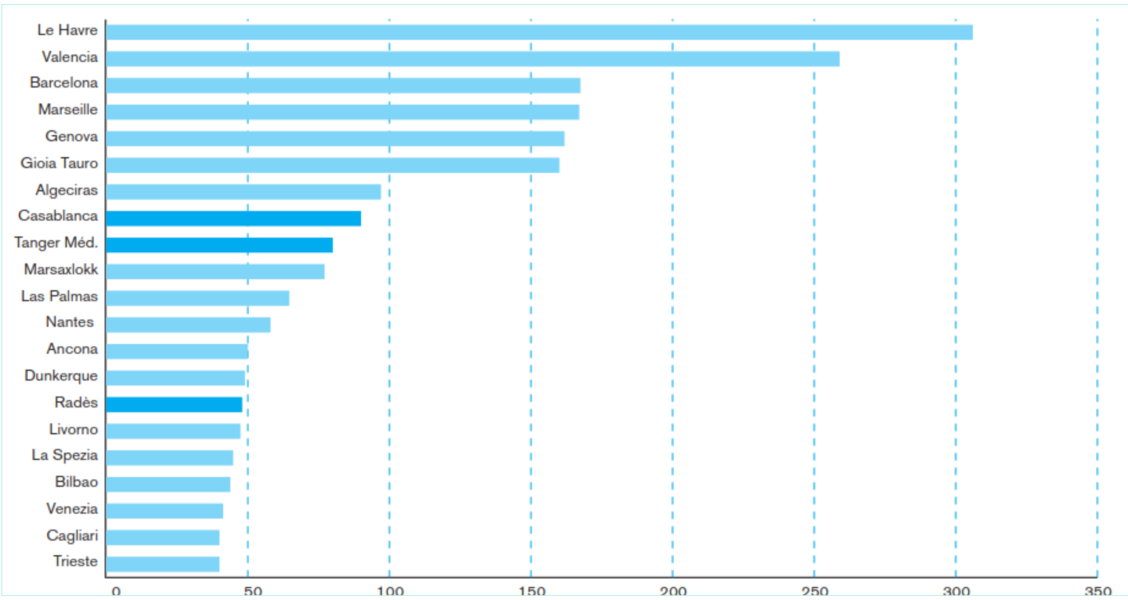


Figure 21: Distribution of the Terminals' Surface in the Main GTMO 5+5 Ports

Source: Produced by CETMO [16]

[1] The GTMO 5+5 is the Group of Transport Ministers of the Western Mediterranean, comprising Algeria, Spain, France, Italy, Libya, Morocco, Malta, Mauritania, Portugal and Tunisia

Therefore, CETMO, the Group of Transport Ministers of the Western Mediterranean, has created a descriptive database for the container port terminals in the countries of the GTMO 5+5. This database includes information on both the terminals' physical parameters and management structure. The analysis of this database contributes to transferring and quantifying the global trends of maritime industry outlined above in the western Mediterranean and allows the patterns of the existing flows in this space to be described in greater detail.

Looking at the distribution of container terminals in the western Mediterranean, differences can be observed between the ports of the GTMO 5+5 countries. It can be observed that the larger terminals are concentrated in a limited number of ports (Figure 21). Out of a total of 48 ports with container terminals, the 21 with over 40 hectares used for container terminals concentrate 80% of the total surface area of this type of terminal in the countries of the western Mediterranean. The six ports with over 150 ha concentrate 47% of the total surface area of the terminals (Figure 22 and Figure 23).

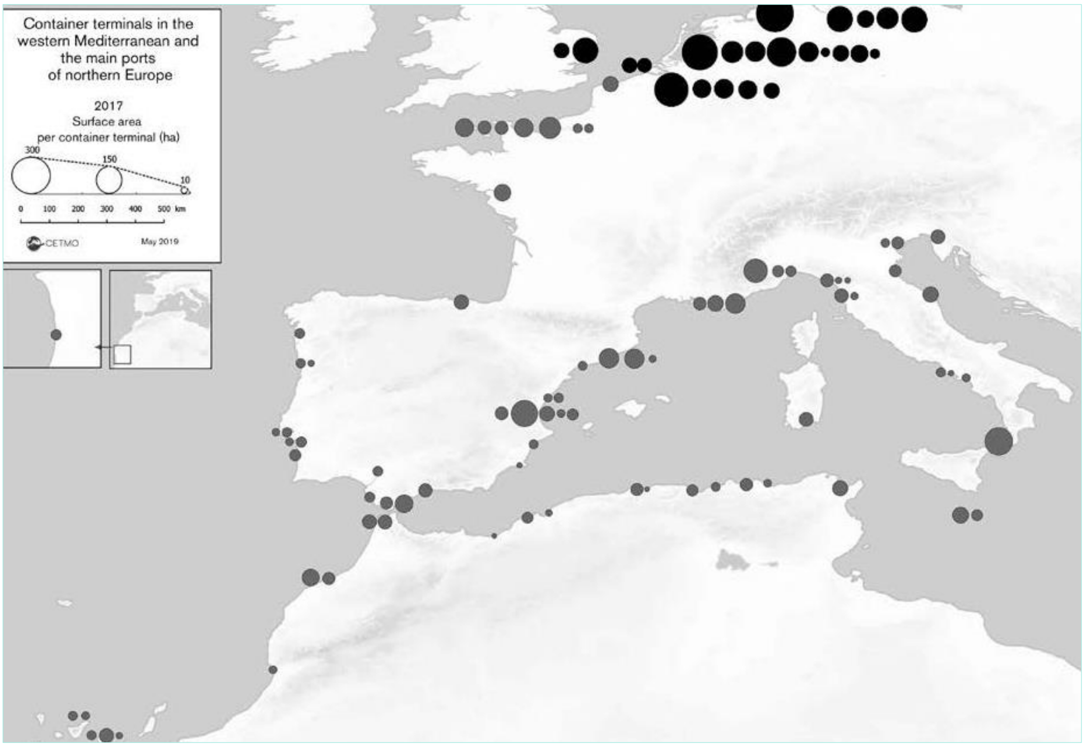


Figure 22: Surface Area by Container Terminal in the GTMO 5+5 Countries

Source: Centre for Transportation Studies for the Western Mediterranean (CETMO), 2019 [16]

Figure 23: Relationship between the Number of Cranes and the Surface of Container Terminals in GTMO 5+5 Countries

Source: Produced by CETMO [16]

The different kinds of operators owning shares in the terminals opens another relevant factor in defining container terminals (Figure 24). In 2019, Two of the big shipping alliances (2M and Ocean Alliance) are shareholders in 32 container terminals of the countries of the GTMO 5+5, which account for 58% of the total surface area [16]. This presence is especially notable in the larger terminals: the alliances are present in 18 of the 24 terminals with over 400 ha and account for 76% of the surface area of this group of terminals. Again, there is a clear difference between the two shores of the Mediterranean (see Figure 24 and Figure 25).

Furthermore, it can be observed that there is a tendency for the large terminals to be concentrated in a limited number of ports, mainly Valencia, Barcelona, Marseille, Genova, Gioia Tauro, and Algeciras. It is this limited group of ports that has the capacity to manage transoceanic flows, acting as major redistribution centres on a regional and intercontinental scale, while many smaller ports, must rely on feeder services to guarantee their container flows. In 2008, the five main ports on the European shore of the western Mediterranean (Valencia, Barcelona, Algeciras, Gioia Tauro and Marseille) concentrated 74% of the overall flows, a figure that rose to 85% in 2016. It is, therefore, not surprising that the rigidity imposed by the organization of the transoceanic outs, ends up affecting the organization of the maritime services between the European and Maghrebi ports, and, consequently, the organization of the flows linked to imports and exports between the countries of the western Mediterranean.

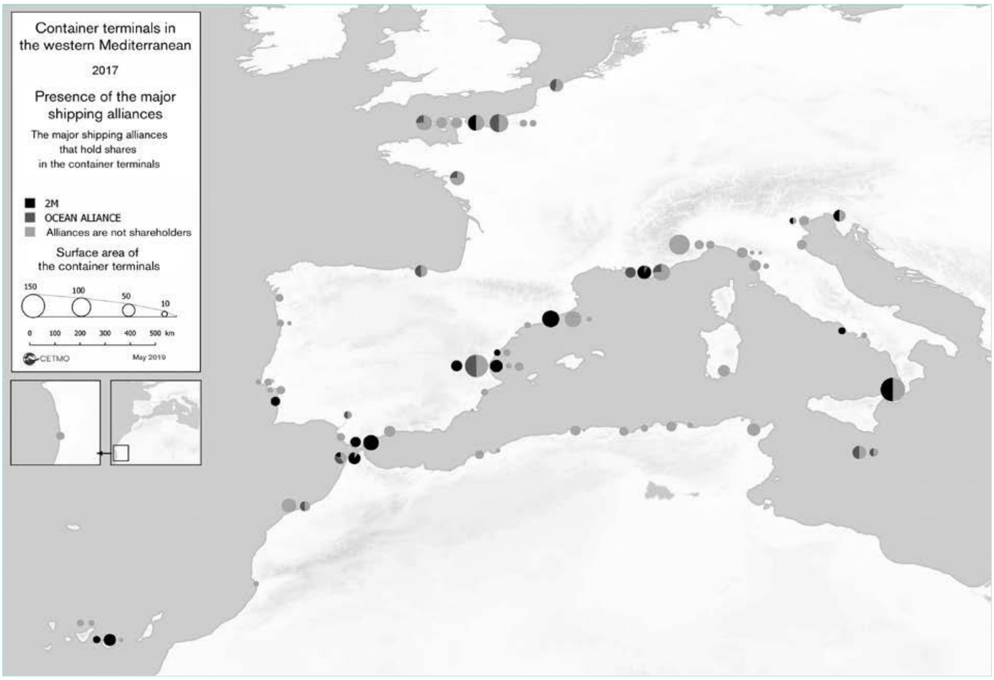


Figure 24: Presence of Container Shipping Alliances in Terminals in GTMO 5+5 Countries

Source: Produced by CETMO [16]

The perspectives of container shipping in the western Mediterranean, bearing in mind the existing container terminal projects with the creation or expansion of major infrastructure in the main ports. However, the new distribution of terminals in african ports of western mediterranean area is affecting the present organization of container flows. The expansion of the number and surface area of terminals in the western Mediterranean brings attention to a set of challenges which include the possible generation of overcapacity in a context of increasing competition between ports. However, main question remains that how this new infrastructure and organization of maritime container shipping can contribute to Euro-Mediterranean integration, the positioning of the western Mediterranean region in the global economy and the formation of more sustainable transport chains [16].

The vertical and horizontal integration of container flows process has been significantly formed by transoceanic flows, which consequently has had an unequal impact on regional maritime stakeholders and regional flows. A set of recommendations published by the International Transport Workers' Federation (ITF) in 2018 recommending : the reforming of the legal structures that regulate competition, improvements in the processes for evaluating port projects and setting port charges, as well as the establishment of port policies that allow a more coherent hierarchization and specialization of ports and their functions.

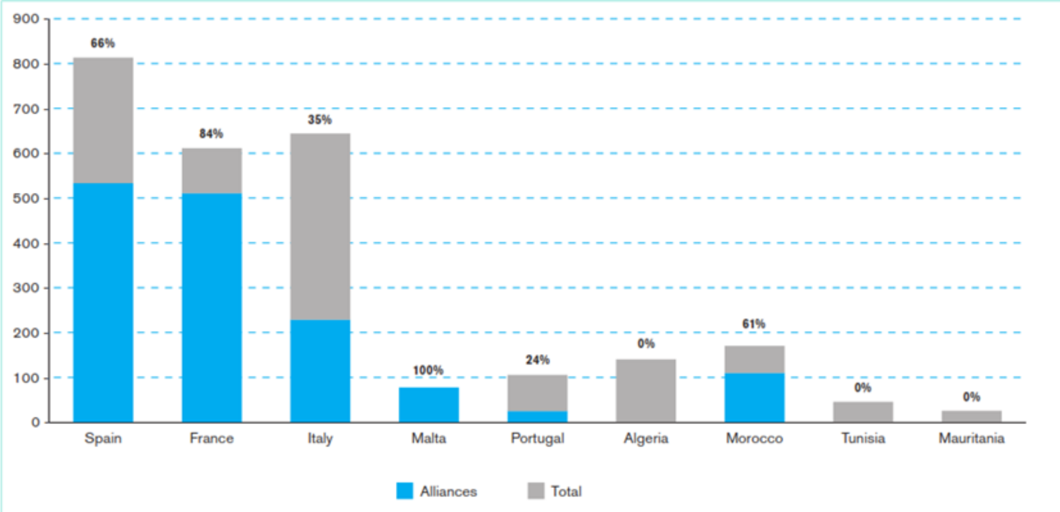


Figure 25: Surface of Container Terminals with Shipping Alliances' Presence per Country

Source : Produced by CETMO

To adapt the recommendations to the context of the western Mediterranean, firstly, the different legal structures and existing regulations in the Mediterranean region should be considered. National structures are still largely determinant of port policies and regulatory frameworks, sometimes hampering collaboration between ports, even within each country.

Furthermore, nowaday's environmental challenges raised from the increasing transport volume and are linked to decarbonization, affecting the maritime and port industry across the world, take on specific relevance in the western Mediterranean. The role of maritime flows must be considered in promoting more sustainable modes of transport between the two shores. This is, in fact, already happening with the implementation of the Motorways of the Sea project aimed at improving communication between the European countries of the GTMO 5+5. Lastly, it is needed to be strongly considered the gap between the two shores in Europe and Africa sides of the western Mediterranean. Overcoming the technological gap and the appropriate use of shared information will be particularly relevant for improving transport flows in the western Mediterranean. In conclusion, the challenge of strengthening Euro-Mediterranean integration, the positioning of the region in the global economy, and the development of far more sustainable transport cannot be considered separately from the need for collaborative strategies and policies between the different stakeholders in container shipping and ports managements in countries of the western Mediterranean.

8. Container Shipping in the Eastern Mediterranean

Mediterranean container port traffic has experienced increasing container traffic from 55 million TEU's in 2014. The Eastern Mediterranean container port traffic was around 35 per cent of the total Mediterranean container port traffic in 2015 [17]. The Eastern Mediterranean basin includes Ports in Greece, Cyprus, Croatia, Slovenia and the Adriatic coast of Italy (see Figure 26). There is a total of 45 core and comprehensive maritime ports in this basin. In the regional shares, the container port traffic will increase more in the coming years in the Eastern Mediterranean. This increase will be due to the widening of the Suez Canal and the expectations of the increases in container port traffic of the regions of the Black sea, the Adriatic and Balkan countries which are the target of the Eastern Mediterranean hub ports.

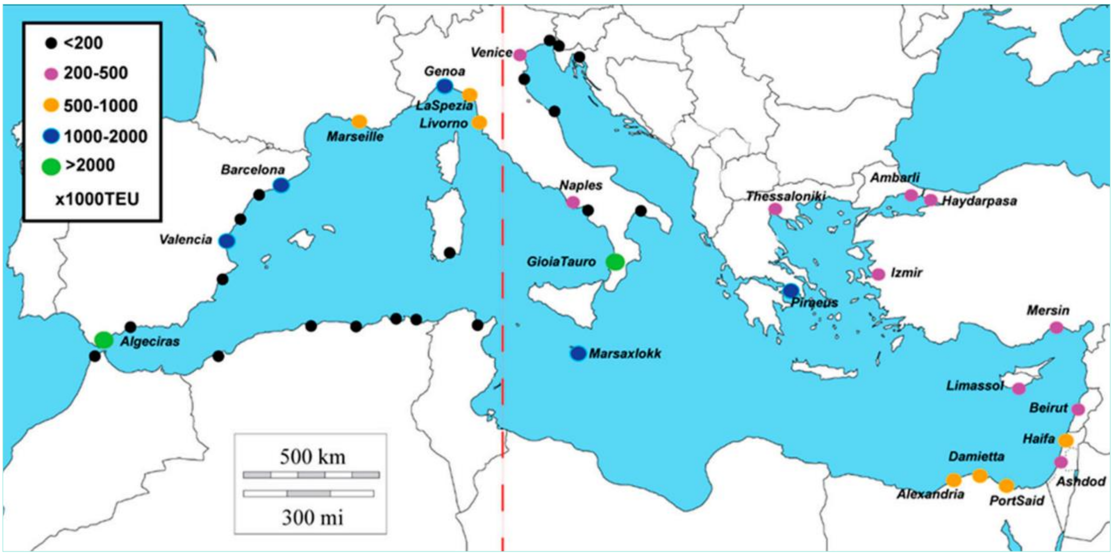


Figure 26: Container Ports in each one of the two west and east regions

Source: Manel Grifoll et al, 2016 [14]

The Chinese Belt and Road Initiative (BRI) and the Medeteranean sea

The Belt and Road Initiative (BRI) known in Chinese and formerly in English as One Belt One Road, is the "New Silk Way," with overland routes for road and rail transportation, whereas "road" is referring to the Indo-Pacific sea routes through Southeast Asia to South Asia, the Middle East, Africa and finally the Mediterranean Sea. It is considered as a bid to enhance regional connectivity and improved transport network (see Figure 27).

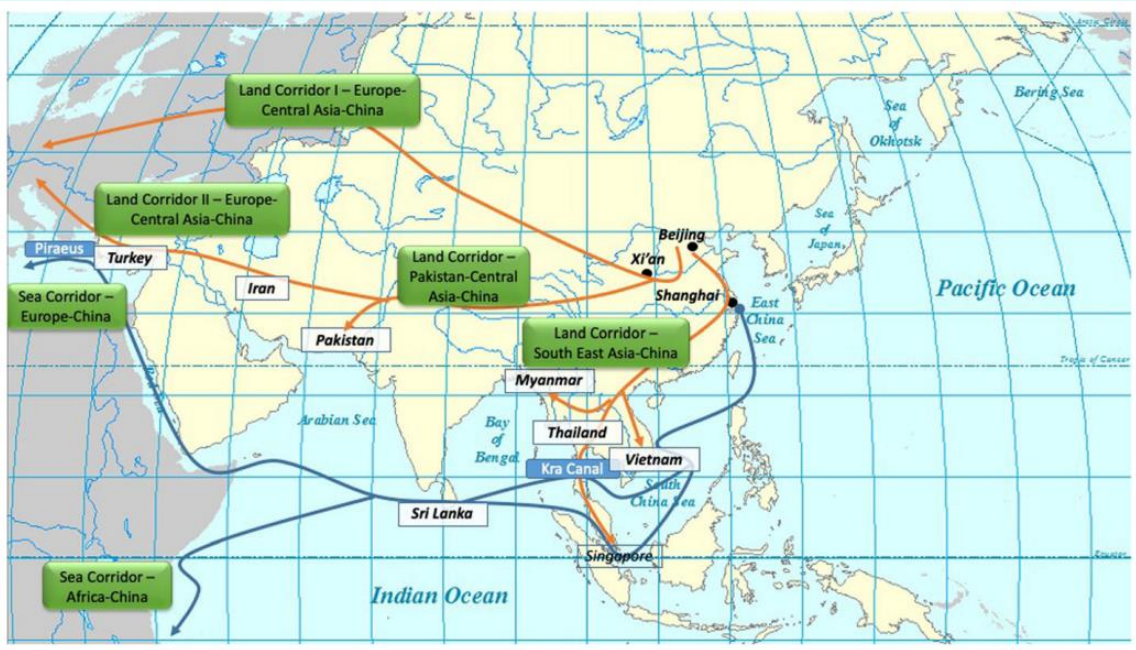


Figure 27: BRI corridors

Source: [28]

European countries have experienced a unique supra-national investment strategy within the Trans-European Transport Network (TEN-T) framework to develop their transport corridors. While most of these investments were thought to assure regional cohesion and accessibility, the Chinese Belt and Road Initiative (BRI) strategy is partially developing complementary projects directing at interconnecting EuroAsia transport ways with the Maritime Silk Road strategy. Nevertheless, whenever BRI and TEN-T overlap in the eastern Mediterranean region, coordination seems essential to avoid an oversupply of transport infrastructure capacity.

Table 3 has summarised the main visions coming from a SWOT analysing point of view, considering the Chinese BRI initiative in the Mediterranean area. While the main strengths of BRI within the Mediterranean region seem to be linked to the current investment levels and with the already established network that can assure positive benefits for the served communities, these elements might also be seen as anti-competitive, generating extra-costs in the long run. A good example might be the extended port network developed by COSCO and the shipping market concentration that might create specific advantages due to network economies and a better capacity utilization [28].

Table 3: SWOT analysing for BRI initiative within the Med Basin

Strengths	Weaknesses
• Local impact	• Contrast with EU institutions
• International view	• Impact inequalities
• Current investment level	• Possible anticompetitive behaviour
• Already established network	• Oversupply of infrastructure
Opportunities	**Threats**
• Complementarities with TEN-T	• Political barriers
• Access to new markets	• Market distortions
• Diversification of transport services	• Public debt of receiving countries

Source: Adopted and reproduced from [28]

The Suez Canal that is located between the Eastern Mediterranean and the Indian Ocean, bringing huge opportunities in container transportation between Europe and the Far East trades. The Suez canal hand to hand with the increase of the capacity of container ships above 20,000 TEUs, are reshaping the Mediterranean transhipment system while feeder service distances are more important than the main route deviation distances. The average transhipment ratio is 80% in the Eastern Mediterranean while for the whole Mediterranean is 43% and various markets of the Eastern Mediterranean, Black Sea, Adriatic Sea, and Balkan countries can easily access it from Cyprus [17]. Within the Central/South Aegean ports cluster, the dominant port is the port of Piraeus, which is the largest and busiest port in Greece. It is a major commercial port handling a variety of cargoes in particular for serving growing transhipment container traffic. The port is an international centre of transit and regional trade and it is the second container handling port in the Eastern Mediterranean region and placed among the first 10 ports in container traffic in Europe [29].

The impressive growth of Far East-Europe container trading, transiting through the Suez Canal has a substantial opportunity for the Eastern Mediterranean ports. The new Suez Canal Waterway will also have a positive effect on the container traffic in the Mediterranean by permitting more traffic and bigger ships passing through. Due to the continuing growth of container ship sizes in recent years, the transhipment operations in the Eastern Mediterranean, are proceeding into a new era [17]. The Eastern Mediterranean, Adriatic and Balkan, and Black Sea range cover more marginal, but rapidly growing economies of Eastern Europe, Russia, and Turkey [18]. In this respect, eastern Mediterranean region has became one of the most important competing regions for cargo, and specifically container, traffic in the world. Major hub ports in the Eastern and Central Mediterranean are competing for more shares from the container distribution at the Eastern Mediterranean, Black Sea, Adriatic Sea, and Balkan countries. The trade areas in the context of the Eastern Mediterranean Hub Ports and container distribution system are illustrated in Figure 28.

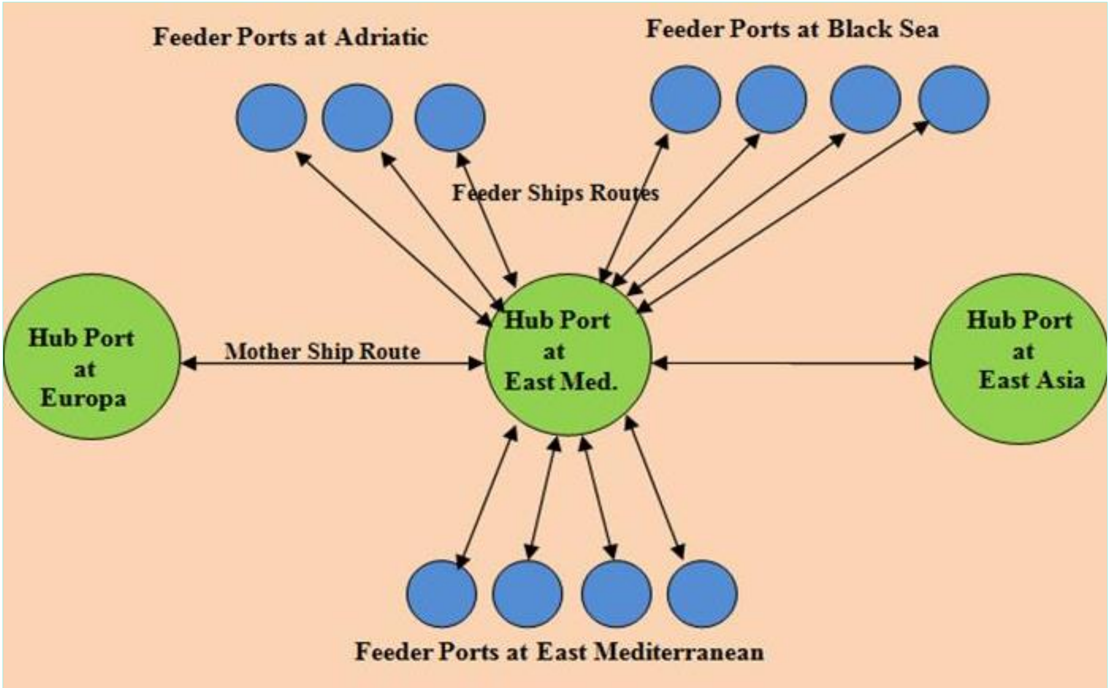


Figure 28: Container Distribution System in the Eastern Mediterranean

Source: Yetkili et al, 2014 [17]

An increase in Asian and Far Eastern trade and corresponding changes in the operational strategies of shipping lines is boosting transhipment and feeder demand in the Mediterranean region. Shipping lines are operating an increasing number of deep-sea relay services through the Mediterranean (calling at a few ports) to meet an increase in Far East trade [19], [20].

According to Drewry, the incidence of transhipment at container terminals worldwide (as a percentage of global throughputs) increased from 17.6% in 1990 to 28.5% in 2010 and did not experience any annual decline during that period [21]. According to the MEDA's 12th Ports Summit, the Mediterranean container port traffic was around 52.1 million TEU's in the year 2013. The 43% of the Mediterranean container port traffic, which was around 22.4 million TEU's in the year 2013 were transhipment units in the hub and spoke system. The Eastern Mediterranean, Black Sea, Adriatic Sea and Balkan countries are the target of the hub ports of Central and Eastern Mediterranean. Hub ports of Central and Eastern Mediterranean serving in the targeted areas. The cause of the high transhipment capacity of the Eastern Mediterranean is that the targeted markets, especially at the Black Sea and the Adriatic Sea, are too far from the mother ship's main route passing through the Suez Canal and Gibraltar (see Figure 29).

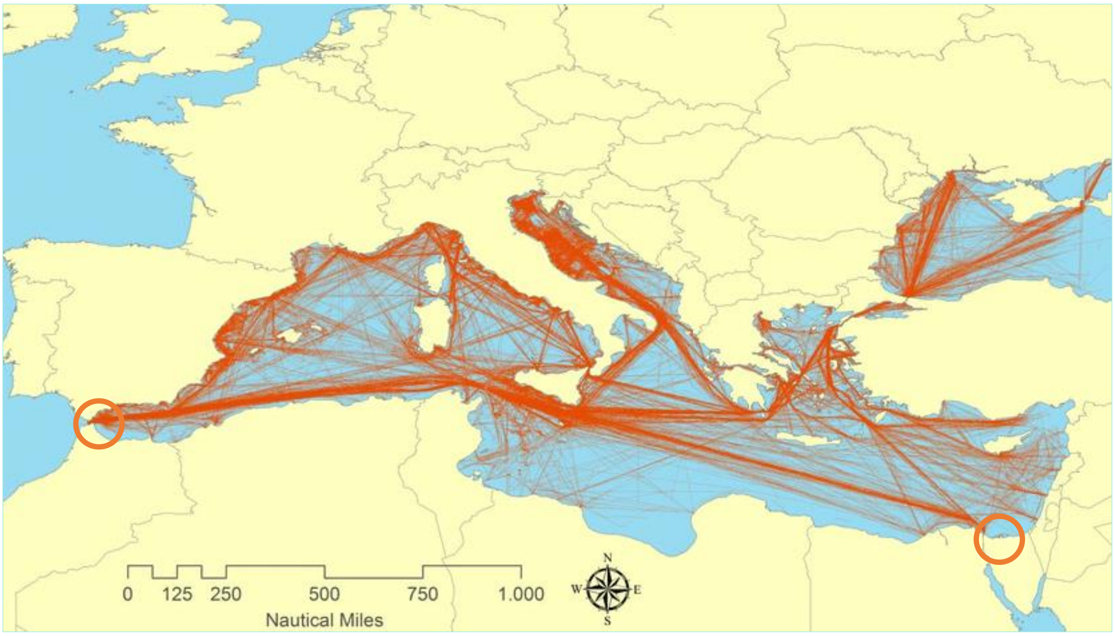


Figure 29: Ship's main route passing through the Suez Canal and Gibraltar

Source : [30]

Feeder Services in Eastern Mediterranean Region

With container ship sizes go above the 22,000 TEUs, Mediterranean transhipment operations are heading into a new era. Due to the changing conditions, facts at container shipping and transhipment operations are changing. According to Ranking ; with the transoceanic mother ships getting bigger in size, there will be new draft requirements up to 17 meters, of which the existing hub ports will not be able to meet. Due to this and some other facts ; one or two major new hub ports in the Mediterranean region will become a serious need in the coming years. Oceanic vessels passing through the Mediterranean are increasing in size and there is an increasing trend to use these ships to service the region through feeder systems" [20]. Another fact for the new era of the Mediterranean transhipment operations is the new Suez Canal. The new Suez Canal will increase trade alongside the canal. The enlarged canal will allow ships to sail in both directions at the same time over much of the canal's length. The new Suez Canal is expected to double the capacity of the existing Suez Canal traffic flow. The new Suez Canal will accelerate container traffic in the Mediterranean in general. This consequently will affect transhipment traffic in the Mediterranean significantly.

On the other hand ; container liner shipping operators are seeking solutions to increasingly competitive conditions in the Mediterranean. The best solution for this competition lies in the reduction of transporting cost per container unit (TEU). For the “door-to-door” transportation system; container liner shipping operators have to deal with the feeder service operations for the distribution of the containers. If the container liner shipping operators get involved with the feeder service operations, today’s container transhipment factors and property will substantially change. Another reality of the new era in the Eastern Mediterranean region for the transhipment process of containers, is the fact that ; containers distributed to the Eastern Mediterranean, Black Sea, Adriatic and Balkan trade areas will be enormously increased in the coming 10 years. According to some researches, the two islands, Crete and Cyprus in the middle of the Eastern Mediterranean, are in the best geographical position of becoming container transhipment hub ports in the Eastern Mediterranean. With the increase of the container mother ship sizes transhipment operations will also be increased. Increases realized in the transhipment operations will bring the need of larger feeder ships operating in the Mediterranean region. “Experts suggest that increased volumes in transhipment will bring about economies of scale in the regional feeder market, which larger shipping lines will take advantage of by establishing their own dedicated direct feeder networks” [17], [20].

9. MOSES Business Cases

9.1 Introduction to the concept of the MOSES business cases

As discussed in previous chapters, ports play a decisive role in the EU's external and internal trade. Although ports and especially Deep-Sea Shipping (DSS) ports are integral nodes within multimodal logistic flows, Short Sea Shipping (SSS) and inland waterways are not so well integrated. The European Union (EU) has aimed for a modal shift from road transport to other more sustainable transport modes, such as waterborne transport. In this respect Short Sea Shipping (SSS) has gained more attention, particularly in the Mediterranean basin. Among all cargo types, container has faced one of the highest growths in the Mediterranean Sea. At EU level, the loaded containers represented 78 % of all containers short sea shipped (in TEUs) in 2019 (see Figure 30). All countries transported more loaded containers than empty ones. Italy, Spain, and Greece in Mediterranean Sea are among the European countries which had the highest share of loaded containers in 2019 [25].

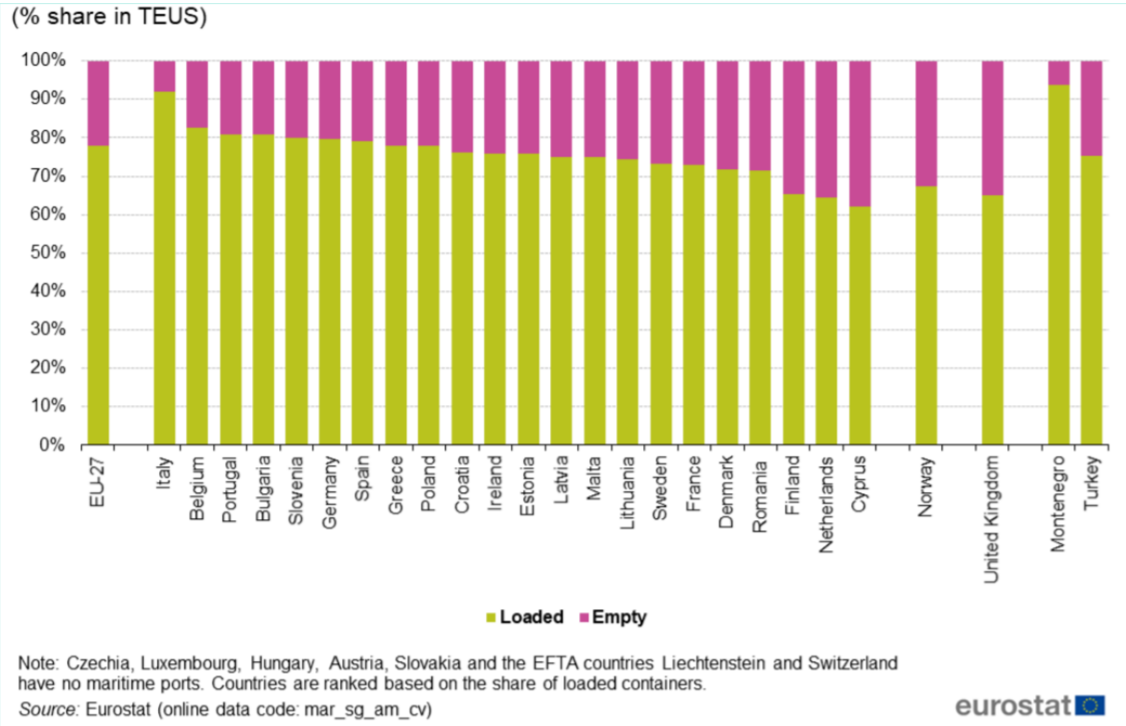


Figure 30: Short sea shipping of containers by loading status, 2019 (% share in TEUs)

Source: Eurostat [25]

To enhance the Short Sea Shipping (SSS) component of the European supply chain, MOSES has introduced, in D2.1 and D2.2, a constellation of innovations including innovative vessels and the optimization of logistic operations. The aim in general is to reduce the total time to berth for TEN-T Hub Ports and to stimulate the use of SSS feeder services in small ports that have limited or no infrastructure [24]. To achieve the objectives, MOSES will implement a constellation of innovations, which are:

- **For Short Sea Shipping,** an innovative, hybrid electric feeder vessel (MOSES innovative feeder vessel) is considered that will be outfitted with a self-sufficient robotic container-handling system.
- **For Deep Sea Shipping ports,** the adoption of an autonomous vessel maneuvering and docking scheme (MOSES AutoDock), it is assumed a cooperation of (i) a coordinated swarm of autonomous tugboats with (ii) an automated docking system (AutoMoor) based on an existing product.
- A digital collaboration and matchmaking platform (MOSES platform) is aimed to maximize and sustain SSS services in the container supply chain by matching demand and supply of cargo volumes by logistics stakeholders [24].

The MOSES concept can be narratively can be described (see Figure 31), as per in Deliverables D2.1 and D2.2: a large containership (mother-vessel) approaches a DSS port (or a large container terminal). Upon her arrival, a combined intelligent mega-system consisting of the MOSES Autonomous tugboat swarm for manoeuvring and the MOSES adapted AutoMoor system. Then, for container handling processes are ready to start to move containers to their destination via hinterland connections (trucks and/or rail) or to be shipped to destinations near small ports (in mainland or island). For the first case, containers are stored to a dedicated port area (Storage area), waiting to be moved via trucks and/or rail. For the second case, containers are stacked by existing port equipment near dedicated berths of the DSS port and then are loaded on the MOSES Innovative Feeder Vessel, which is equipped with the MOSES Robotic Container-Handling System that provides (semi-) autonomous (un)loading of the feeder.

The Robotic Container-Handling System is remotely monitored through a Shore Control Centre. As soon as the MOSES innovative Feeder vessel approaches the small port, where her docking is achieved without the need of tugboats, she automatically unloads the containers by using the Robotic Container-Handling System, on the quay or directly on trucks. As a result, ports with minimal or no available infrastructure may be effectively integrated in the container supply chain. The MOSES innovative feeder vessel, then, continues her voyage to the next small port or she returns to the DSS port.

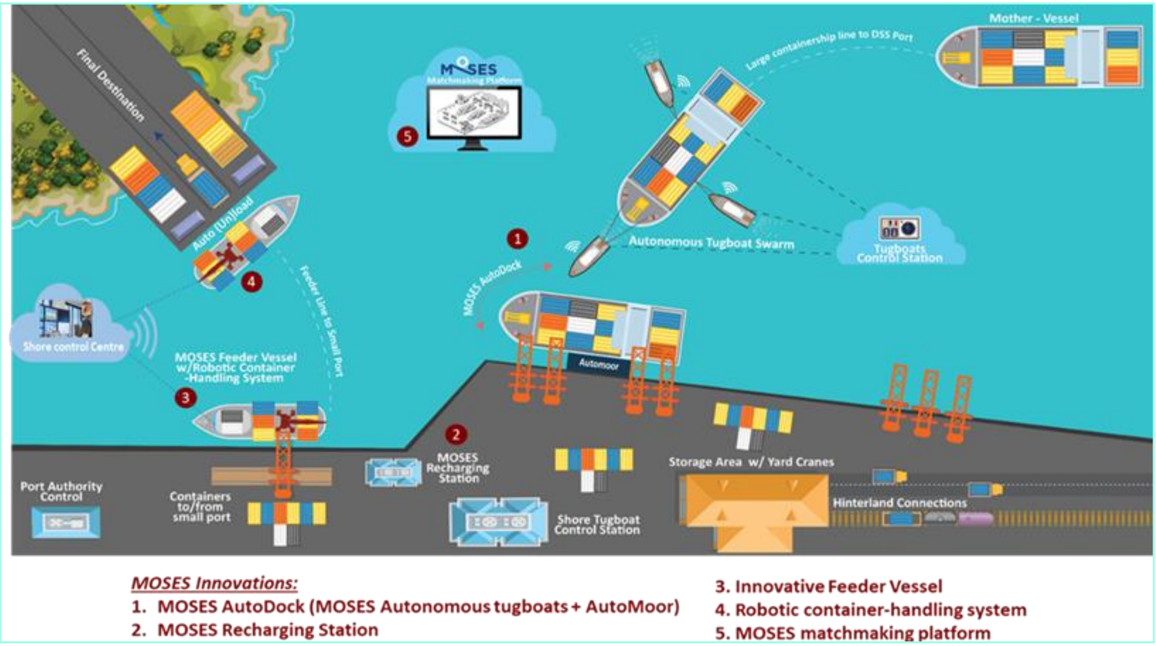


Figure 31: MOSES innovations

Source: MOSES D2.1 and D2.2

To introduce the MOSES business cases for the above-mentioned MOSES innovations, initially in previous chapters, the container traffic flows between major European container Hub Ports and connected small ports, and the intermodal interfaces in Hub ports and connected small ports reviewed. In addition, the main problems and the status were mapped.

More specifically, this chapter identifies the market opportunities and business cases for these innovations, in the context of the shortsea shipping of the container supply chain and by developing the MOSES Business Cases 1 (Western MED-Spain) and 2 (Easter MED-Greece), while exploring other promising business cases (in view of the MOSES Transferability Business Case).

The development of the MOSES Business Cases includes a preliminary evaluation of the benefits of implementing the MOSES innovations for the specific cases, as well as an assessment of the required costs and the technical and operational limitations that may act as a barrier for implementation. It provides input for the cost-benefit analysis that will be conducted after the MOSES pilot demonstrations (Task 7.5), and for the MOSES exploitation activities (Task 8.3). However, it should be noted that the transferability business case will be managed and executed in the context of Task 6.3.

9.2 Preliminary typology of ports for MOSES innovations in view of MOSES Business Case

Innovative Feeder Vessel

The MOSES Innovative Feeder Vessel is a low-capacity container feeder vessel equipped with a highly automated loading/unloading arrangement (the Robotic Container-Handling System) and environmentally sustainable propulsion in conjunction with the MOSES Recharging Station. The vessel will be designed considering Short-term design: hybrid electric, automated functionalities, and also Long-term design: fully electric, automated functionalities, potentially fully autonomous navigation, potential for simultaneous transportation of containers and passengers.

The main mission of the vessel will be to transport containers (and potentially passengers) from large container terminals (DSS ports) to small ports with no container handling infrastructure. For this purpose, 20 large container ports by the opportunity of transferring a substantial part of the land-based transhipment of containers to their nearby small ports that are identified as examples for port typologies, i.e., the classes of ports that can be extended to other EU ports with similar profiles. More in detail, for selecting the small ports for this innovation, it is taken into consideration two elements of no [or very low]container ship calls per year, and also non-existing proper equipment for container (un)loading in the targeted small ports.

For innovation of “Robotic Container-Handling System “, the assumption is based on the scenario of the main mission of the container-handling system to load/unload containers to/from the innovative feeder vessel in a (semi)autonomous manner, i.e., without needing a human operator onboard the vessel.

The EU core ports are selected (mostly) near to these 20 small ports and with the help of ShortSea Schedule website, the Route for connecting the 20 Core ports to their small 20 ports near-by is illustrated in screenshots (Table 4). For many of the identified cases, there are some lines connecting those ports as shown by ShortSea Schedule in below figures, however in most cases not regular and frequent container shipping. Therefore, can they be considered MOSES use cases for small new feeder vessel.

Table 4: Proposed ports as targets for Innovative Feeder Vessel and Robotic Container-Handling System innovations

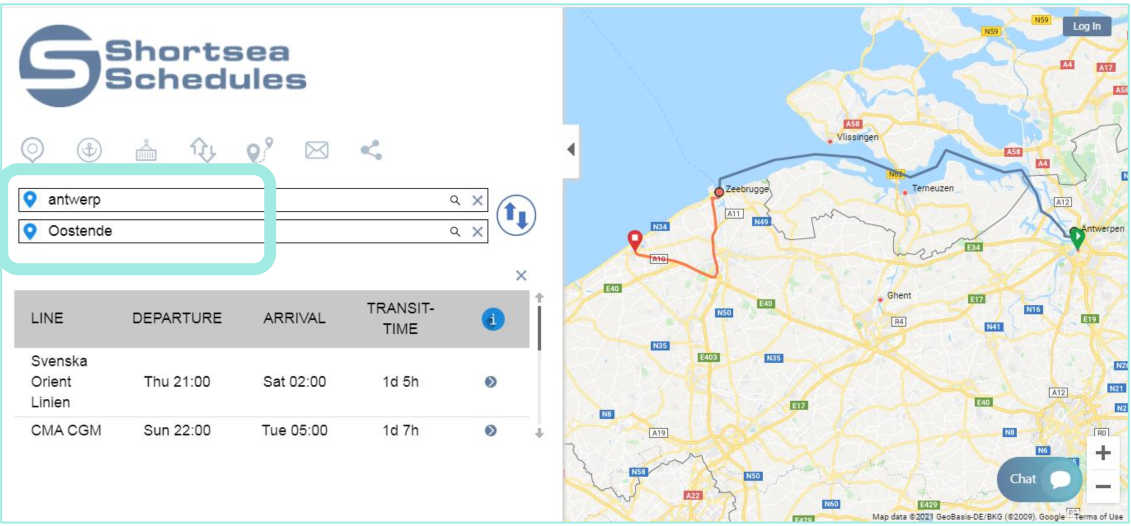
Port	Country	Port Profile	Container ship calls (2018)	RoRo ship calls (2018)
Antwerpen (BE)	Belgium	Core port		
Oostende (BE)	Belgium	MOSES small port	**0**	0
Burgas (BG)	Bulgaria	Core port		
Nessebar (BG)	Bulgaria	MOSES small port	**0**	0
Larnaka (CY)	Cyprus	MOSES small port	**7**	0
Limassol (CY)	Cyprus	Core port		
Sassnitz (DE)	Germany	MOSES small port	**0**	55
Lubeck (DE)	Germany	Core port		
Ebeltoft (DK)	Denmark	MOSES small port	**0**	0
Aarhus (DK)	Denmark	Core port		
Rohuküla (EE)	Estonia	MOSES small port	**0**	0
Tallinn (EE)	Estonia	Core port		
Sagunto (ES)	Spain	MOSES small port	**0**	0
Valencia (ES)	Spain	Core port		
Kotka (FI)	Finland	MOSES small port	**0**	0
Helsinki (FI)	Finland	Core port		
Nantes (FR)	France	Core port		
Lorient (FR)	France	MOSES small port	**0**	0
Piraeus (GR)	Greece	Core port		
Mykonos (GR)	Greece	MOSES small port	**0**	0
Dublin (IE)	Ireland	Core port		
Rosslare (IE)	Ireland	MOSES small port	**0**	2098
Trieste (IT)	Italy	Core port		
Monfalcone (IT)	Italy	MOSES small port	**2**	754
Amsterdam (NL)	Netherlands	Core port		
Delfzijl (NL)	Netherlands	MOSES small port	**92**	64
Lisbon (PT)	Portugal	Core port		
Porto Santo (PT)	Portugal	MOSES small port	**8**	0
Constanta (RO)	Romania	Core port		
Sulina (RO)	Romania	MOSES small port	**0**	0
Malmo (SE)	Sweden	Core port		
Ystad (SE)	Sweden	MOSES small port	**0**	3597
zadar	Croatia	MOSES small port	**0**	0
Rijeka	Croatia	Core port		
Gozo	Malta	MOSES small port	**0**	0
Marsaxlokk	Malta	Core port		
Gdynia	Poland	Core port		
Świnoujście	Poland	MOSES small port	**37**	6417
Riga	Latvia	Core port		
Ventspils	Latvia	MOSES small port	**14**	1341

The extracted information from Motorways of the Sea Study 2020 for each of these small 20 ports are mentioned in below cells including the number of ports' ship calls in 2018 by two categories of container ships and ro-ro ships, as illustrated below. In most cases there are currently no feeder services between the selected ports, therefore, the routes are shown on the map are for other type of shipping services.

Ostend - Belgium

Container	RoRo
0	0

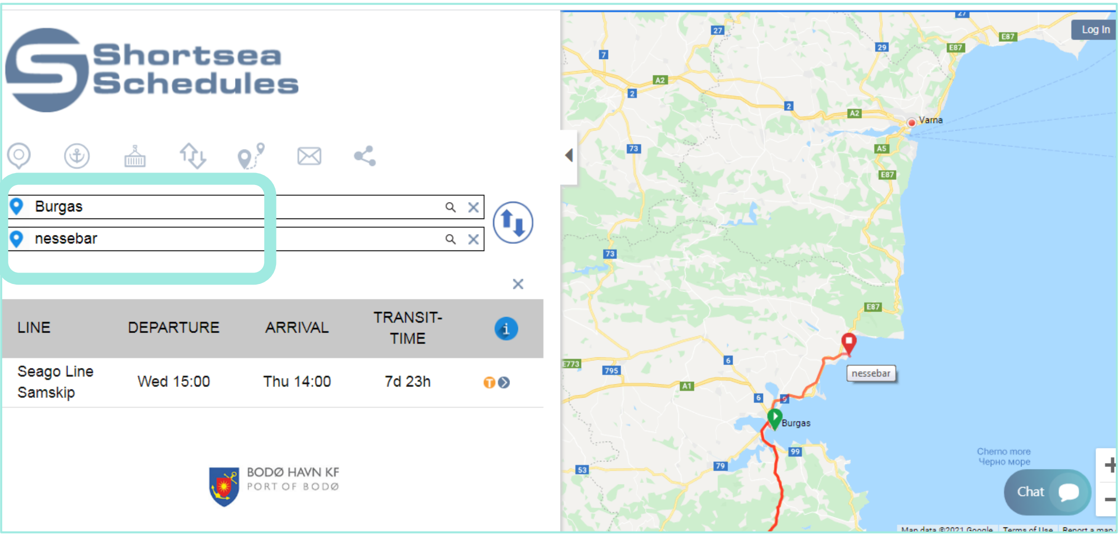
Source: http://www.4allports.com/port-overview-oostende-belgium-pid17.html



Nessebar - Bulgaria

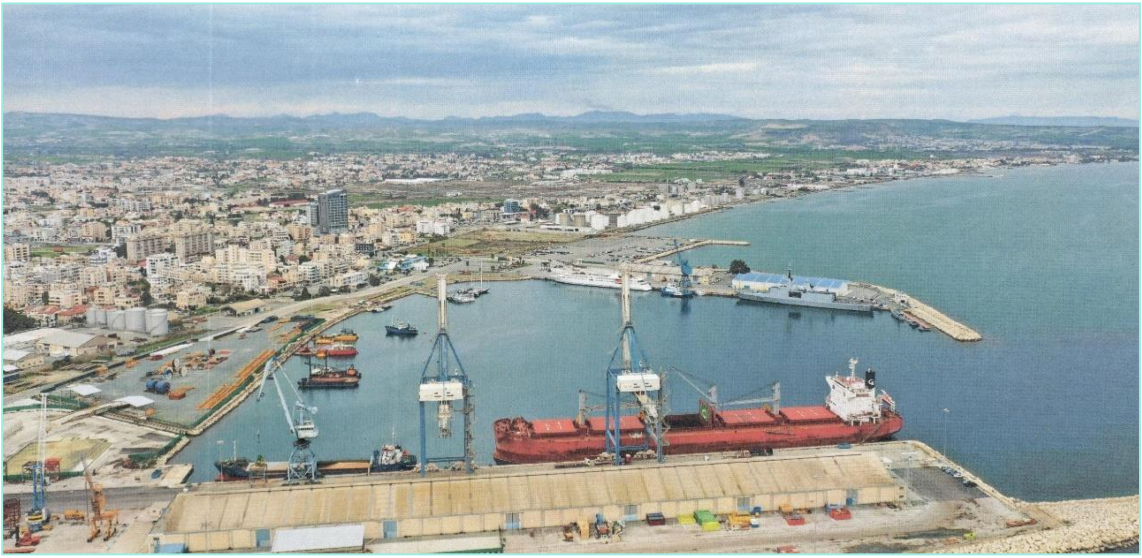
Container	RoRo
816	78

Source: http://www.4allports.com/port-overview-oostende-belgium-pid17.html

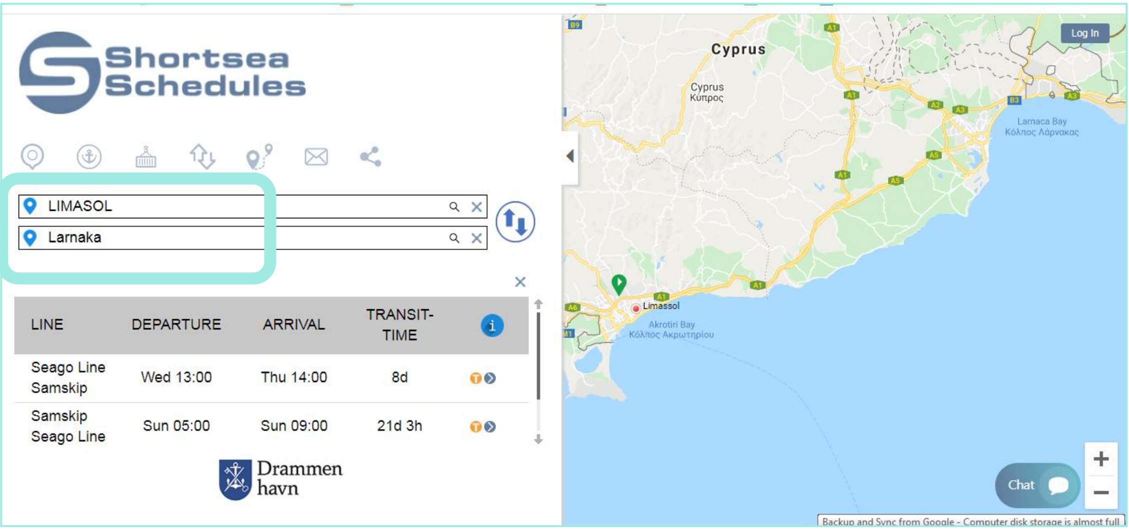


Larnaca – Cyprus

Container	RoRo
7	0

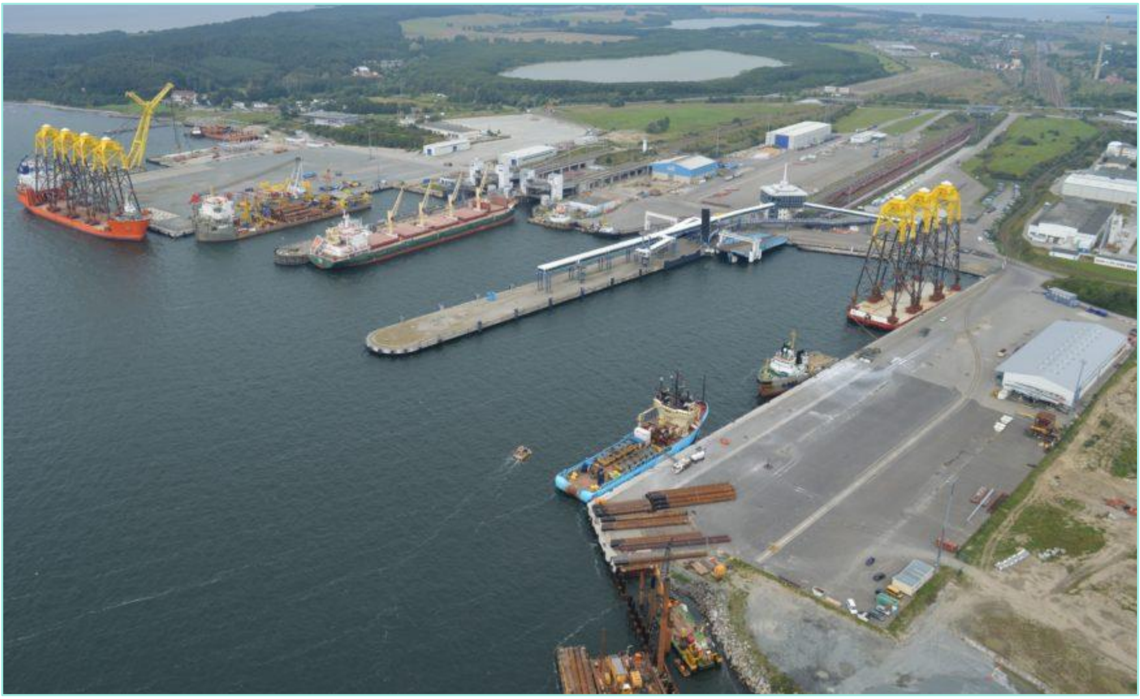


Source: https://www.csa-cy.org/article/ports

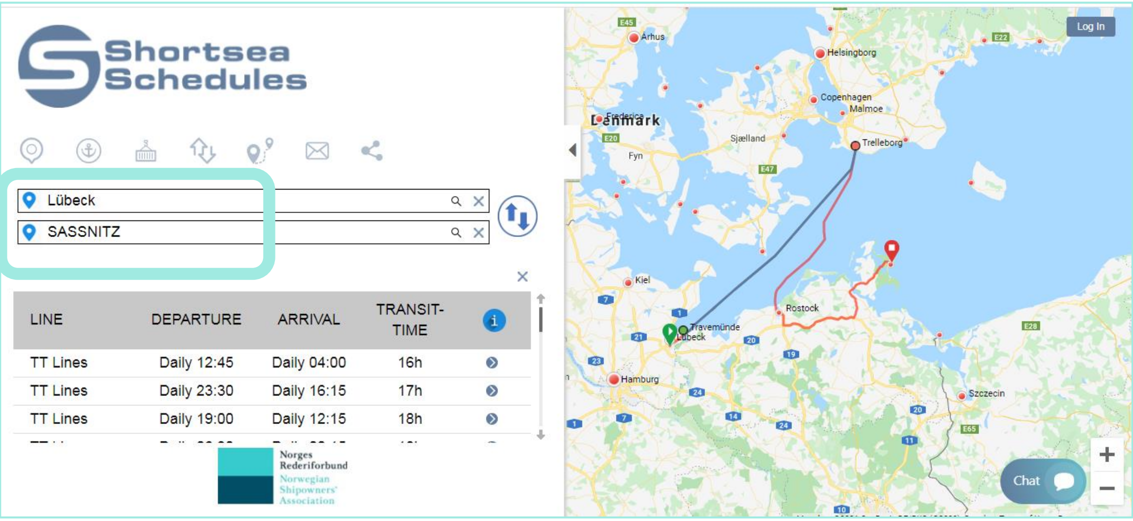


Assnitz – Germany

Container	RoRo
0	55



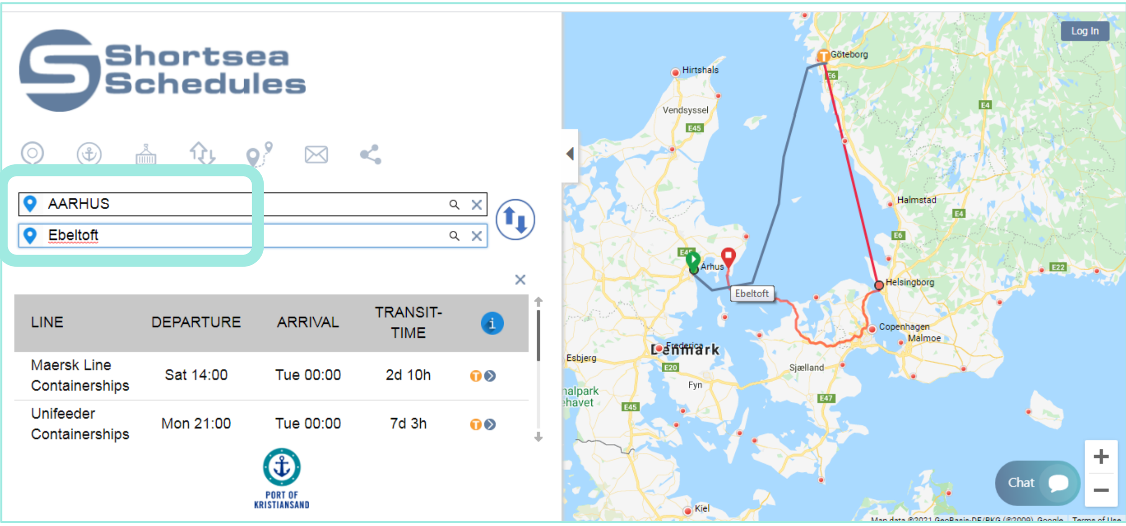
Source: https://oevz.com/en/faehrhafen-sassnitz-gmbh-30th-anniversary-of-mukran-port/



Ebeltoft- Denmark

Container	RoRo
0	0

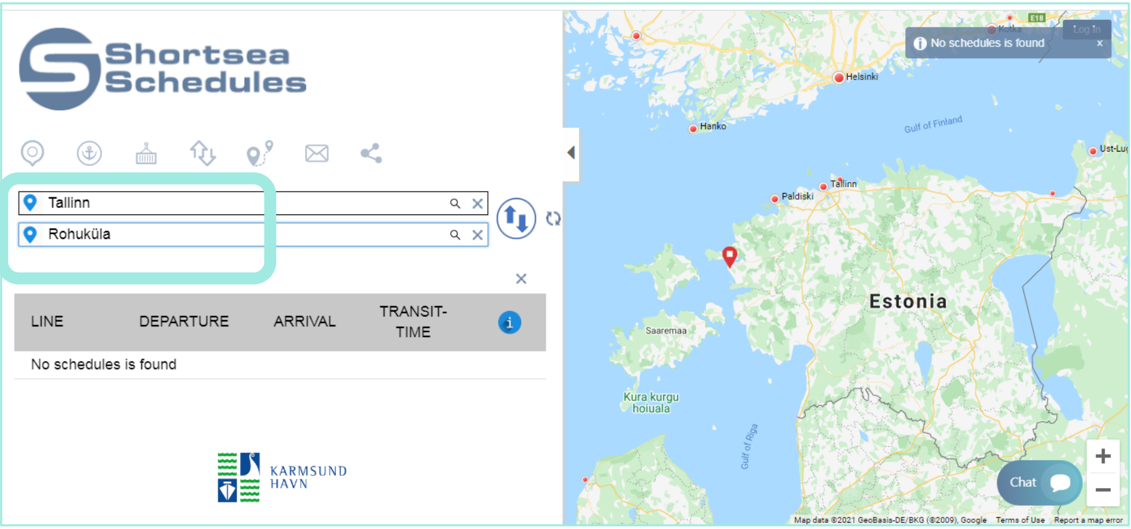
Source : https://www.bucketlist127.com/goal/visit-ebeltoft-denmark



Rohuküla – Estonia

Container	RoRo
0	0

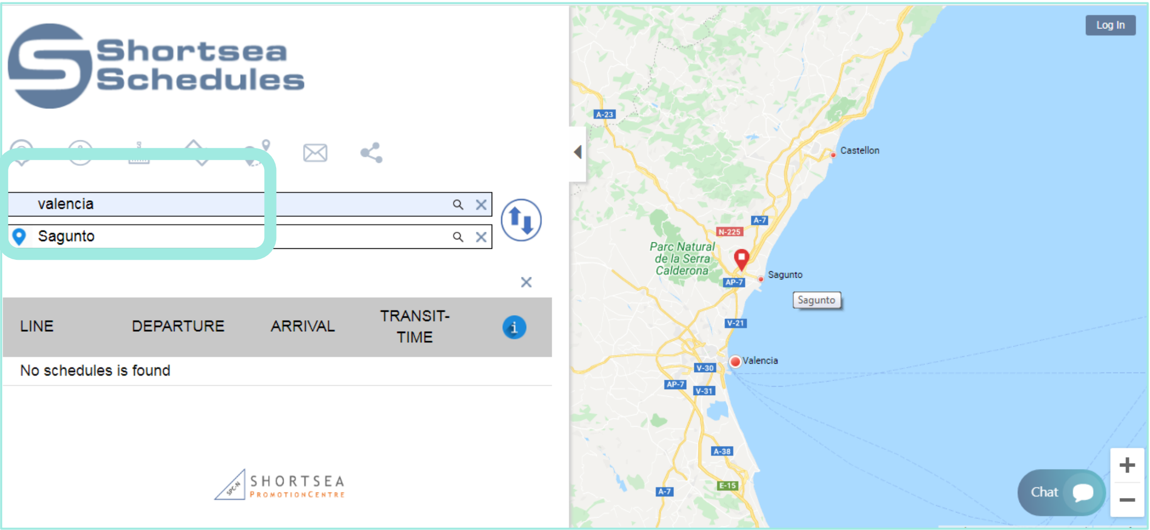
Source: https://en.wikipedia.org/wiki/Rohuk%C3%BCla



Sagunto - Spain

Container	RoRo
0	0

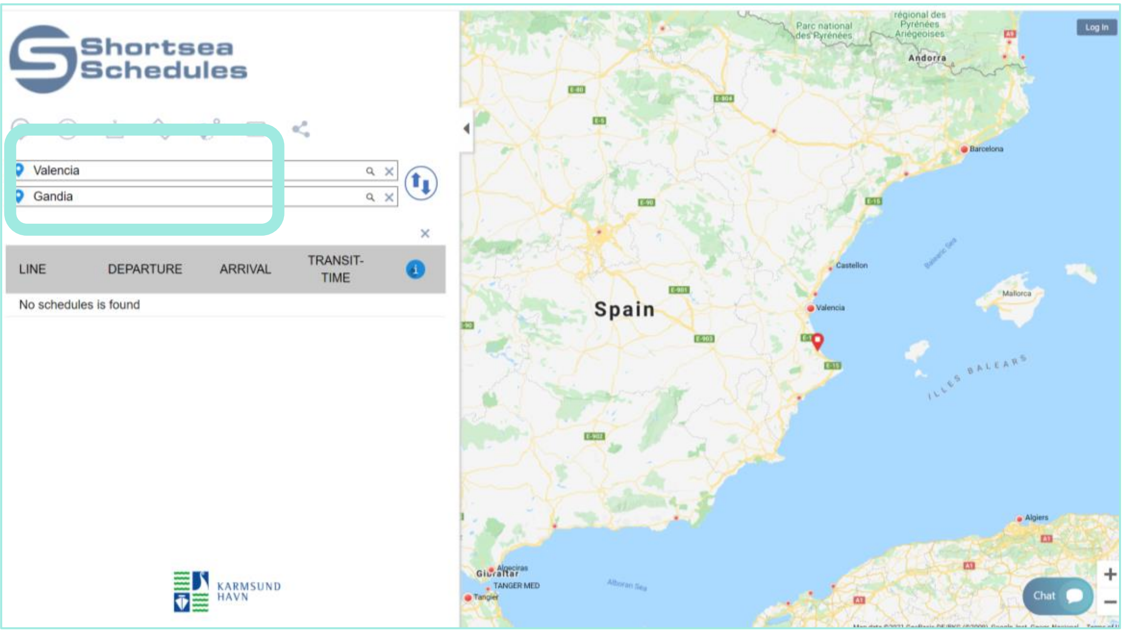
Source: https://www.marinetraffic.com/en/ais/details/ports/188



Gandia – Spain

Container	RoRo
0	0

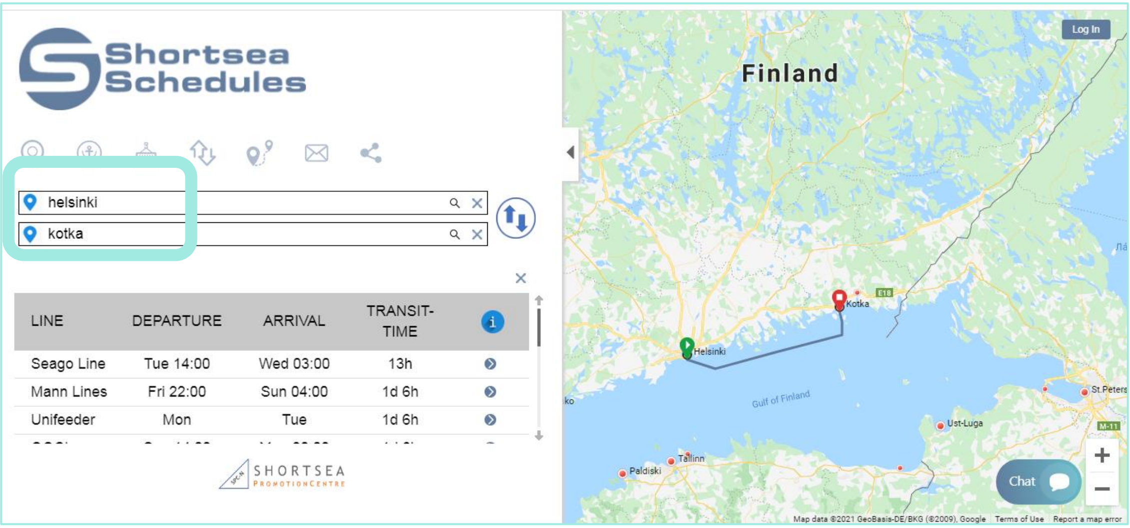
Source: http://www.spanishports.es/texto-diario/mostrar/1384538/fomento-pone-servicio-acceso-sur-puerto-gandia-valencia



Kotka- Hamina   Finland

Container	RoRo
0	0

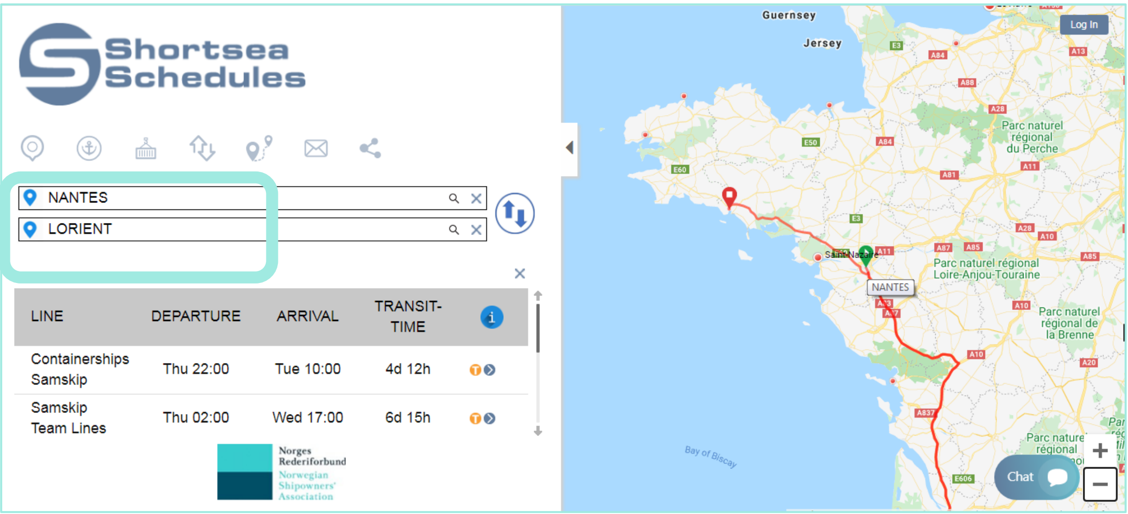
Source: https://www.haminakotka.com/fi/palvelut-ja-hinnasto/bulk-satama



Lorient – France

Container	RoRo
0	0

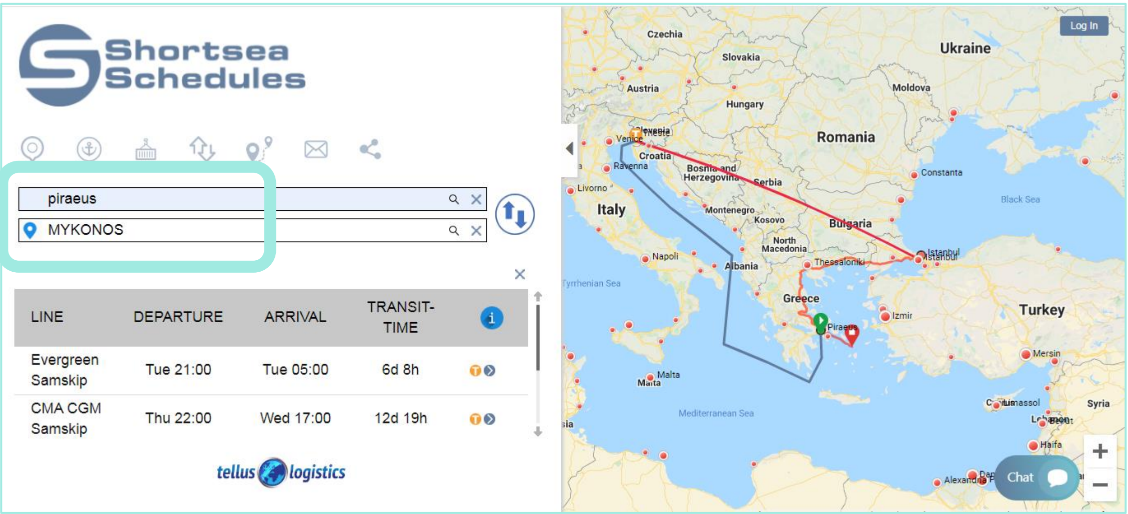
Source: https://en.wikipedia.org/wiki/Lorient#/media/File:Lorient.jpg



Greece - Mykonos

Container	RoRo
0	0

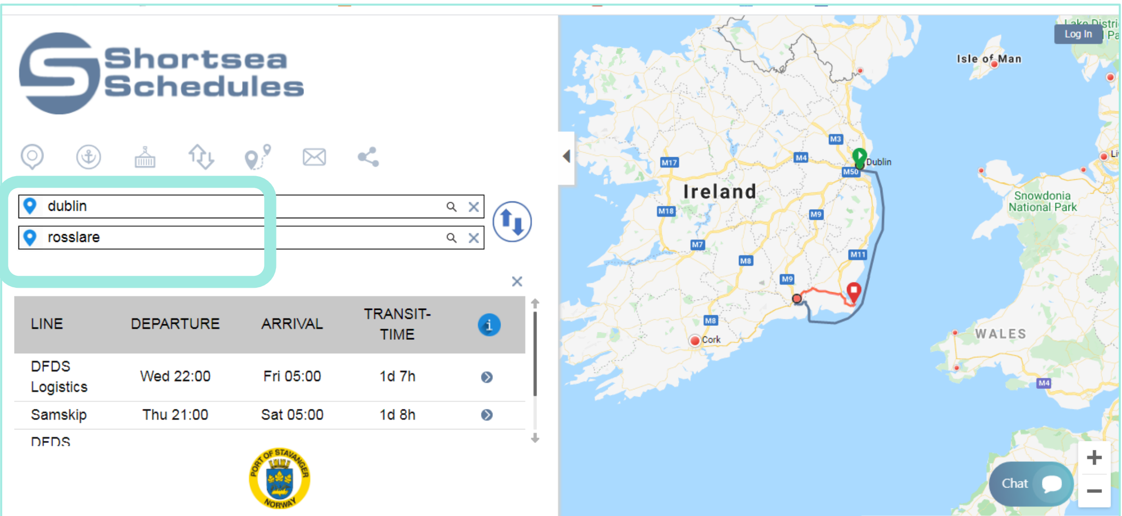
Source: https://mykonostraveller.com/mykonos-port/



Rosslare- Ireland

Container	RoRo
0	2098

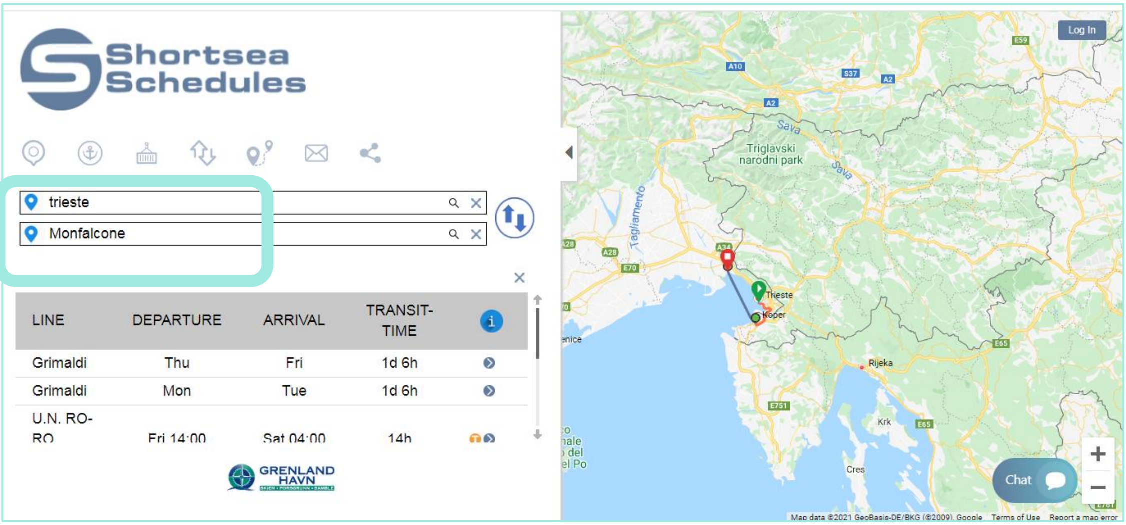
Source: https://www.irishrail.ie/en-ie/station/rosslare-europort



Monfalcone - Italy

Container	RoRo
2	754

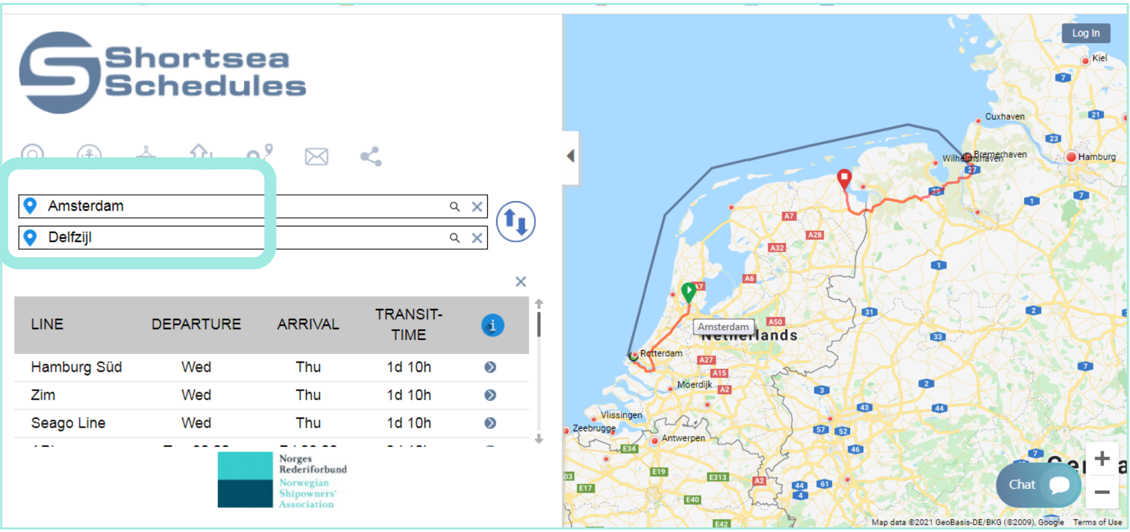
Source: https://www.adriaports.com/en/tags/port-monfalcone?page=1



Delfzijl - Netherlands

Container	RoRo
92	64

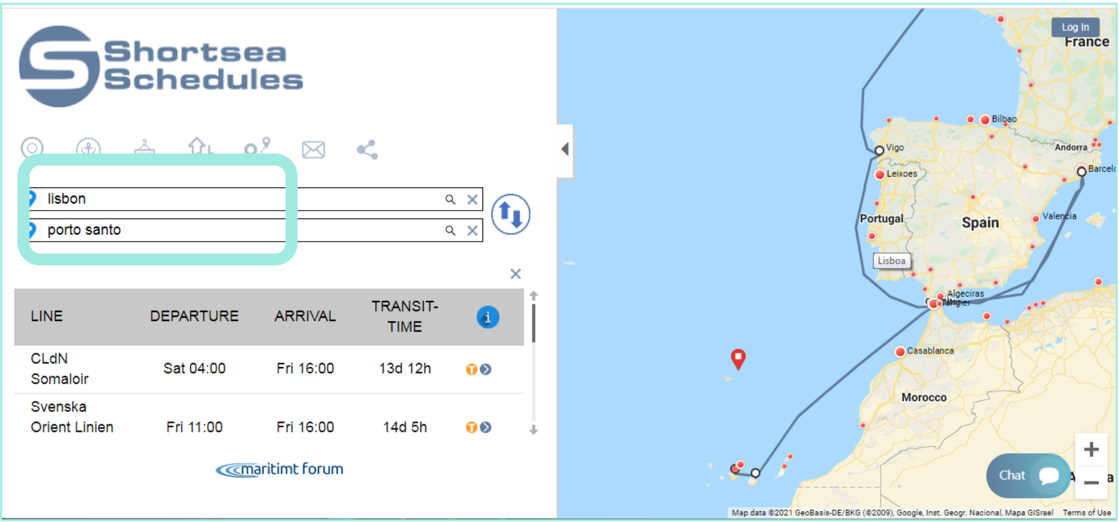
Source: https://www.cruisemapper.com/ports/delfzijl-port-13710



Porto Santo – Portugal

Container	RoRo
8	0

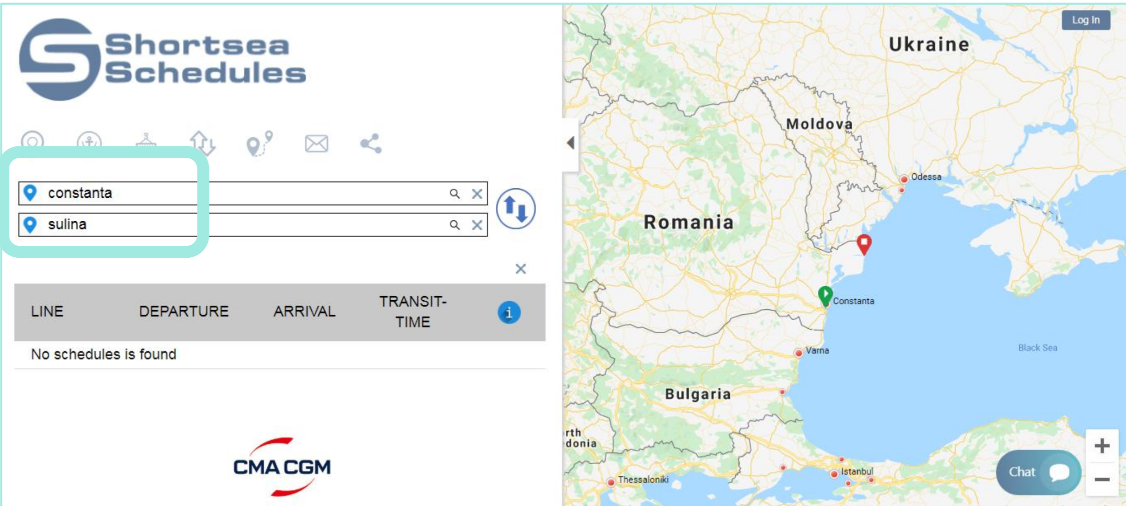
Source: https://www.visitportugal.com/it/NR/exeres/09A6840D-5C04-4F1F-BF96-7D65A7CD25A9



Sulina – Romania

Container	RoRo
0	0

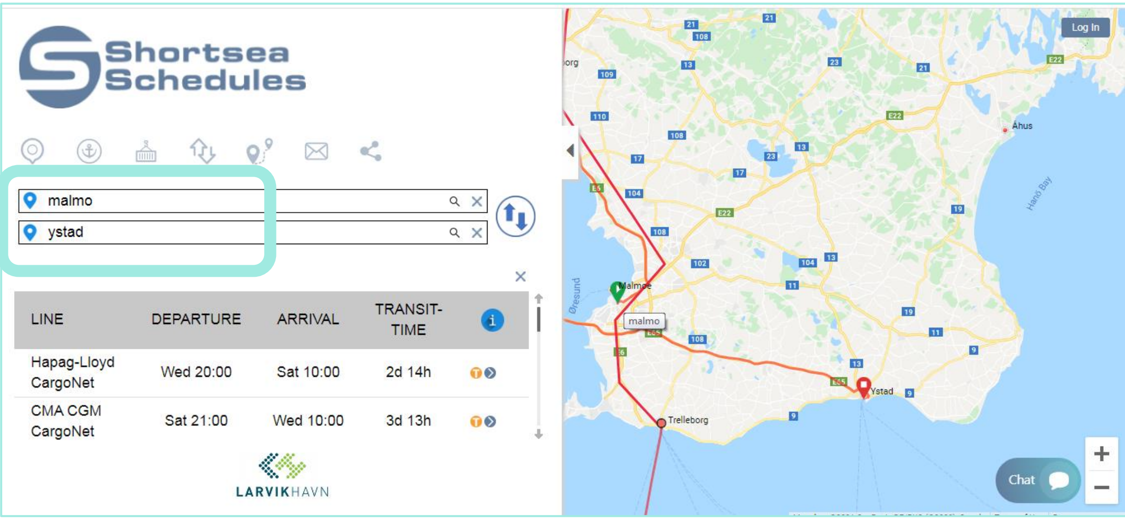
Source: https://www.cruisemapper.com/ports/sulina-port-3233



Ystad - Sweden

Container	RoRo
0	3597

Source: https://www.promyskat.pl/przeglad-promowy/2198-port-of-ystad-z-unijnym-dofinansowaniem-na-rozbudowe-ale-zyska-tez-swinoujscie



Autonomous Tugboats innovation

A large containership (mother-vessel) approaches a DSS port (or a large container terminal). MOSES aims to reduce the total time to berth for TEN-T Hub Ports and to stimulate the use of SSS feeder services in small ports that have limited or no infrastructure. To achieve its objectives, MOSES will implement a constellation of innovations, including **Autonomous Tugboats innovation**. It can be explained as a large containership (mother-vessel) approaches a DSS port (or a large container terminal). Upon her arrival, she asks for assistance to safely moor at the dock. The assistance is provided by the MOSES AutoDock, a combined intelligent mega-system consisting of the MOSES Autonomous tugboat swarm for manoeuvring and the MOSES adapted AutoMoor system. The MOSES **Autonomous tugboats** are dispatched and assist the containership with the manoeuvring process in a swarm/cooperative formation. The MOSES autonomous tugboats are monitored through a remote-control station located in the DSS port (MOSES Shore Tugboat Control Station), which continuously monitors and gathers information about the process. The swarm of the tugboats automatically adapts its operation to the varying environmental conditions and the orders given by the Pilot of the large containership.

The MOSES Autonomous Tugboats will be highly automated tugboats that will operate collaboratively in a swarm configuration. The tugboats will be fitted with state-of-the-art sensors to enable autonomous navigation (payload, LIDAR, accelerometers, differential GNSS) and collision avoidance (swath multibeam sonar for seabed mapping). The tugboat swarm will be able to make real-time decisions and adapt to a dynamic environment. Furthermore, the tugboats will be designed to collaborate and exchange information with the MOSES auto-docking system. In the future, the tugboats are envisioned with hybrid electric propulsion that will be matched to their operational profile, in conjunction with the MOSES Recharging Station.

For innovation of “Autonomous Tugboats “, the main criteria for selecting and proposing the European ports is based on the main mission of the tugboats that will be to manoeuvre and dock large containerships in large container terminals (DSS Ports). In this way, there will be not only a reduction in manoeuvring and docking time of large containerships in large container terminals, but also improvement in operational safety, efficiency, and environmental impact of the manoeuvring and docking process in large container terminals.

Therefore, for the scenario of the main mission of the Autonomous Tugboats, 20 big ports with large container terminals ports/terminals are chosen across 20 EU countries with high container traffic at these ports. Moreover, the info of the above table for each of these 20 big ports with large container terminals /ports are accompanied with the number of container ship visits in 2018. (SeeTable 5).

Table 5: Twenty ports with large container terminals ports/terminals for Autonomous Tugboats innovation

No	Port	Country	Port Profile	Container ship calls 2018
1	Antwerpen (BE)	Belgium	Port with Large Container Terminal	107,666
2	Burgas (BG)	Bulgaria	Port with Large Container Terminal	816
3	Limassol (CY)	Cyprus	Port with Large Container Terminal	2409
4	Lubeck (DE)	Germany	Port with Large Container Terminal	1,907
5	Aarhus (DK)	Denmark	Port with Large Container Terminal	3,388
6	Tallinn (EE)	Estonia	Port with Large Container Terminal	1,879
7	Valencia (ES)	Spain	Port with Large Container Terminal	3,059
8	Helsinki (FI)	Finland	Port with Large Container Terminal	3,638
9	Nantes (FR)	France	Port with Large Container Terminal	1,453
10	Piraeus (GR)	Greece	Port with Large Container Terminal	44,614
11	Dublin (IE)	Ireland	Port with Large Container Terminal	5,530
12	Trieste (IT)	Italy	Port with Large Container Terminal	8,630
13	Amsterdam (NL)	Netherlands	Port with Large Container Terminal	686
14	Lisbon (PT)	Portugal	Port with Large Container Terminal	3,463
15	Constanta (RO)	Romania	Port with Large Container Terminal	5,225
16	Malmo (SE)	Sweden	Port with Large Container Terminal	202
17	Rijeka	Croatia	Port with Large Container Terminal	2,034
18	Marsaxlokk	Malta	Port with Large Container Terminal	799
19	Gdynia	Poland	Port with Large Container Terminal	6,984
20	Riga	Latvia	Port with Large Container Terminal	385,937 TEUs

9.3 The specific business case of feeder vessel in two MOSES Business Cases

One of the main objectives of MOSES project is to stimulate the use of Short Sea Shipping (SSS) feeder services between small ports, that have limited or no infrastructure, and hub ports. Within the framework of this project, an electric hybrid feeder vessel will be tested for Short Sea Shipping traffic (SSS), together with an autonomous system for ship manoeuvring and docking (MOSES AutoDock) and a digital platform (MOSES platform), aimed at matching the demand and supply of cargo volumes. These innovations in the feeder vessel, will allow it to be self-sufficient in terms of (un)loading containerised cargo, which will solve the problem of operational capacity in small ports and, at the same time, let it to be independent from the availability of port services in the hub ports.

The objective of this section is to do a preliminary analysis to evaluate the viability for a container feeder lines, with some innovations in the feeder vessel, versus the current transport system. The analysis will be particularized for the cases of the ports of Piraeus and Valencia.

However, in this comparison it should be taken into consideration that the main difference is the demand, much higher in the case of Valencia. As regards to the port of Piraeus, the scope of work concerns a potential feeder line between the port of Piraeus, Mykonos and some nearby Greek islands. In the current situation, all the general cargo traffic between Piraeus and Mykonos and nearby islands is handled by Ro-Ro or Ro-Pax vessels. As regards to the port of Valencia, the scope of work concerns a potential feeder line between the three ports managed by the Valencia Port Authority: Valencia, Sagunto and Gandia ports. For our particular case, the containers that reach Sagunto and Gandia hinterlands are loaded/unloaded in Valencia port. In this case, it should be noted that there currently no feeder service between Valencia and Gandia/Sagunto.

9.3.1 Analysis of the potential traffic for a container feeder line (Lo-Lo): the case of the port of Piraeus

This section is inline with the main objective of this deliverable in providing the identified market opportunities for the implementation of the MOSES innovations and the description of MOSES Business Cases 1 and 2, while including details for other promising use cases. Case 1 is the “Analysis of the potential traffic for a container feeder line (Lo-Lo): the case of the port of Piraeus”. The objective of this section is to evaluate the viability for a container feeder line that links Piraeus port and Mykonos and some nearby islands ports. For that, the following methodology is proposed:

- Analysis of the current container transport system between Piraeus, Mykonos and nearby islands.
  - Current lines between both destinations (cargo typology).
  - Traffic between Piraeus port and Mykonos and nearby islands ports.
- Analysis of the potential demand for a feeder line that links Piraeus port and Mykonos and nearby islands ports.
- Comparative cost analysis between using the potential feeder line or the current transport situation (Ro-Ro lines), to determinate the potential cost savings in the use of a container feeder (Lo-Lo), compared to current lines (Ro-Ro).

Finally, based on this analysis, the final paragraph covers a summary and the main conclusions and recommendations reached.

Analysis of the current transport system between Piraeus, Mykonos, and nearby islands

Currently, all the general cargo transported to Mykonos are handled by trucks and trailers, from Piraeus and Rafina ports. So, nowadays there is not any container traffic between this island and Piraeus port (neither Lo-Lo traffic nor doing the maritime travel over a platform as Ro-Ro traffic). Most of the traffic is accompanied (with a driver). In the following tables Ro-pax and Ro-Ro lines that link Piraeus port and Mykonos port are shown:

Table 6: Ro-pax lines between Piraeus and Mykonos Ports

Name of the vessel	Type of vessel	Company	Route	Frequency
BLUE STAR CHIOS	Ro-Ro/Passenger	BLUE STAR FERRIES	Piraeus - Syros - Mykonos - Ikaria - Samos - Chios - Mytilini - Limnos - Kavala	3 times a week
BLUE STAR PAROS	Ro-Ro/Passenger	BLUE STAR FERRIES	Piraeus - Syros - Tinos - Mykonos	Daily
NEARCHOS	Ro-Ro/Passenger	CRETAN CARGO	n.a.	Weekly

Source: Port Authority of Mykonos

Table 7: Ro-ro lines between Piraeus and Mykonos Ports

Name of the vessel	Type of vessel	Company	Route	Frecuency
KAPETAN CHRISTOS	Ro-Ro Cargo	KAPETAN CHRISTOS	n.a.	Weekly
BLUE CARRIER 1	Ro-Ro Cargo	BLUE STAR FERRIES	n.a.	Weekly

Source: Port Authority of Mykonos

As information's provided by the Port Authority of Mykonos, the average transit time from Piraeus to Mykonos is around six hours.

Analysis of the potential demand of the feeder line

In the following figure the ports of Mykonos and nearby islands are shown.

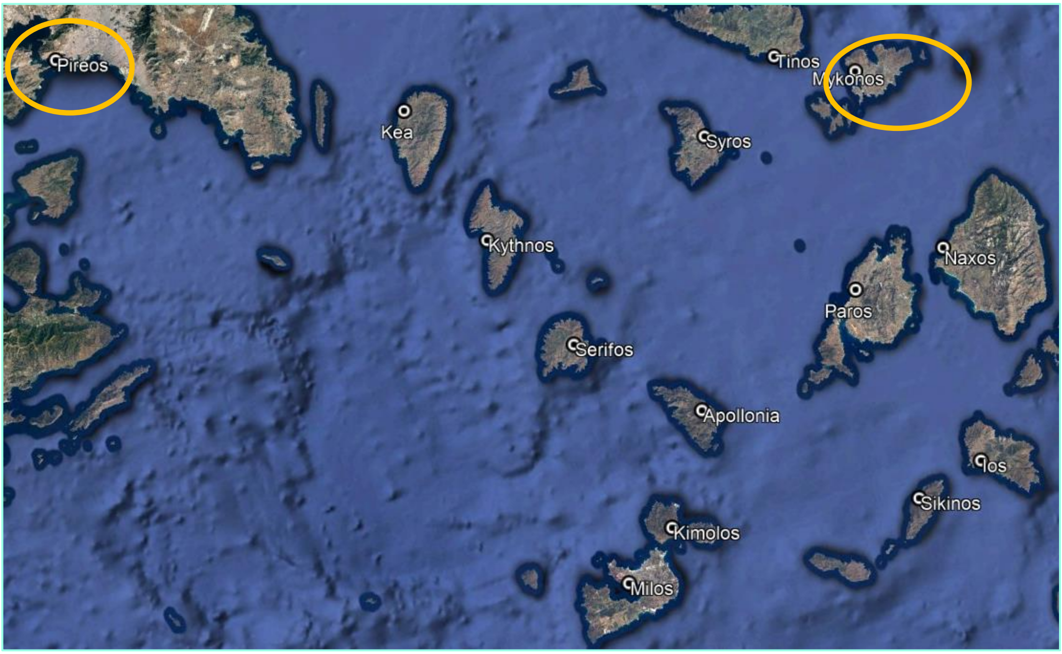


Figure 32: Piraeus, and Mykonos and nearby islands ports

Source: Epc through Google Maps

In 2019, the Ro-Ro traffic handled in these ports (previous COVID-19 pandemic impact) is shown below:

Table 8: Ro-Ro traffic in Mykonos and nearby islands, 2019 (tonnes and %)

Ports	Traffic (tonnes)	%
Mykonos	**204.595**	**29,6%**
Paros	**153.765**	**22,2%**
Naxos	**87.405**	**12,6%**
Syros	**57.543**	**8,3%**
Kea	**55.514**	**8,0%**

Ports	Traffic (tonnes)	%
Tinos	**45.100**	**6,5%**
Kythnos	27.843	4,0%
Milos (Adamas)	25.514	3,7%
Ios	11.723	1,7%
Sifnos	10.768	1,6%
Serifos	7.705	1,1%
Kimolos	2.867	0,4%
Iraklia Kyklades	1.325	0,2%
Sikinos Kyklades	680	0,1%
Total	692.347	100%

Source: EPC through Hellenic Statistical Authority

As can be seen, there is a strong concentration of the traffic in very few ports. The six ports with higher general cargo traffic in 2019 concentrate 87% of the total traffic of the islands shown above. There are two peak seasons in the year, in the second and third quarter, with 31% and 33% of total traffic (see Table 9).

Table 9: Distribution of Ro-Ro traffic in Mykonos and nearby islands in 2019, by quarters (tonnes)

Ports	1Q 2019		2Q 2019		3Q 2019		4Q 2019		2019	
	TEUs	%	TEUs	%	TEUs	%	TEUs	%	TEUs	%
Mykonos	37.201	18%	68.899	34%	67.938	33%	30.557	15%	204.595	34%
Paros	24.916	16%	45.757	30%	58.596	38%	24.496	16%	153.765	25%
Naxos	19.354	22%	24.143	28%	24.422	28%	19.486	22%	87.405	14%
Syros	14.292	25%	15.960	28%	15.307	27%	11.984	21%	57.543	10%
Kea	6.897	12%	16.935	31%	16.830	30%	14.852	27%	55.514	9%
Tinos	9.334	21%	13.572	30%	13.546	30%	8.648	19%	45.100	7%
Total	111.994	19%	185.266	31%	196.639	33%	110.023	18%	603.922	100%

Source: EPC through Hellenic Statistical Authority

Based on the above, to determine the potential demand of the feeder line, the proposed feeder route is shown. This route includes the six ports with higher Ro-Ro traffic in 2019:

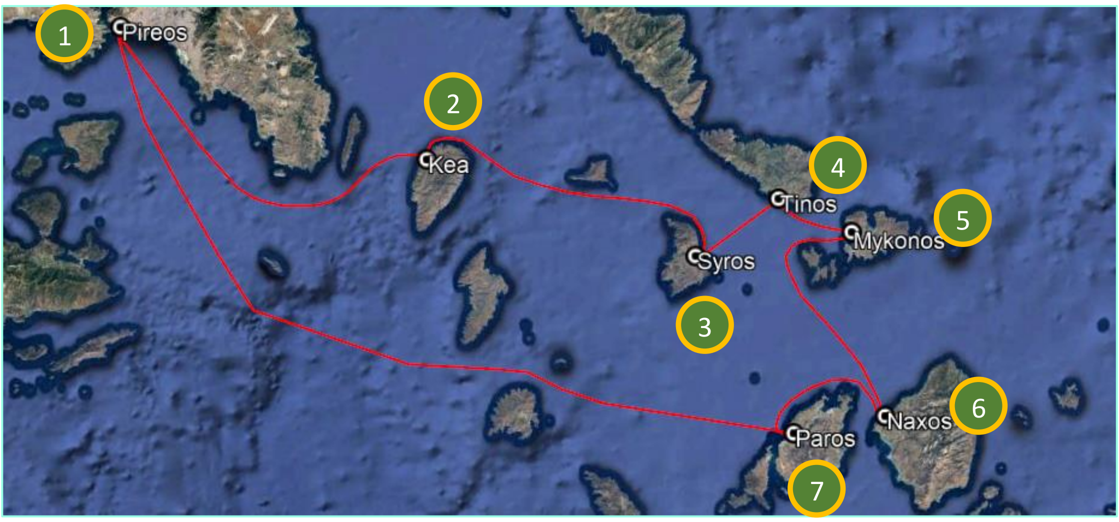


Figure 33: Feeder route proposed to link the ports of Piraeus, Kea, Syros, Tinos, Mykonos, Naxos and Paros

Source: EPC [23]

Nearly a 35% of total general cargo traffic of Mykonos port is loaded/unloaded in Piraeus port, according to the information provided by the Mykonos Port Authority. As hypothesis, it has been assumed the same percentage for the nearby islands. So, in the following table is shown the Ro-Ro traffic between Piraeus and Mykonos and nearby islands:

Table 10: Ro-Ro traffic between Piraeus and Mykonos and nearby islands, 2019 (tonnes)

Port	Load (tonnes)	Unload (tonnes)	Total (tonnes)
Paros	21.916	29.966	51.881
Mykonos	**70.593**	**1.016**	**71.608**
Naxos	26.115	4.477	30.592
Kea	19.410	20	19.430
Syros	17.071	3.069	20.140
Tinos	13.836	1.950	15.785
Total	**168.939**	**40.497**	**209.436**

Source: EPC through Hellenic Statistical Authority

Assuming the whole current traffic was transported by the feeder line, and a cargo of 12 tonnes/ TEU (similar cargo for full containers import/export in Canary Islands (Spain) in 2019), the maximum potential demand of the feeder line should be the following:

Table 11: Container potential traffic between Piraeus port and the islands of Mykonos and nearby islands, 2019 (full TEUs)

Port	Load (TEUs)	Unload (TEUs)	Total (TEUs)
Paros	1.826	2.497	4.323
Mykonos	**5.883**	**85**	**5.967**
Naxos	2.176	373	2.549
Kea	1.618	2	1.619
Syros	1.423	256	1.678
Tinos	1.153	162	1.315
Total	**14.079**	**3.375**	**17.451**

Source: EPC through Hellenic Statistical Authority

However, it seems unreasonable to expect that the feeder line will capture the whole current traffic. Therefore, it has been supposed a 40% of demand capture by the feeder line. To reach this container demand, it seems reasonable that the container line has at least two weekly services in each port (104 services per year). If this minimum frequency is not reached, it would be very difficult for the feeder line to be attractive to customers, compared to Ro-Ro lines with daily frequencies and the customers would use the ferries lines. Additionally, a traffic of empty containers should be handled in these islands, to compensate the imbalance of their traffic (loaded/unloaded). So, the potential demand should be as in Table 12.

Table 12: Container potential traffic of the feeder line Piraeus port and the islands of Mykonos and nearby islands, 2019 (full TEUs)

Port	Full containers			Empty containers (TEUs)	Feeder line demand (TEUs)
	Load (TEUs)	Unload (TEUs)	Total (TEUs)		
Paros	730	999	1.729	269	1.998
Mykonos	**2.353**	**34**	**2.387**	**2.319**	**4.706**
Naxos	870	149	1.019	721	1.740
Kea	647	1	648	646	1.294
Syros	569	102	671	467	1.138
Tinos	461	65	526	396	922
Total	**5.630**	**1.350**	**6.980**	**4.818**	**11.798**

Source: EPC [23]

Based on the above, the container demand of the feeder line would be 11.798 TEUs/year.

Comparative cost analysis

Methodology

This point summarises the methodology used to do a cost analysis comparison between Lo-Lo logistic chain and Ro-Ro logistic chain as homogeneous as possible. The methodology proposed includes a round trip between Piraeus and Mykonos and nearby islands (outbound trip and return trip). The cost elements considered in the cost analysis of each logistic chain are listed below.

A short introduction to Lo-Lo Logistic chain

The unitary cost of this logistic chain has been obtained considering:

- Costs related with the feeder container line operator (cost per container has been obtained dividing the total costs of the feeder operator by total container demand)
- Handling cost on Piraeus port.
- Handling cost on Mykonos or nearby islands (The advantage of Ro-Ro services is that the container-truck combination will be used upon arrival at the local port to deliver the container to the end customer. In contrast, Lo-Lo services will deliver containers as such. As a result, a Lo-Lo service requires, a currently non-existent local transport service for "last mile" delivery to the end customer. However, the benefit of Lo-Lo service is that vessel's actual capacity is much higher than the Ro-Ro vessel of the same size. Also, the containers will be unloaded from the feeder vessel to the concrete floor of the quay side or docking area. Therefore, this means that the containers must then be put on truck chassis for 'last-mile' transport to the end-customer, using mobile reach stackers. In some ports reach stackers are currently lacking as containers are transported by trucks using Ro-Ro ferries in present logistic practice)
- Local haulage in the island of origin / destination.

The costs related with the feeder container line operator, are included in:

- Port link costs (port taxes, technical Nautical Services tariffs and vessel-generated waste collection service tariff).
- Maritime link costs (bunker and time charter vessel).

So, the Lo-Lo Logistic chain includes the following costs elements:

- **Port link costs**:
  - Ship related costs:
    - Port taxes.
    - Technical Nautical Services tariffs.

- Vessel-generated waste collection service tariff.

- Container related costs:
  - Container terminal cost

- **Maritime link costs**:
  - Time charter vessel cost.
  - Bunker consumption cost.
- **Land link costs:**
  - Local haulage in the destination islands

Ro-Ro Logistic chain

The Ro-Ro Logistic chain includes the following parts:

- **Maritime link costs**:
  - Ferry tariffs between Piraeus and Mykonos and nearby islands (trough Mykonos Authority Port).
  - Ferry tariffs between Mykonos and nearby islands and Piraeus (trough Mykonos Authority Port).
- **Land link costs**:
  - Costs associated to the accompanied truck transport (cost of the truck, salary of the driver, local haulage, etc).

Cost of logistics chain between the port of Piraeus and Mykonos and nearby islands

Cost of a Lo-Lo Logistic chain

First of all, to determine the cost of a lo-lo chain it's necessary to select a vessel. As an indicative example. a 384 TEU geared vessel has been selected for the analysis. The citeria for choosing such a vessel is tha considering the low demand conditions, a small container vessel has been selected, but one that must be able to navigate the Aegean Sea area. In addition, possible peaks in demand should be considered, especially during the summer season. An example of this type of vessel is the Maria Reina, shown in Figure 34.

Figure 34: Maria Reina vessel

Source: EPC through Marinetraffic [23]

Its main characteristics are:

- Container capacity: 384 TEUs.
- Gross Tonnage: 4.276 GT.
- Length overall: 100,59 m.
- Beam: 16,24 m.

So, with 104 services per year in each port, the average cargo of every round trip would be 113 TEUs. During the peak season of the third quarter, with a demand of 33%, which it reaches to 3.893 TEUs, the average cargo of every round trip would be 162 TEUs. The selected vessel of the feeder has a capacity of 384 TEUS, which should be enough to cover eventual peak loads, especially during the summer season. Hereafter, are detailed the cost parts considered.

Port link costs

The cost of this link is broken down into the following parts:

- Ship related costs:
  - Port taxes: 30,38 €/call (Losif K Ro-Ro Cargo (2107 gt): 14,97€).
  - Technical Nautical Services tariffs. In this sub-charter are included the following port services:
    - Vessel pilotage: 225,22 €/call (same cost as per Apiliotis Oil Products Tanker (1530 gt)).
    - Port tugboats: 1.338 €/call (cost of Protugs company in Piraeus port).
    - Mooring and unmooring: 96,22 €/call (same cost as in Valencia port).
    - Vessel-generated waste collection service tariff: 205,25 € (same cost as in Valencia port).

These costs should be considered for all the calls made by the ship during a year, regardless of whether they are the origin / destination of the container.

- Container related costs:
  - Container terminal costs.

In the case of the ports of Piraeus and Mykonos and nearby islands, it has been assumed that the containers will be handled by the own cranes of the vessel, as an optimist hypothesis, considering they do not have any container handling infrastructure. So, the costs that has been considered in this study, includes those concerning the operations from the side of the vessel until the gates of the terminal, or vice versa. These costs should be considered only at the origin and destination port of the container.

Maritime link costs

This link of the logistics chain contains the following main cost elements:

- Time charter vessel cost.
- Bunker consumption cost.

Time charter vessel cost

A time charter is a time-bound agreement, where the shipowner leases a vessel to a charterer for a fixed period of time, and it is free to sail to any port and transport any cargo, subject to legal regulations. Although the charterer controls the ship, the shipowner must cover all costs associated with crewing, maintenance of the vessel and insurance, but vessel fuel consumption and port charges will be compensated by the charterer. The time charter agreement can span anywhere from a few days to a few years. This is a long-term agreement that works on a single rate of payment known as the freight rate. To estimate this freight rate has been applied the costs of the Hamburg Index Containership Time Charter Rates.

It is developed by the Hamburg and Bremen Shipbrokers' Association (VHBS), the only company-independent market analysis of container ship time-charter rates. It is based on the broad data base of Hamburg freight brokers (over 50% of the entire worldwide fleet of container vessels is operated from Germany or by international companies that are mainly in German ownership). For the vessel proposed, the cost is 4.440 $ per day (polynomial regression adjusted cost for 2020).

Bunker consumption cost

Bunker costs have been calculated with the Trozzi model ("Update of emission Estimate Methodology for Maritime Navigation"), for a speed vessel of 10 knots, which requires a ship power of 2.920 kW. The distance to cover by the vessel to do a round trip of the route proposed, is shown in Table 13.

Table 13: Distance of the feeder line round trip (Km and NM)

	Distance	
	Km	Nm
Piraeus - Kea	89,40	48,27
Kea - Syros	73,90	39,90
Syros - Tinos	22,60	12,20
Tinos - Mykonos	18,70	10,10
Mykonos - Naxos	58,00	100,38
Naxos - Paros	37,30	152,48
Paros - Piraeus	188,00	265,06
Total distance	487,90	628,40

Source: EPC through Google Maps

With a speed of 10 knots, the sailing time of the round trip is 67 hours, to which must be added the time spend in each port. Based on the above, it is concluded that is enough to have **two weekly services**, as a hypothesis supposed. Finally, the bunker consumption is calculated as shown below:

$$\text{Bunker consumption (t)} = \text{Ship power (kw)} \cdot \text{Time (h)} \cdot \mathit{Unitary\ Consumption}^{2}\ (\frac{t}{kw\ h})$$

Equation 1: Bunker consumption calculation

The bunker type selected is BFO 0,5% S (500 $/t in February 2021 rates of Bunkerworld Index), to comply with IMO2020 regulations.

Land link cost

Based on the demand (only full containers must be considered), assuming 1,6 TEUs/container, the haulages, per island, are shown in Table 14.:

Table 14: Demand for container land transport in Mykonos and nearby islands

Port	Container land transport (haulages)	Container land transport (Haulages/call)
Paros	1.081	10
Mykonos	**1.492**	**14**
Naxos	637	6
Kea	405	4
Syros	419	4
Tinos	329	3
Total	**4.363**	**41**

Source: EPC [23]

[2] 213 g/kwh in Trozzi Model

Assuming that the maximum dwell time could be two days, and that each driver could make three haulages per day, the following truck drivers would be needed (Table 15):

Table 15: Truck driver needs in Mykonos and nearby islands

Port	Truck drivers (number)	Haulages per driver (haulages/year)
Paros	2	541
Mykonos	**3**	**497**
Naxos	1	637
Kea	1	405
Syros	1	419
Tinos	1	329
Total	**9**	**2.828**

Source: EPC [23]

The cost of land transport has been calculated with Acotram software, an application of the Ministry of Transport, Mobility and Urban Agenda of Spain, developed to calculate the operating costs of road freight vehicles. Assuming a haulage of 10 km (5 outward and 5 return), the cost of the haulages would be the following:

Table 16: Cost of haulages in Mykonos and nearby islands

Port	Cost (€/km)	Cost (€/haulage)
Paros	12	120
Mykonos	12	120
Naxos	10	95
Kea	12	120
Syros	12	120
Tinos	12	120

Source: EPC [23]

Results of the cost analysis

The results of the analysis for Lo-Lo logistic chain (Mykonos case) are shown in theTable 17:

Table 17: Costs results for Lo-Lo logistic chain, Mykonos-Piraeus (€/TEU and €/40' container)

	(€/TEU)	(€/40' container)
Piraeus port link cost	**111,86**	**223,73**
Ship related costs	16,70	33,41
Port taxes	0,27	0,54
Technical Nautical Services tariff	14,63	29,26
Marpol waste collection service tariff	1,81	3,62
Container related costs	95,16	190,32
Stevedoring in the port of Piraeus (outbound trip)	47,58	95,16
Stevedoring in the port of Piraeus (return trip)	47,58	95,16
Maritime link cost (outbound trip)	**232,14**	**464,28**
Time charter costs	113,14	226,29
Bunker consumption cost	119,00	237,99
Maritime link cost (return trip)	**232,14**	**464,28**
Time charter costs	113,14	226,29
Bunker consumption cost	119,00	237,99
Mykonos and nearby islands port link cost	**195,39**	**390,78**
Ship related costs	100,23	200,46
Port taxes	1,61	3,21
Technical Nautical Services tariff	87,77	175,54
Marpol waste collection service tariff	10,85	21,71
Container related costs	95,16	190,32
Stevedoring in Mykonos or Nearby islands (outbound trip)	47,58	95,16
Stevedoring in Mykonos or Nearby islands (return trip)	47,58	95,16
Land link cost	**75,00**	**120,00**
Haulage	75,00	120,00
Total costs	**847**	**1.663**

Source: EPC [23]

Cost of a Ro-Ro logistic chain

The cost of the Ro-Ro logistic chain, expressed in €/TEU, includes the following links:

- Maritime link costs (outbound trip).
- Maritime link costs (return trip).
- Costs associated to the accompanied transport (cost of the truck, salary of the driver, haulage etc.).

Maritime link costs

The tariffs of the ferries (€/Intermodal Transport Unit) between Piraeus and Greek islands with the current Ro-Ro lines are the following (as information from Mykonos Port Authority):

- Piraeus - Paros: 29,00 €/meter of truck & 30,00 €/meter of refrigerator truck.
- Piraeus - Mykonos: 21,00 €/meter of truck & 22,00 €/meter of refrigerator truck.
- Piraeus - Naxos: 29,00 €/meter of truck & 30,00 €/meter of refrigerator truck.
- Piraeus - Syros (if available): 19,00 €/meter of truck & 22,00 €/meter of refrigerator truck.
- Piraeus - Tinos (if available): 19,00€/meter of truck & 22,00€/meter of refrigerator truck.

As a favourable hypothesis for the viability for the container feeder line, it is assumed that the cargo that it can be transported in a 40' container would be transported into a truck which dimensions are the maximums for an articulated vehicle in Greece (16,5 m as information of the International Transport Forum).

With this hypothesis, the costs are shown in Table 18:

Table 18: Costs results for Ro-Ro logistic chain, single trip (€/truck)

	(€/m)	(€/truck)
Piraeus - Paros	29	479
Piraeus - Mykonos	21	347
Piraeus - Naxos	29	479
Piraeus - Syros	19	314
Piraeus – Kea	na	na
Piraeus - Tinos	19	314

Source: EPC [23]

Costs associated to the accompanied transport

These costs have also been calculated with Acotram software. The annual costs associated to the accompanied transport, that is, one truck, are 59.828,70 €. Assuming that the transit time is two days, and the yearly working days are 225 days, it would be possible to do 112 haulages.

So, the unitary cost is 534,18 €/haulage.

Results of the cost analysis

The results of the analysis for Ro-Ro logistic chain, for Mykonos cargo, are shown in Table 19.

Table 19: Costs results for Ro-Ro logistic chain, Mykonos case (€/truck)

	(€/truck)
Ferry tariff (outbound trip)	346,50
Ferry tariff (return trip)	346,50
Truck cost (including truck driver salary)	534,18
Total costs	**1.227**

Source: EPC [23]

As it can be seen, the costs of the Ro-Ro logistic chain are significantly lower than Lo-Lo chain. Even in the most favourable scenario for the feeder container line (Naxos and Paros ports where ferry tariffs are higher) the costs of Ro-Ro chain are lower than Lo-Lo logistic chain, as it can be seen in the following table:

Table 20: Costs results for Ro-Ro logistic chain, Naxos, and Paros case (€/truck)

	(€/truck)
Ferry tariff (outbound trip)	478,50
Ferry tariff (return trip)	478,50
Truck cost (including truck driver salary)	534,18
Total costs	**1.491**

Source: EPC [23]

Comparison of a Lo-Lo and a Ro-Ro logistics chains

In the following tables the cost comparison between lo-lo and Ro-Ro chains is shown:

Table 21: Costs comparison between lo-lo and Ro-Ro chains, Piraeus- Mykonos (€/40' container and articulated vehicle 16,5m)

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	223,7	-
Maritime link cost (outbound trip)	464,3	346,5
Maritime link cost (return trip)	464,3	346,5
Mykonos and nearby islands port link cost	390,8	-
Land link cost	120,0	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1663,1**	**1227,2**

Source: EPC [23]

Table 22: Costs comparison between lo-lo and Ro-Ro chains, Piraeus- Naxos (€/40' container and articulated vehicle 16,5m)

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	223,7	-
Maritime link cost (outbound trip)	464,3	478,5
Maritime link cost (return trip)	464,3	478,5
Mykonos and nearby islands port link cost	390,8	-
Land link cost	95,2	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1638,2**	**1491,2**

Source: EPC [23]

Table 23: Costs comparison between lo-lo and Ro-Ro chains, Piraeus- Paros (€/40' container and articulated vehicle 16,5m)

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	223,7	-
Maritime link cost (outbound trip)	464,3	478,5
Maritime link cost (return trip)	464,3	478,5
Mykonos and nearby islands port link cost	390,8	-
Land link cost	119,7	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1662,7**	**1491,2**

Source: EPC [23]

Table 24: Costs comparison between lo-lo and Ro-Ro chains, Piraeus - Syros and Tinos (€/40' container and articulated vehicle 16,5m)

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	223,7	-
Maritime link cost (outbound trip)	464,3	313,5
Maritime link cost (return trip)	464,3	313,5
Mykonos and nearby islands port link cost	390,8	-
Land link cost	119,7	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1662,7**	**1161,2**

Source: EPC [23]

The cost of the Lo-Lo logistic chain is significantly higher than Ro-Ro ferry traffic.

Even in the most favourable case to the feeder line, for the origins or destinations in the islands of Naxos and Paros, the costs are higher in the Lo-Lo Logistic chain.

The feeder line has important fixed costs, mainly linked to:

- Maritime link cost: time charter cost and bunker cost.
- Port link costs associated with the vessel: port taxes, technical nautical services and Marpol tariff.

Considering the bunker costs are only € 238 (14%), the efficiency required to make the service viable does not appear to be realistic in some ports. In the case of Mykonos, directly, the difference between logistics chains is higher than the full cost per bunker. To reduce the unitary costs, expressed in € / TEU, it is initially estimated that there could be two options:

- Reducing the attended ports:
  - Those with less container demand.
  - Those furthest from the port of Piraeus.
- Increasing the demand captured by feeder line.

To quantify this possible influence, a sensitivity analysis has been carried out below.

Sensitivity analysis

Reducing the attended ports

As a first step is proposed to eliminate the ports with lower container demand (Kea, Syros and Tynos). So, the container demand will be the following:

Table 25: Container potential traffic of the feeder line Piraeus port and the islands of Mykonos, Naxos and Paros, 2019 (TEUs)

Port	Full containers			Empty containers (TEUs)	Feeder line demand (TEUs)
	Load (TEUs)	Unload (TEUs)	Total (TEUs)		
Paros	730	999	1.729	269	1.998
Mykonos	**2.353**	**34**	**2.387**	**2.319**	**4.706**
Naxos	870	149	1.019	721	1.740
Total	**3.953**	**1.182**	**5.135**	**3.309**	**8.444**

Source: EPC [23]

In this case the route will be 444 km long.

The results of this cost analysis, for each island (Mykonos, Naxos, Paros) are shown in the following tables. The cost differences of each destinations are due the land transport in multimodal chain and the ferry tariffs in the unimodal chain.

Table 26: Cost comparison between lo-lo and Ro-Ro chains, Piraeus- Mykonos

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	237,0	-
Maritime link cost (outbound trip)	618,8	346,5
Maritime link cost (return trip)	618,8	346,5
Mykonos and nearby islands port link cost	330,4	-
Land link cost	120,0	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1924,9**	**1227,2**

Source: EPC [23]

Table 27: Cost comparison between Lo-Lo and Ro-Ro chains, Piraeus - Naxos

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	237,0	-
Maritime link cost (outbound trip)	618,8	478,5
Maritime link cost (return trip)	618,8	478,5
Mykonos and nearby islands port link cost	330,4	-
Land link cost	95,2	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1900,1**	**1491,2**

Source: EPC [23]

Table 28: Cost comparison between Lo-Lo and Ro-Ro chains, Piraeus - Paros

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	237,0	-
Maritime link cost (outbound trip)	618,8	478,5
Maritime link cost (return trip)	618,8	478,5
Mykonos and nearby islands port link cost	330,4	-
Land link cost	119,7	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1924,6**	**1491,2**

Source: EPC [23]

Although, as it can be seen, the associated costs to Mykonos and nearby islands port link cost have been reduced. However, the decrease of the container demand, due a smaller attended port by the feeder route, results in maritime link costs significantly higher than the savings reached. **Due to all these reasons, the cost of the lo-lo chain in this scenario is higher than in the base case.**

Increasing the demand captured by feeder line

As an optimistic scenario has been assumed that the feeder line would capture a 80% of the potential demand.

Table 29: Container potential traffic of the feeder line Piraeus port and the islands of Mykonos, Naxos and Paros, sensitivity analysis 2, 2019 (TEUs)

Port	Full containers			Empty containers (TEUs)	Feeder line demand (TEUs)
	Load (TEUs)	Unload (TEUs)	Total (TEUs)		
Paros	1.370	1.873	3.243	503	3.746
Mykonos	**4.412**	**64**	**4.476**	**4.348**	**8.824**
Naxos	1.632	280	1.912	1.352	3.264
Kea	1.214	2	1.216	1.212	2.428
Syros	1.067	192	1.259	875	2.134
Tinos	865	122	987	743	1.730
Total	**10.560**	**2.533**	**13.093**	**9.033**	**22.126**

Source: EPC [23]

The results of this cost analysis are shown below:

Table 30: Cost comparison between Lo-Lo and Ro-Ro chains, Mykonos - Piraeus

	Lo-Lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	208,1	-
Maritime link cost (outbound trip)	247,6	346,5
Maritime link cost (return trip)	247,6	346,5
Mykonos and nearby islands port link cost	297,2	-
Land link cost	120,0	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1120,5**	**1227,2**

Source: EPC [23]

Table 31: Cost comparison between lo-lo and Ro-Ro chains, Naxos - Piraeus

	(€/40' container)	(€/truck)
Piraeus port link cost	208,1	-
Maritime link cost (outbound trip)	247,6	478,5
Maritime link cost (return trip)	247,6	478,5
Mykonos and nearby islands port link cost	297,2	-
Land link cost	95,2	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1095,6**	**1491,2**

Source: EPC [23]

Table 32: Cost comparison between lo-lo and Ro-Ro chains, Paros - Piraeus

	(€/40' container)	(€/truck)
Piraeus port link cost	208,1	-
Maritime link cost (outbound trip)	247,6	478,5
Maritime link cost (return trip)	247,6	478,5
Mykonos and nearby islands port link cost	297,2	-
Land link cost	119,7	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1120,1**	**1491,2**

Source: EPC [23]

Table 33: Cost comparison between lo-lo and Ro-Ro chains, Siros and Tinos - Piraeus

	(€/40' container)	(€/truck)
Piraeus port link cost	208,1	-
Maritime link cost (outbound trip)	247,6	313,5
Maritime link cost (return trip)	247,6	313,5
Mykonos and nearby islands port link cost	297,2	-
Land link cost	119,7	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1120,1**	**1161,2**

Source: EPC [23]

In this scenario, costs of the Lo-Lo logistic chain are lower than Ro-Ro ferry traffic, especially for further away islands from Piraeus Port. However, it is considered optimistic to catch the 80% of total demand. This is a percentage that could make the service viable in all the ports analyzed. In the case of Siros and Tinos, the difference is very low compared to the Ro-ro logistics chain.

Summary, conclusions, and recommendations of the case of the port of Piraeus

- Nowadays, **the whole general cargo traffic between Mykonos and nearby islands is Ro-Ro traffic, composed by trucks and trailers** (accompanied and non-accompanied and no at all containers over platforms).

  Therefore, to develop a container feeder line, **the cargo should not only be transferred from the Ro-Ro logistic chain to the Lo-Lo logistic chain but should also be consolidated/deconsolidated in a different way, which will be a significant added difficulty**.

- To maximize the potential container demand of the feeder line, the route includes six ports (Kea, Syros, Tinos, Mykonos, Naxos, and Paros).

The maximum potential container demand of these islands is 81.372 TEUs in 2019 (the year before the COVID-19 pandemic).

However, only a 35% of the general cargo traffic has its origin or destination in Piraeus Port, **which limits the maximum potential container demand of the feeder line to 28.482 TEUs** (17.454 full TEUs and 12.046 empty TEUs). The main traffic would be with Mykonos (11.766 TEUs).

The following table shows the estimation of traffic for each island:

Table 34: Estimation of container traffic for each island (TEUs)

Port	Full containers			Empty containers (TEUs)	Feeder line potential demand (TEUs)
	Load (TEUs)	Unload (TEUs)	Total (TEUs)		
Paros	1.826	2.497	4.323	671	4.994
Mykonos	**5.883**	**85**	**5.968**	**5.798**	**11.766**
Naxos	2.176	373	2.549	1.803	4.352
Kea	1.618	2	1.620	1.616	3.236
Syros	1.423	256	1.679	1.167	2.846
Tinos	1.153	162	1.315	991	2.306
Total	**14.079**	**3.375**	**17.454**	**12.046**	**29.500**

Source: EPC [23]

- Assuming the **hypothesis of a capturing quote of about a 40% of the maximum potential demand**, **the traffic from Piraeus to these islands would be, approximately, 11.798 TEUs** (including full and empty containers).

  To reach this hypothetical quote, it seems reasonable that the feeder line should have at least **two weekly services** in each port, with a travel speed average of 10 knots. Increasing the speed of the route could increase the weekly frequencies. This could make the line more attractive to customers. Therefore, the identified speed is a balance between frequency and port costs.

- So, with 104 services per year in each port (2 per week), the average cargo of every round trip would be 113 TEUs (162 in summer peak season).

  The vessel that has been considered for the analysis has a capacity of **384 TEUS**. However, the demand is lower than the capacity. For example, another vessel, with a capacity of 250 TEUs has 4.155 GT, nearly to 4.276 of the vessels considered. So, the cost of these two vessels is similar. If there was a much higher demand it would be necessary, the first one.

  The chosen vessel should be enough to cover eventual peak loads, especially during the summer season. However, it should be noted that a reduction in vessel capacity would not bring about a significant reduction in vessel size. In addition, the cost reduction would not be linear, as both ships have very similar fixed costs, such as the crew. Finally, as has been said, the demand is a statistical distribution, which would make a small vessel unable for some peaks in demand.

- Since the ports of Mykonos and nearby islands currently do not have the infrastructure and facilities necessary to handle container traffic, **the container should be handled by the vessel with its own deck cranes. However, a container yard is also necessary.**
- The new infrastructure and facilities necessary to handle container traffic could reach to a relatively significant investment, in each port (it would be the infrastructures and facilities of a container terminal, except for the cranes).

  Given the low demand, the containers could be handled with a reach stacker. It should be noted that due to the reduced container to be handled in each port, the investments in each port would not be significant (neither in infrastructures nor handling equipment (reach stackers would be enough).
- To make a comparison as homogeneous as possible, in the **cost analysis of Lo-Lo and Ro-Ro chains, it has been considered a logistic chain that includes a round trip between Piraeus and Mykonos and nearby islands** (outbound trip and return trip).
  - So, the Lo-Lo logistic chain cost analysed includes the following main parts:
    - Port link costs at Piraeus port: port taxes, nautical services, stevedoring, etc.
    - Maritime link costs (outbound trip): time charter cost and bunker cost.
    - Land transport in Mykonos and nearby islands: local haulage.
    - Port link costs in Mykonos and nearby island ports: port taxes, technical services, Marpol in each port of the route and stevedoring at destination island.
    - Maritime link costs (return trip): time charter cost and bunker cost.
  - The Ro-Ro Logistic chain cost analysed includes the following main parts:
    - Ferry tariff (outbound trip).
    - Ferry tariff (return trip).
    - Costs associated to the truck (amortisation and maintenance of the truck, salary of the driver, local haulage at destination, etc).

The costs of the Lo-Lo logistic chain are significantly higher than Ro-Ro logistic chain in all ports considered.

As an example, for a container from Piraeus to Mykonos the difference reaches to 435,9 € (35,5%), see Table: 35:

Table: 35 The costs of the Lo-Lo logistic chain and Ro-Ro logistic chain in all ports considered

Mykonos case	Lo-Lo Chain (€/40' container)	Ro-Ro Chain (€/truck)
Piraeus port link cost	223,7	-
Maritime link cost (outbound trip)	464,3	346,5
Maritime link cost (return trip)	464,3	346,5
Mykonos and nearby islands port link cost	390,8	-
Land link cost	120,0	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1.663,1**	**1.227,2**

- However, Lo-Lo chain optimizes the land transport, but the maritime and port link costs are higher, because there is a low demand, so the container vessel is too small, and it does not have economies of scale.
- **To reduce the unitary costs of the feeder line**, expressed in € / TEU, it is initially estimated that there **could be two options**:
  - **Reducing the number of the attended ports** (those ports with less container demand), to reduce port link unitary costs.
  - **Increasing the demand captured by feeder line**, to reduce maritime and port link unitary costs.
- **The reduction of the number of attended ports (selecting only Mykonos, Naxos, and Paros):** reduces the port link costs, but with this measure the container demand would be lower, with resulting of an increase of maritime link costs.

  This increase of maritime link costs is higher than the savings in the port links costs.
- **The increment of the quote up to 80% of the maximum potential container demand: The Lo-Lo logistic chain would be cheaper than the Ro-Ro logistic chain in all the ports analysed.**

In the case of a container from Piraeus to Mykonos, the costs difference reaches to 106,7 € (8,6%), being cheaper the Lo-Lo chain (see Table 36).

Table 36: The costs difference in the case of a container from Piraeus to Mykonos

	Lo-lo chain (€/40' container)	Ro-Ro chain (€/truck)
Piraeus port link cost	208,1	-
Maritime link cost (outbound trip)	247,6	346,5
Maritime link cost (return trip)	247,6	346,5
Mykonos and nearby islands port link cost	297,2	-
Land link cost	120,0	-
Truck cost (including truck driver salary)	-	534,2
Total Cost	**1120,5**	**1227,2**

9.3.2 Analysis of the potential traffic for a container feeder line (Lo-Lo): the case of the port of Valencia

The objective of this point is evaluating the viability for a container feeder line that links the port of Valencia with Sagunto and Gandia ports. For that, the following methodology is proposed:

- Analysis of the current container transport system in the ports managed by APV: Valencia, Sagunto and Gandia:
  - Container traffic analysis of the ports managed by APV.
  - Current container lines in the ports managed by APV.
- Comparative cost analysis between using the potential feeder line versus the current transport situation (land transport), to get the potential cost savings in the use of a container feeder line (lo-lo), compared to current situation.
- Analysis of the potential traffic for a container feeder line, linking the ports of Valencia, Sagunto and Gandia.

Finally, based on these analyses, the final paragraph covers a summary and the main conclusions and recommendations reached.

Analysis of the current container transport system in the ports managed by APV

Container traffic analysis of the ports managed by APV

Due to the objective and scope of this study, to develop a container feeder line, only the import/export traffic has been considered.

Port of Valencia

In the following figure, the evolution of import/export container traffic in the port of Valencia for the last seven years, from 2014 to 2020 is shown (Figure 35).

As can be seen, in the port of Valencia has been handled more than 2,3 million TEUs in 2020 (import/export). Despite COVID-19 crisis, it’s very close to the historical record reached in 2019, with over 2,4 million TEUs.The container traffic has experienced growth since 2014, when it reached 1,94 million TEUs, so the compounded annual growth rate (CAGR) of container traffic for the past seven years was 3%.Full containers traffic has been reached 1,6 million TEUs in 2020 (70% of total import/export traffic), so the CAGR for the past seven years was 4%.Empty containers traffic has remained stable for the last seven years, reaching in 2020 691 thousand TEUs.

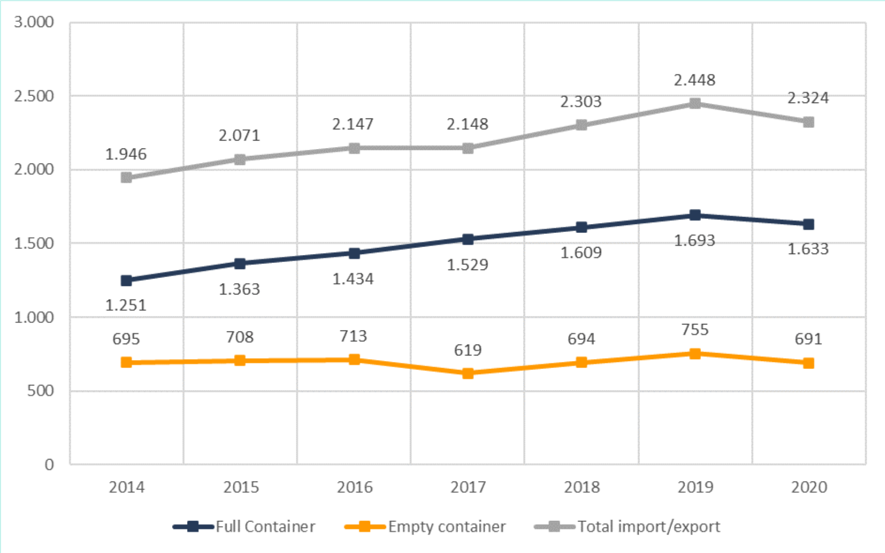


Figure 35: Evolution of container import/export traffic in the port of Valencia, 2014-2020 (thousands of TEUs)

Source: EPC through APV data

Port of Sagunto

In the following figure, the evolution of import/export container traffic in the port of Sagunto for the last seven years (2014-2020) is shown:

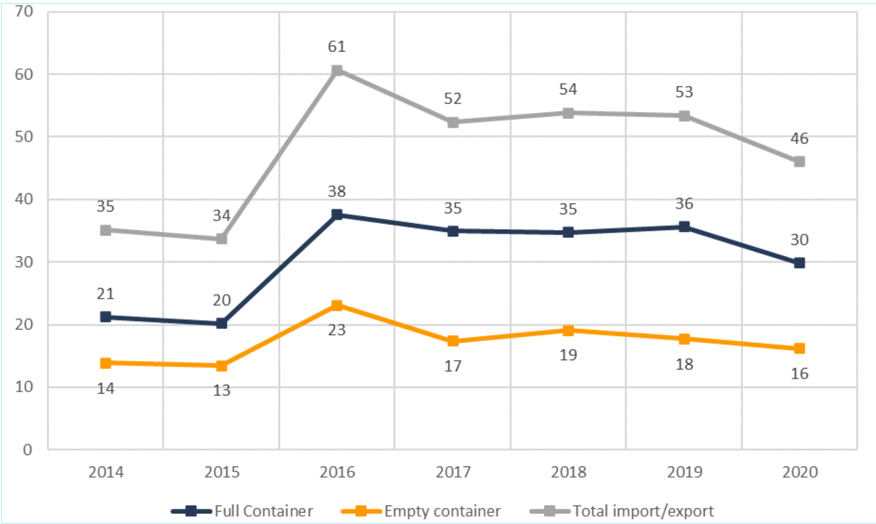


Figure 36: Evolution of container import/export traffic in the port of Sagunto, 2014-2020 (thousands of TEUs)

Source: EPC through APV data

As can be seen, in the port of Sagunto has been handled more than 46 thousand TEUs in 2020 (import/export). The container traffic has decreased since 2016, when it reached 61 thousand TEUs, so the compounded annual growth rate (CAGR) of container traffic for the past five years was -6,67%.

Full containers traffic has been reached 30 thousand TEUs in 2020 (65% of total import/export traffic), so the CAGR for the past five years was -5,6%. Empty containers traffic has already decreased for the last five years, reaching in 2020 16 thousand TEUs, so the CAGR for the past five years was -8,55%. The port of Sagunto handles three container lines, as can be seen below:

Port of Gandia

Finally, in the following table, the evolution of import/export container traffic in the port of Gandia for the last seven years (2014-2020) is shown:

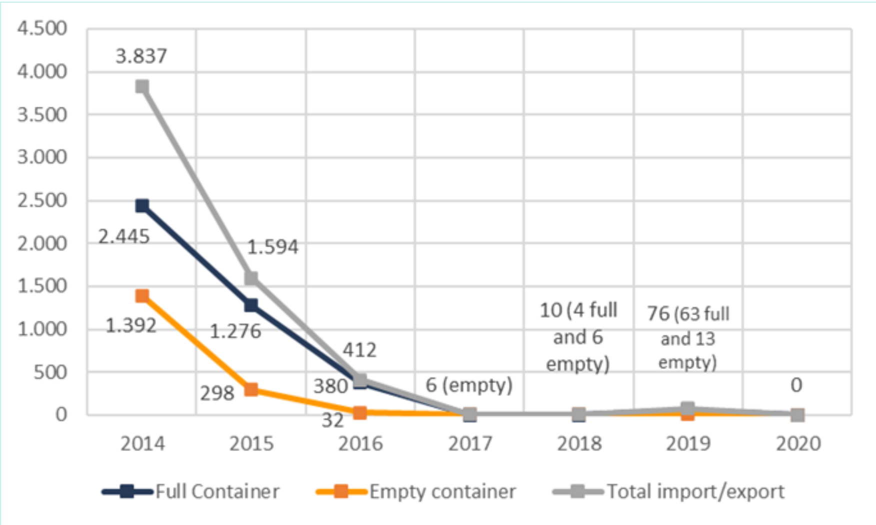


Figure 37: Evolution of container import/export traffic in port of Gandia, 2014-2020 (TEUs)

Source: EPC through APV data

As can be seen, in the port of Gandia has not been handled any TEUs in 2020 (import/export). The container traffic has disappeared since 2016, when it reached 3.837 TEUs.

Current container lines in the ports managed by APV

The vast majority of container traffics of APV are handled in Valencia Port. This port has numerous container lines which connects it with the principal ports around the world.

Figure 38: Container regular lines of the port of Valencia

As regards to Sagunto port, it has three container lines, linking it with some ports of Spain, Italy, Canada, Morocco, and Equatorial Guinea.

Table 37: Container regular lines of the port of Sagunto

Service	Company	Frequency	ROUND TRIP
Hapag-Lloyd - Med-Canada service - MCA	Hapag-Lloyd CMA CGM (slotter) Maersk A/S (Slotter)	Weekly	Salerno, Leghorn (aka Livorno), Genoa, Fos, Algeciras, Tanger Med, Vigo, Montreal, Tanger Med, Sagunto, Salerno
DAL (Direct Africa Line) - Spain-Equatorial Guinea service	DAL (Direct Africa Line)	Monthly	Tarragona, Sagunto, Las Palmas, Malabo, Bata, Tarragona
Arkas Spain / Nisa Maritima - Spain-Canary service (PCS)	NISA Maritima Arkas Line / EMES (slotter)	Biweekly	Barcelona, Sagunto, Santa Cruz de Tenerife, Las Palmas, Santa Cruz de Tenerife, Arrecife, Sagunto, Barcelona

Source: APV

Finally, nowadays, Gandia port has not any container line. In this situation, despite the longer land distances to the Sagunto and Gandia area, the shortage or absence of container lines in Sagunto and Gandia port, has as a result that most of the traffic is handled through the port of Valencia.

Comparative cost analysis

Methodology is the same as explained in the above section 9.3.1 for the case of Piraeus.

Multimodal Logistic chain

The unitary cost of this logistic chain has been obtained considering all the costs related with the feeder container line operator (cost per container has been obtained dividing the total costs of the feeder operator by total container demand), to which has been added the handling container cost in origin and destination container terminal and the local haulage on Gandia or Sagunto Area.

The costs related with the feeder container line operator, logically, are in the port link (port taxes, technical Nautical Services tariffs, and vessel-generated waste collection service tariff) and in the maritime link (bunker and time charter vessel). It should be noted that that the port link costs related with the feeder line operator has been considered for all attended ports, regardless of whether it is the origin/destination port of the container.

So, the multimodal Logistic chain includes the following cost elements:

- Port link costs at Valencia port (using container terminal cranes).
- Maritime link costs.
- Port link costs in Sagunto or Gandia ports (using vessel cranes).
- Land link costs in Sagunto or Gandia area.

In the **port link costs** have been included the following costs:

- Ship related costs:
  - Port taxes.
  - Technical Nautical Services tariffs.
  - Vessel-generated waste collection service tariff
- Container related costs:
  - Container terminal cost.
  - Good tax (only should be considered in Sagunto or Gandia port).

In the **maritime link** have been included the following costs:

- Time charter vessel cost.
- Bunker consumption cost.

Finally, the **land link** costs include the following items:

- Local haulage in Sagunto or Gandia area.

Unimodal Logistic chain

The unitary cost of this logistic chain has been obtained considering the following parts:

- Port link costs at Valencia port (using container terminal cranes).
- Land link costs in Sagunto or Gandia area.

In the **port link costs** have been included the following costs:

- Container related costs:
  - Container terminal cost.

Finally, the **land link** costs include the following items:

- Local haulage in Sagunto or Gandia area.

Cost of multimodal logistic chain (feeder lines)

First, in the following figure, the feeder route proposed as hypothesis in this analysis, to link the ports of Valencia, Sagunto and Gandia is shown:

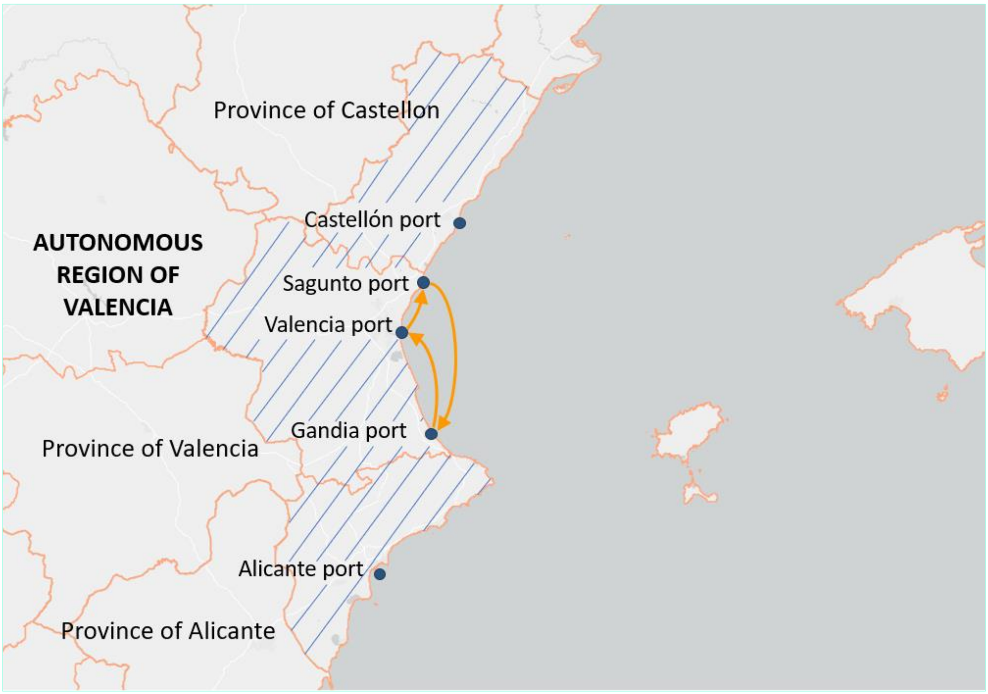


Figure 39: Feeder route proposed to link the ports of Valencia, Sagunto and Gandia

Source: EPC [23]

To obtain the multimodal chain cost, expressed in €/TEU, the costs have been broken down in the following parts:

Table 38: Composition of multimodal cost chain, by parts

Maritime link cost
Time charter vessel cost
Bunker consumption cost
Port link cost
Ship related costs
Port taxes
Technical Nautical Services tariff
Marpol waste collection service tariff
Container related costs
Loading and stevedoring in the port of Valencia cost
Storage, reception and delivery in the port of Sagunto and Gandia cost
Good tax
Land link cost
Land Transport cost
Total multimodal chain cost

Source: EPC [23]

The methodology applied to obtain each one that makes up the multimodal chain cost is explained below.

Maritime link cost

This link of the logistics chain contains the following cost elements:

- Time charter vessel cost.
- Bunker consumption cost.

To determine the cost of these two cost parts it has been selected a 670 TEU geared vessel (very close to 700-799 TEU category considered in Hamburg Index). An example of this vessel is the Janina, shown below:

Figure 40: Janina vessel

Source: EPC through Marinetraffic

Its main characteristics are:

- Container capacity: 670 TEUs.
- Gross Tonnage: 6.409 GT.
- Length overall: 123,11 m.
- Beam: 20,8 m.

To determine the unitary cost, expressed in €/TEU, of the cost of the vessel and the bunker the following hypotheses have been taken:

- The average load of the ship, per itinerary, will be 40%.
- The frequency will be three services per week.

Based on the above, the container demand will be 83.316 TEUs per year.

These two initial hypotheses assumed now, let to calculate the unitary costs and the competitiveness of the container feeder line in the hinterland of Gandia and Sagunto ports.

However, these hypotheses have been verified later, resulting that the potential container demand of the feeder line is between 79.714 and 132.857 TEUs, so the previous hypothesis are reasonable.

Time charter vessel cost

For the vessel proposed, the cost is 6.777 $ per day (average cost for 2020).

Bunker consumption cost

Bunker costs have been calculated with the Trozzi model ("Update of emission Estimate Methodology for Maritime Navigation"), for a speed vessel of 5 knots (a medium speed, regarding the given reduced distances to travel, this speed is sufficient), which requires a ship power of 1.250 kW. The distance to cover one itinerary by the vessel, of the route proposed, is shown in Table 39:

Table 39: Distance to cover one itinerary by the vessel of the feeder line (Km and NM)

	Distance	
	Km	Nm
Valencia-Sagunto	28,22	15,24
Sagunto- Gandia	74,69	40,33
Gandia-Valencia	54,50	29,43
Total distance	157,41	84,99

Source: EPC through Google Maps

With a speed of five knots, the sailing time of the itinerary is seventeen hours, to which must be added the time spend in each port. Based on the above, it is concluded that is enough to have **three weekly services**, as the hypothesis supposed. Finally, the bunker consumption is calculated as shown below:

$$\text{Bunker consumption (t)} = \text{Ship power (kw)} \cdot \text{Time (h)} \cdot \mathit{Unitary\ Consumption}^{3}\ (\frac{t}{kw\ h})$$

Equation 2: The bunker consumption

The bunker type selected is BFO 0,5% S (500 $/t in February 2021 rates of Bunkerworld Index), to comply with IMO2020 regulations.

Port link cost

In this cost element, it can be differentiated the ship related costs ant the container related costs (good charge).

Ship related costs

<u>Port taxes</u>
In Spain exists two taxes related with the vessel:

- T-0 (Aid navigation tax):

  WT-1 (Vessel tax).

<u>Technical Nautical Services tariffs</u>
In this sub-charter are included the following port services:

- Vessel pilotage.
- Port tugboats.
- Mooring and unmooring.

It has been considered a 100% use of these services (as it is quite common and demanded by port pilots), twice times for every port call (entrance and departure), without any discounts of the maximum tariffs for providing these services. The maximum tariffs are published in the APV web.

The assumption of 100% use and no discounts for these services could be a conservative hypothesis.

[3] 213 g/kwh in Trozzi Model

Vessel-generated waste collection service tariff

It has been considered a 100% use of this service, once time for every port call, without any discounts of the maximum tariff for providing this service. The maximum tariffs are published in the APV web.

The assumption of 100% use for this service could be probably a conservative hypothesis.

Container related costs

Goods loading and unloading, stevedoring and transhipment service

The cost model implemented is based on the one carried out in the study of the "*Implementation and Design Study of an Automated Container Terminal in the North Extension of the Port of Valencia*", May 2018.

In the case of the **port of Valencia**, only has been considered the cost of the container movement from the storage yard to the vessel, loaded/unloaded by terminal cranes, or vice versa.

In the case of the **ports of Sagunto and Gandia**, it has been assumed that the containers will be handled by the own cranes of the vessel. So, the costs that has been considered in this study, includes those concerning the operations from the side of the vessel until the truck operations area, or vice versa.

Good tax

In the case of the **port of Valencia**, there are not differences in this port in the goods charge with respect to the unimodal logistic, because transhipment operations are considered as disembarkation operation for this tax.

In the case of the **ports of Sagunto and Gandia**, the containers loaded/unloaded will have an extra good tax respect the unimodal logistic chain, calculated as shown below:

- Tax for 20': 28,32 € (44% percent of container traffic in the ports managed by Valencia Port Authority in 2019).
- Tax for 40': 42,48 €. (56% percent of container traffic in the ports managed by Valencia Port Authority in 2019).

So, the average tax, expressed in €/TEU, is 24,41 €/TEU.

It has been considered a 20% discount for both ports, as at present in the port of Sagunto.

Land link cost

The final link calculated is referent to the truck transport between the container terminal and the hinterland, or vice versa. For this first analysis the points of comparation between unimodal logistic chain and multimodal logistic chain are shown below:

Figure 41: Unimodal and Multimodal transport itineraries and analysis, Sagunto Area

Source: EPC [23]

Figure 42: Unimodal and Multimodal transport itineraries and analysis, Gandia Area

Source: EPC [23]

The distance of each itinerary is shown in Table 40:

Table 40: Distances of each itinerary, by zones and ports (km)

	Valencia port	Sagunto Port	Valencia port	Gandia port
	Analysis point in Sagunto area		Analysis point in Gandia Area	
Distance from the port (km)	45	9	73	6

Source: EPC through Google Earth

The cost of land transport has been calculated with Acotram software, an application of the Ministry of Transport, Mobility and Urban Agenda of Spain, developed to calculate the operating costs of road freight vehicles. It has been considered two scenarios:

- Scenario 1, where the truck could do two haulages per day.
- Scenario 2, where the truck could do three haulages per day.

Table 41: Cost of land transport, by zones and cases (€/km)

	Sagunto Area		Gandia Area	
	Two haulages per day	Three haulages per day	Two haulages per day	Three haulages per day
Working days (days per year)	225	225	225	225
Distance from the port (km)	9	9	6	6
Haulages (units per day)	2	3	2	3
Truck charged	50%	50%	50%	50%
Distance (km per year)	8.073	12.110	5.553	8.330
Cost (€/km)	8,54	5,85	12,20	8,29

Source: EPC [23]

Results of the cost analysis

The results of the analysis for multimodal logistic chain are shown in Table 42:

Table 42: Costs results for multimodal logistic chain, by zones and cases (€/TEU)

	Sagunto Area		Gandia Area	
	Two haulages per day (€/TEU)	Three haulages per day (€/TEU)	Two haulages per day (€/TEU)	Three haulages per day (€/TEU)
Maritime link cost	**31,32**	**31,32**	**31,32**	**31,32**
Time charter costs	24,37	24,37	24,37	24,37
Bunker consumption cost	6,95	6,95	6,95	6,95
Port link cost	**128,96**	**128,96**	**128,96**	**128,96**
Ship related costs	16,88	16,88	16,88	16,88
Port taxes	1,64	1,64	1,64	1,64
Technical Nautical Services tariff	13,53	13,53	13,53	13,53
Marpol waste collection service tariff	1,72	1,72	1,72	1,72
Container related costs	112,07	112,07	112,07	112,07
In the container terminal of port of Valencia	40,08	40,08	40,08	40,08
In the container terminal of port of Sagunto or Gandia	47,58	47,58	47,58	47,58
Good tax	24,41	24,41	24,41	24,41
Land link cost	**95,71**	**65,55**	**94,08**	**63,92**
Land Transport	95,71	65,55	94,08	63,92
Total costs	**255,99**	**225,83**	**254,36**	**224,20**

Source: EPC [23]

Cost of unimodal logistic chain

To obtain the cost of the unimodal chain, expressed in €/TEU, the costs have been broken down in the following parts:

Table 43: Composition of unimodal cost chain, parts

Port link cost
Storage, drop/pick up cost in the port of Valencia
Land link cost
Land Transport
Total costs

Source: EPC [23]

Port link cost

In this case, only has been considered the container movement from the storage yard to the pick-up zone in the port of Valencia, or vice versa, applying the same model as in the multimodal logistic case.

Land link cost

The cost of land transport has been already calculated with Acotram software. It has been considered that in unimodal logistic chain the tuck could do only one haulage per day.

Table 44: Cost of land transport, by zones (€/km)

	Sagunto Area	Gandia Area
Working days (days per year)	225	225
Distance from the port (km)	45	73
Haulages (units per day)	1	1
Truck charged	50%	50%
Distance (km per year)	20.340	32.940
Cost (€/km)	3,67	2,44
Hauling cost (€/TEU)	207,3	223,6

Source: EPC [23]

Results of the cost analysis

The results of the analysis for unimodal logistic chain are shown inTable 45:

Table 45: Costs results for unimodal logistic chain, by zones (€/TEU)

Unimodal logistic chain cost	Sagunto Area (€/TEU)	Gandia Area (€/TEU)
Port link cost	**27,12**	**27,12**
Storage, drop/pick up in the port of Valencia	27,12	27,12
Land link cost	**207,30**	**223,58**
Land Transport	207,30	223,58
Total costs	**234,42**	**250,70**

Source: EPC [23]

Comparison of the logistics chains costs

The results of the comparison are shown in Table 46:

Table 46: Comparative costs between multimodal and unimodal logistic chain, Sagunto Area (€/TEU)

	Multimodal logistic chain (€/TEU)		Unimodal logistic chain (€/TEU)
	Two haulages per day	Three haulages per day	
Maritime link cost	31,32	31,32	-
Port link cost	128,96	128,96	27,12
Land link cost	95,71	65,55	207,30
Total costs	255,99	225,83	234,42

Source: EPC [23]

So, in the basis of above, multimodal logistic chain only is competitive against unimodal transport in the scenario where the truck driver is capable to do three haulages per day.

Table 47: Comparative costs between multimodal and unimodal logistic chain, Gandia Area (€/TEU)

	Multimodal logistic chain (€/TEU)		Unimodal logistic chain (€/TEU)
	Two haulages per day	Three haulages per day	
Maritime link cost	31,32	31,32	-
Port link cost	128,96	128,96	27,12
Land link cost	94,08	63,92	223,58
Total costs	254,36	224,20	250,70

Source: EPC [23]

So, the main conclusions for Gandia area are:

- The multimodal logistic chain is more competitive than unimodal logistic chain in the scenario where the truck driver is capable to do three haulages per day.
- In the scenario where the truck driver is capable to do two haulages per day, the costs of both logistics chains are very similar.

Determination of the distance following the main existing roads where the port of Sagunto and Gandia can be competitive

To determinate the distance where the port of Gandia and Sagunto can be competitive, following main roads, there are two limits:

- For the far away areas of the port of Valencia (to the south of Gandia and to the north of Sagunto), the limit point will be those where the truck driver is capable to do three haulages per day.
- For the closest areas of the port of Valencia (to the north of Gandia and to the south of Sagunto), the limit point will be those where the costs are equal for both transport chains (unimodal transport and multimodal transport).

Sagunto area

North and west limits

According to the Spanish Law the maximum working day for a truck driver is limited by:

- 40 hours per week of time of effective work: time in which the worker is at his place of work and performs the specific driving functions.
- 20 hours per week of time of presence: the time in which the worker is at the disposal of the employer without providing effective work as for example, waiting time at warehouses or container terminal.

Assuming a five-day work week, the maximum working day is 12 hours. So, the driving time is the difference the maximum working day and waiting times at the warehouses or container terminals. It has been assumed the following waiting times:

- At the Container terminal of the port of Sagunto: 45 minutes.
- At Warehouse for consolidation/unconsolidation: 2 hours.

In the basis of above, the daily driving time is 3 hours and 45 minutes. Finally, assuming an average speed of the truck of 70 km/h (urban areas), the maximum distance from Sagunto to do three haulages per day is 43,75 km (P1N, P2N and P3N in the Figure 43).

South limits

the point of the itinerary where the costs are equal for both transport chains has been calculated.

- A-7 highroad itinerary: the distance between both ports is 54,17 km.

  The equal cost for both ports is 231,11 €/TEU, and it is located at 9,69 km from the port of Sagunto (P1S).
- A-23 highroad itinerary: the distance between both ports is 54,17 km.

- The equal cost for both ports is 225,64 €/TEU, and it is located at 9 km from the port of Sagunto (P2S).

In the following figure the limit points and the competitive area for Sagunto Area are shown:

Figure 43: Competitive area for the Sagunto Area

Source: EPC through Google Earth

Gandia Area

South and west limits

As in the case of the Sagunto port, the maximum distance from Gandia to do three haulages per day is 43,75 km (P1N, P2N and P3N in the Figure 44).

North limits

the point of the itinerary where the costs are equal for both transport chains has been calculated.

- AP-7 highroad itinerary: the distance between both ports is 79 km.
- The equal cost for both ports is 244,67 €/TEU, and it is located at 8,15 km from the port of Gandia (P1N).

In the following figure the limit points and the competitive area for Sagunto Area are shown:

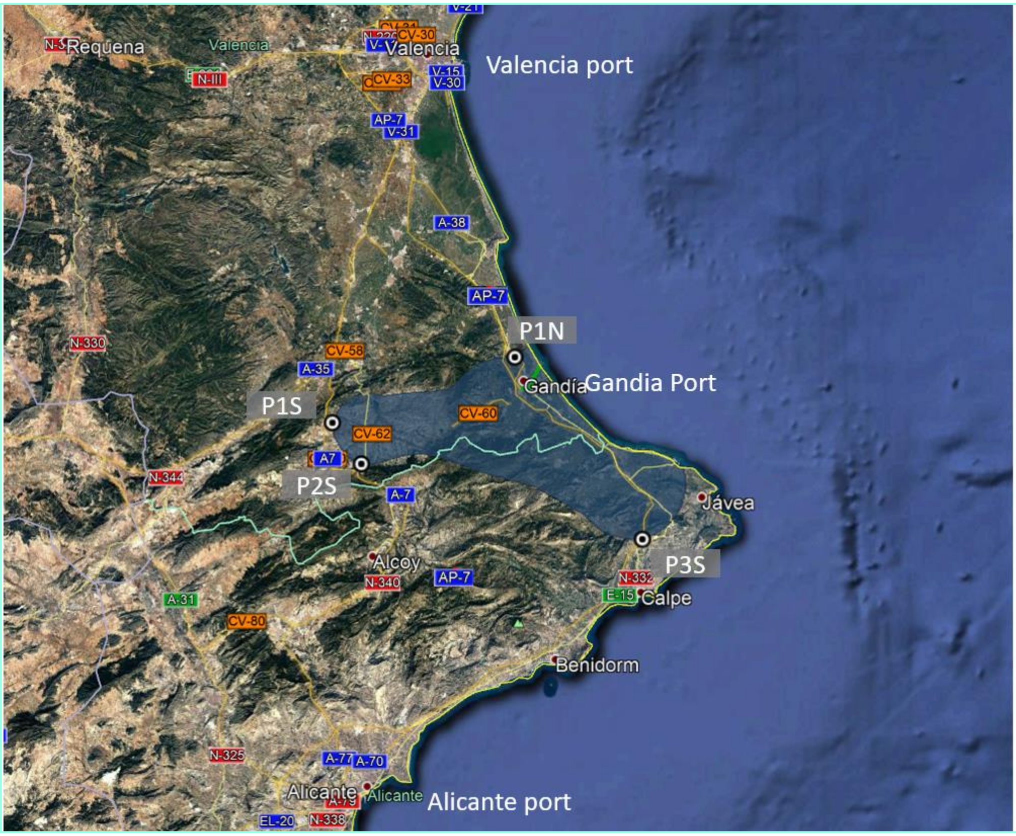


Figure 44: Competitive area for the Gandia Area

Source: EPC through Google Earth

Analysis of the potential traffic for a container feeder line, linking the ports of Valencia, Sagunto and Gandia

Given the conditions of the feeder line, the main potential for capturing cargo by the feeder line is in the autonomous region of Valencia, mainly the following areas indicated above:

- The south of the province of Castellón and the north of the province of Valencia, for the port of Sagunto.
- The south of the province of Valencia and the north of the province of Alicante.

To estimate the container demand of each of these provinces, expressed in TEUs, the data has been extracted from the public data of the Secretary of Foreign Trade, dependent on the Ministry of Industry, Commerce and Tourism, for the year 2019 (due to the anomalies caused by the COVID-19 in the year 2020).

The main results are shown in the following table:

Table 48: Container demand in Autonomous Region of Valencia, by province (TEUs and %)

Province	Demand			
	Export (TEUs)	Import (TEUs)	Total (TEUs)	Total (%)
Valencia	219.052	229.454	448.505	36,7%
Castellon	580.888	47.383	628.271	51,4%
Alicante	96.821	47.849	144.670	11,8%
Total	896.760	324.686	1.221.447	100%

Source: EPC

However, in addition to the ports that are part of the route proposed, as can be seen, in the autonomous region of Valencia are located two ports that handle container traffics:

- The port of Castellón is located to the north, close to Sagunto port (approximately 64 km by road).
- The port of Alicante is located to the south (approximately 124 km by road to Gandia port).

Therefore, as first step, for the provinces of:

- Castellon, the container demand for those countries where the port of Castellon and Sagunto have direct connection has been eliminated.
- Alicante, the container demand for those countries where the port of Alicante has direct connection has been eliminated.
- Valencia, the container demand for those countries where Sagunto port has direct connection has been eliminated.

The main results are shown in the following table:

Table 49: Potential Container demand of the feeder line in the Autonomous Region of Valencia, by province (TEUs and %)

Province	Demand			
	Export (TEUs)	Import (TEUs)	Total (TEUs)	Total (%)
Valencia	309.688	199.554	509.242	55,28%
Castellon	279.815	29.873	273.652	29,71%
Alicante	85.822	46.141	138.240	15,01%
Total	675.324	275.568	921.134	100%

Source: EPC

Next, an estimate of the demand has been made for the two areas where the ports of Gandia and Sagunto can be competitive.

Province of Castellon

As regards to the export traffics, in the province of Castellon are located several ceramic pavement and tiles plants, whose exports represents 478.000 TEUs (over than 82% container export of the province). As it can be seen in the Figure 45, in the south of the province are located seven of total plants (8,1%).

Figure 45: Location of the ceramic tile production plants in the Province of Castellón

Source: ASCER

Without those countries where the port of Castellon and Sagunto have direct connection, the ceramic exports in container of the province of Castellon reached 226.760 TEUs in 2019. So, approximately, the exports demand of the zone where port of Sagunto is competitive is 18.457 TEUs. For the rest of the demand of the province, it has been made an approximation based on the population that is in the area where the port of Sagunto is competitive.

Figure 46: Regions of the province of Castellon

Source: BC Maps

As can it be seen in the figure above, approximately the region where Sagunto port can be competitive is La Plana Baixa.

Table 50: Population of the province of Castellon, by region (pop and %)

Region	Population	
	Pop	%
Alto Mijares	3.857	0,7%
Alto Palancia	23.966	4,1%
Baix Maestrat	82.437	14,1%
Els Ports	4.357	0,7%
La Plana Alta	256.455	43,8%
La Plana Baixa	**192.283**	**32,8%**
L'Alcalatén	15.613	2,7%
L'Alt Maestrat	6.622	1,1%
Total population	585.590	100,0%

Source: EPC through Autonomous Region of Valencia Government

In 2020, their population reached 192.283 pop, representing 32,8% of total population of the province of Castellon. So, for the remaining demand of 82.927 containers

(53,055 export and 29,873 import), it has been assumed that 36,9% would be in this area, that is, 27.200 containers.

Province of Valencia

As regards to the province of Valencia, the following table shows the distribution of the containers demand broken down by zones:

Table 51: Distribution of the containers demand in the province of Valencia, by zones (%)

Area	Subareas	%
North	North of Sagunto, A-23 area and Horta Nord	30,7
Surroundings of Valencia	CV-35 area and Valencia surroundings	42,5
West	A-3 Area	8,3
South	South of the Valencia province	18,4

Source: Estudio de alternativas de conexión viaria y ferroviaria entre los puertos de Sagunto y València (June 2020)

So, only can be captured the demand of the:

- North Area, through Sagunto Port, which it reaches 129.439 TEUs.
- South Area (through Gandia Port), which it reaches 84.011 TEUs.

Province of Alicante

Finally, for the demand of the province of Alicante, it has been made an approximation based on the population that is in the area where the port of Sagunto is competitive.

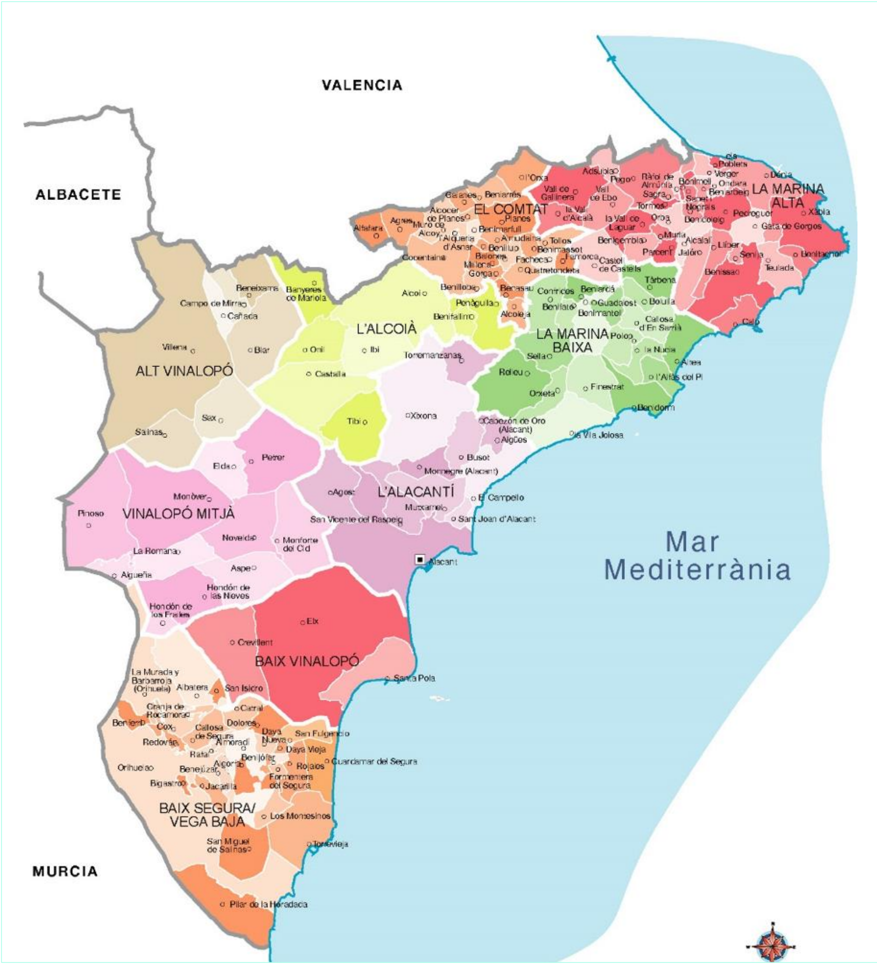


Figure 47: Regions of the province of Alicante

Source: BC Maps

Approximately, the region where Gandia port can be competitive is a half of the La Marina Alta.

Table 52: Population of the province of Castellon, by region (pop and %)

Region	Population	
	Pop	%
Campo de Alicante	487.113	26,6%
Vega Baja del Segura	355.257	19,4%
Bajo Vinalopó	293.775	16,0%
Marina Baja	188.623	10,3%
Marina Alta	**175.156**	**9,6%**
Vinalopó Medio	171.069	9,3%
Hoya de Alcoy	109.193	6,0%
Alto Vinalopó	52.401	2,9%
Total population	1.832.587	100,0%

Source: EPC through Autonomous Region of Valencia Government

So, for the 138.240 containers demand of the province of Alicante (53.055 export and 29.873 import), it has been assumed that 4,77% would be located in this area, that is, 6.600 containers.

Main results of the potential traffic for a container feeder line

On the basis of the total demand of the two zones analysed, three scenarios have been calculated of the potential traffic for a container feeder line:

- Pessimistic scenario: with a quote of a 30% of total demand.
- Base scenario: with a quote of a 40% of total demand.
- Optimistic scenario: with a quote of a 50% of total demand.

The results are shown below:

Table 53: Container demand of the feeder, by ports and cases (TEUs)

Port	Region	Demand on hinterland	Demand captured by feeder line		
			pessimistic scenario	Base scenario	Optimistic scenario
Sagunto	Castellon	45.657	13.697	18.263	22.829
	Valencia	129.439	38.832	51.776	64.719
Gandia	Valencia	84.011	25.203	33.604	42.006
	Alicante	6.606	1.982	2.643	3.303
Total		265.714	79.714	106.285	132.857

Source: EPC

It is observed how the demand of the pessimistic scenario is slightly below than the supposed as hypothesis in the cost analysis of the feeder line.

In contrast, the demand of the base and optimist scenarios are higher than the supposed as hypothesis in the cost analysis of the feeder line, so in these scenarios the feeder line would become more competitive.

The results of the analysis cost for multimodal logistic chain, with the demand of these three scenarios, are shown in the following table:

Table 54: Costs results for multimodal logistic chain, by scenarios (two haulages per day) (€/TEU)

	Sagunto Area			Gandia Area		
	Pessimistic scenario (€/TEU)	Base scenario (€/TEU)	Optimistic scenario (€/TEU)	Pessimistic scenario (€/TEU)	Base scenario (€/TEU)	Optimistic scenario (€/TEU)
Maritime link cost	32,86	24,64	19,71	32,86	24,64	19,71
Port link cost	129,78	125,36	122,70	129,78	125,36	122,70
Land link cost	95,71	95,71	95,71	94,08	94,08	94,08
Total costs	**258,35**	**245,71**	**238,13**	**256,72**	**244,08**	**236,49**

Source: EPC

Table 55: Costs results for multimodal logistic chain, by scenarios (three haulages per day) (€/TEU)

	Sagunto Area			Gandia Area		
	Pessimistic scenario (€/TEU)	Base scenario (€/TEU)	Optimistic scenario (€/TEU)	Pessimistic scenario (€/TEU)	Base scenario (€/TEU)	Optimistic scenario (€/TEU)
Maritime link cost	32,86	24,64	19,71	32,86	24,64	19,71
Port link cost	129,78	125,36	122,70	129,78	125,36	122,70
Land link cost	65,55	65,55	65,55	63,92	63,92	63,92
Total costs	**228,19**	**215,55**	**207,97**	**226,56**	**213,92**	**206,34**

Source: EPC

As it can be seen, in the base and optimistic scenario, the feeder line would be competitive in Gandia Area even the truck drivers could do only two haulages per day.

Summary, conclusions, and recommendations for the case of the port of Valencia

- Nowadays, despite the longer land distances to the Sagunto and Gandia hinterlands, the shortage or absence of container lines in Sagunto and Gandia port, has as a result that most of the traffic is handled through the port of Valencia, and carried to the hinterland by truck or rail depending of the case.
- To evaluate the possibility of developing a container feeder line that links the three ports managed by APV (Valencia, Sagunto and Gandia), it has been proposed a feeder service with a frequency of three weekly services, with geared ships.
- To make a comparison as homogeneous as possible, it has been analysed both logistics chain from the container stack at the port of Valencia to the final destination in the hinterland or vice versa:
  - Unimodal: truck transport from/to Valencia port.
  - Multimodal:
    - Maritime transport from/to Valencia port to/from Sagunto or Gandia port.
    - Truck transport from/to Sagunto or Gandia port.
- It has been observed that the feeder line would be competitive in Sagunto and in the area of Gandia (see Table 56).

  Nevertheless, to be competitive the distance to the port of Gandia or Sagunto must be short enough so that the truck driver is capable to do three haulages per day. As can be seen below, the land link cost in multimodal transport is cheaper in the scenario where the truck driver is capable to do three haulages per day, which is limited by the distance from the port.

- In the case of Gandia port, the costs of multimodal chain are like unimodal chain, if the truck drivers could do only two haulages per day.

Table 56: Comparative costs between multimodal and unimodal logistic chain, Sagunto Area (€/TEU)

	Multimodal logistic chain (€/TEU)		Unimodal logistic chain (€/TEU)
	Two haulages per day case	Three haulages per day case	
Maritime link costs	31,32	31,32	-
Port link costs	128,96	128,96	27,12
Ship related costs	16,88	16,88	-
Container related costs	112,07	112,07	27,12
Land link costs	95,71	65,55	207,30
Total costs	255,99	225,83	234,42

Source: EPC

Table 57: Comparative costs between multimodal and unimodal logistic chain, Gandia Area (€/TEU)

	Multimodal logistic chain (€/TEU)		Unimodal logistic chain (€/TEU)
	Two haulages per day case	Three haulages per day case	
Maritime link costs	31,32	31,32	-
Port link costs	128,96	128,96	27,12
Ship related costs	16,88	16,88	-
Container related costs	112,07	112,07	27,12
Land link costs	94,08	63,92	223,58
Total costs	254,36	224,20	250,70

Source: EPC

- It should be noted that the costs associated to the vessel (maritime link cost and ship related costs in the port link) are very low.

These costs are the only one dependent on the demand, what makes the results more robust in the face of demand variations. So, the fact of increasing the ship size, does not change much the cost difference between both chains.

- Because of the cost analysed the areas where the feeder line can be competitive, are located in (see Figure 48):
  - The south of the province of Castellón and the north of the province of Valencia, for the port of Sagunto.
  - The south of the province of Valencia and the north of the province of Alicante for the port of Gandia.

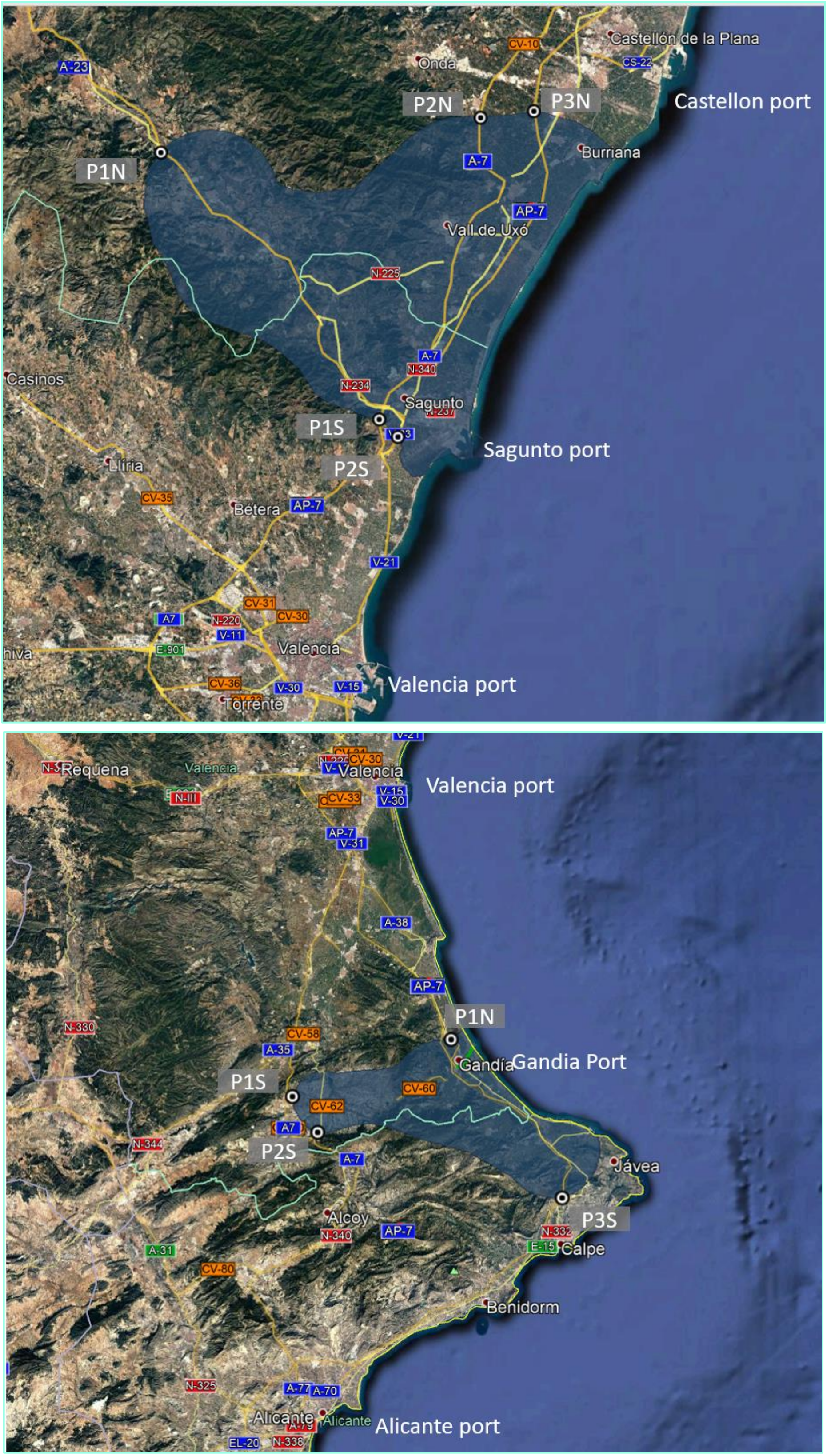


Figure 48: The locations of Valencia, Castellón, and Sagunto ports

- In this these areas, the following container demand have been estimated:

Table 58: Container potential demand in competitive areas, by port

Area	Region	Demand on hinterland (TEUS/year)
Sagunto	Castellon	45.657
	Valencia	129.439
	Total Sagunto Area	**175.096**
Gandia	Valencia	84.011
	Alicante	6.606
	Total Gandia Area	**90.617**
Total		265.714

Source: EPC [23]

- Based on the total demand of the two zones analysed, three scenarios have been calculated of the potential traffic for a container feeder line:
  - Pessimistic Case: with a quote of a 30% of total demand.
  - Base case: with a quote of a 40% of total demand.
  - Optimistic Case: with a quote of a 50% of total demand.

Table 59: Container demand of the feeder, by ports and cases (TEUs/year)

Port	Region	Demand captured by feeder line (TEUS/year)		
		Pessimistic scenario	Base scenario	Optimistic scenario
Sagunto	Castellon	13.697	18.263	22.829
	Valencia	38.832	51.776	64.719
	Total Sagunto Area	**52.529**	**70.039**	**87.548**
Gandia	Valencia	25.203	33.604	42.006
	Alicante	1.982	2.643	3.303
	Total Gandia Area	**27.185**	**36.247**	**45.309**
Total per year		79.714	106.285	132.857
Average per week		1.532	2.043	2.554
Average per service (assuming 3 weekly services)		511	681	851

Source: EPC [23]

- This means that, depending on the capture scenario considered, the demand reaches between 79.714 and 132.857 TEUs (from 511 TEUs per service to 851 TEUs per service), of the total of 1,21 million TEUs in the Autonomous Region of Valencia (Valencia, Castellon, and Alicante) provinces.

Main conclusions of the comparison of the case of Valencia and Piraeus:

- Currently, there are no container lines linking the ports analysed, both in the case of Valencia and Piraeus.
- In the case of Valencia, currently the goods are handled in containers at the port, and carried by truck or rail depending of the case.
- Road transport to the north (Sagunto area) is penalized by the fact the road access to Valencia Port is through the South.
- Valencia, Sagunto and Gandia ports have the necessary infrastructure to handle container traffic.
- In the case of Piraeus, general cargo traffic between Mykonos and nearby islands is Ro-Ro traffic, composed by trucks and trailers.
- In addition, Ro-pax lines handle two types of traffic: passengers and goods, which reinforces their competitiveness.
- Finally, Mykonos and nearby islands do not have the necessary infrastructure to handle container traffic.
- The demand in the case of Pireaus is low, which hinders the viability of a container feeder line.
- In addition, currently the goods are not transported in container, they are transported by truck, which could be a barrier to capture the cargo. Also, the cargo should be consolidated/deconsolidated in a different way, which is a significant added difficulty for a feeder container line.
- In the Piraeus Case, it is needed a market share of 80% of the maximum potential container demand, for the feeder line to be competitive versus ro-ro chain.
- Instead, for the Valencia case, with a strong demand, this market share decreases to 40%, for the feeder to be competitive with the monomodal logistic chain, both in the Sagunto and Gandia area.

9.4 Preliminary MOSES Business Canvass Models

A business model is simply a plan describing how a business intends to make money. However, a creative approach to sustainability can also be applied to an organization's business models. This section begins with the assumption that every business model innovation can consider a triple-layer approach to be more sustainable over time. In this regard, the focus is on the conceptual stage when the business model ideas are generated. In this way, the business models, such as MOSES innovations with a structured canvas, will be explored to create the concepts of more sustainable models. This analysis is in line with the European Commission's aims in creating an optimal business environment for sustainable growth and helps to be in the competitive market of the climate-neutral economy in Europe which is in transition.

Furthermore, it also helps in the identification of the MOSES market opportunities during the development of the MOSES innovations. In this section, a tool that has been named the "Triple layered business model canvas" is used. It is to ensure that business models create, deliver, and capture multiple forms of value by adding a second layer with nine environmental elements that follow a lifecycle approach, and by adding a third layer with nine social elements that follow a stakeholder approach, to the preliminary first layer of economy. In these three layers of analyses, some elements are considered, as below:

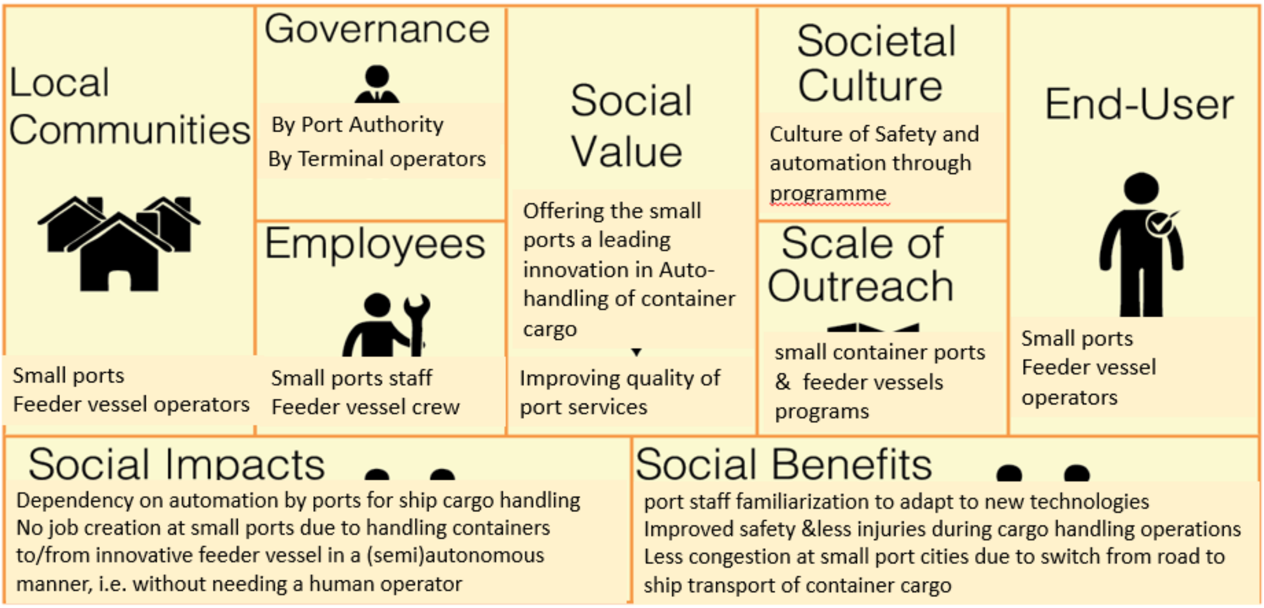
- **Social Stakeholder Business Canvas model**: Local communities, governance, employees, social value, societal culture, scale of outreach, end-user, social impacts, and social benefits.
- **Economic Business Model Canvas**: Partners, activities, value proposition, customer relationship, channels, customer segments, costs, and revenues.
- **Environmental Life-Cycle Business Model Canvas:** Supplies and out-sourcing, production, functional value, end-of-life, distribution, use phase, environmental impacts, and environmental benefits.

In short, projects such as MOSES can use this canvas to better understand and visualize the relationships between the economic, environmental, and social aspects of their business models and innovation that gives a higher opportunity in exploiting the market too.

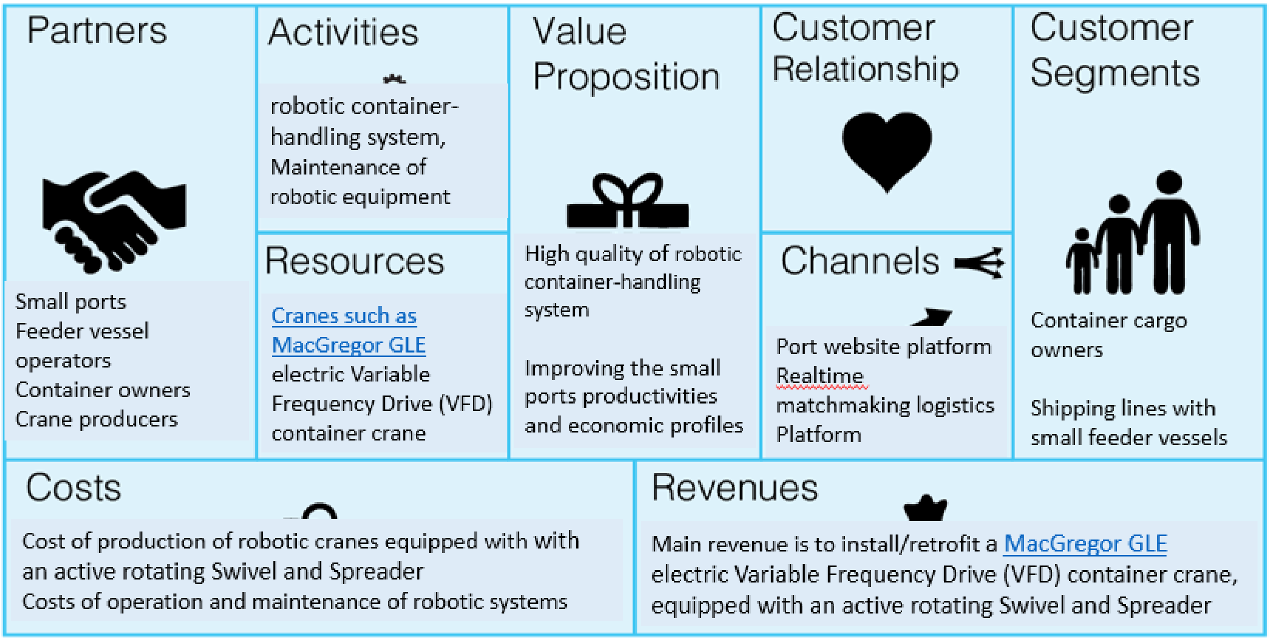
As illustrated below, the three layers of Canvas business models are discussed for each of the MOSES innovations, however, these are the preliminary versions and they will be addressed, analysed, and completed with the project progress in WP6 and WP8 thoroughly.

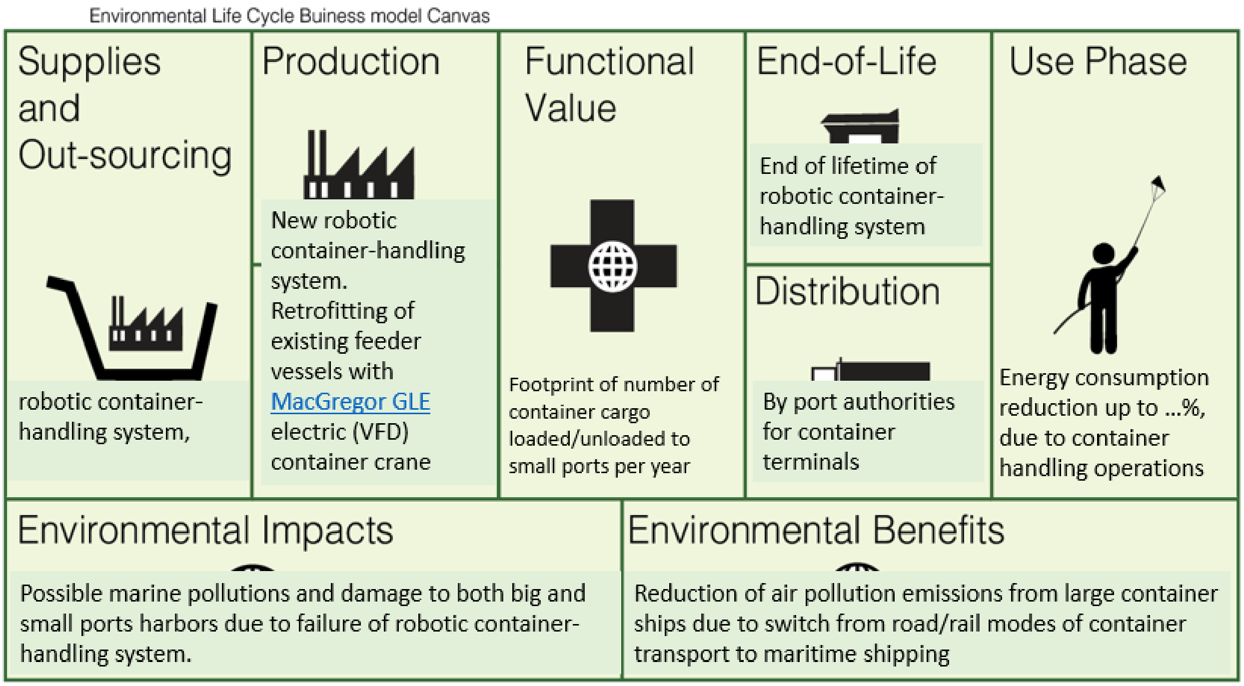
Preliminary MOSES Business Canvass Models for Robotic Container-Handling System

Social Stakeholder Buiness model Canvas

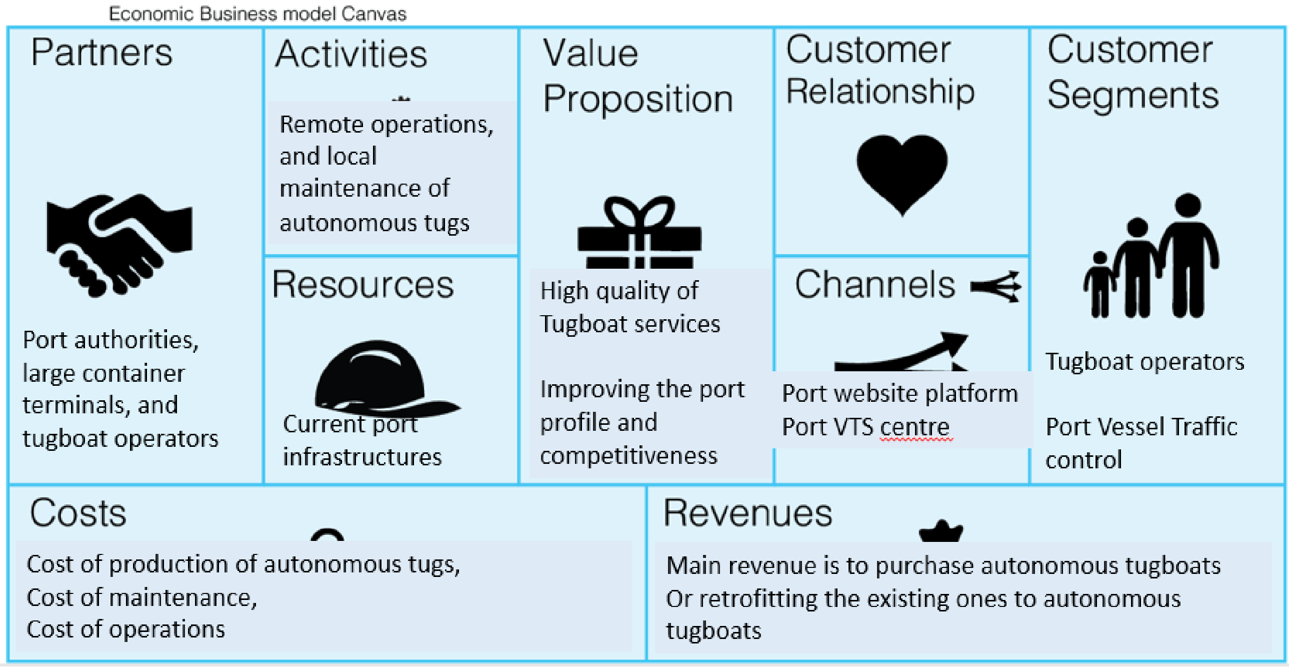


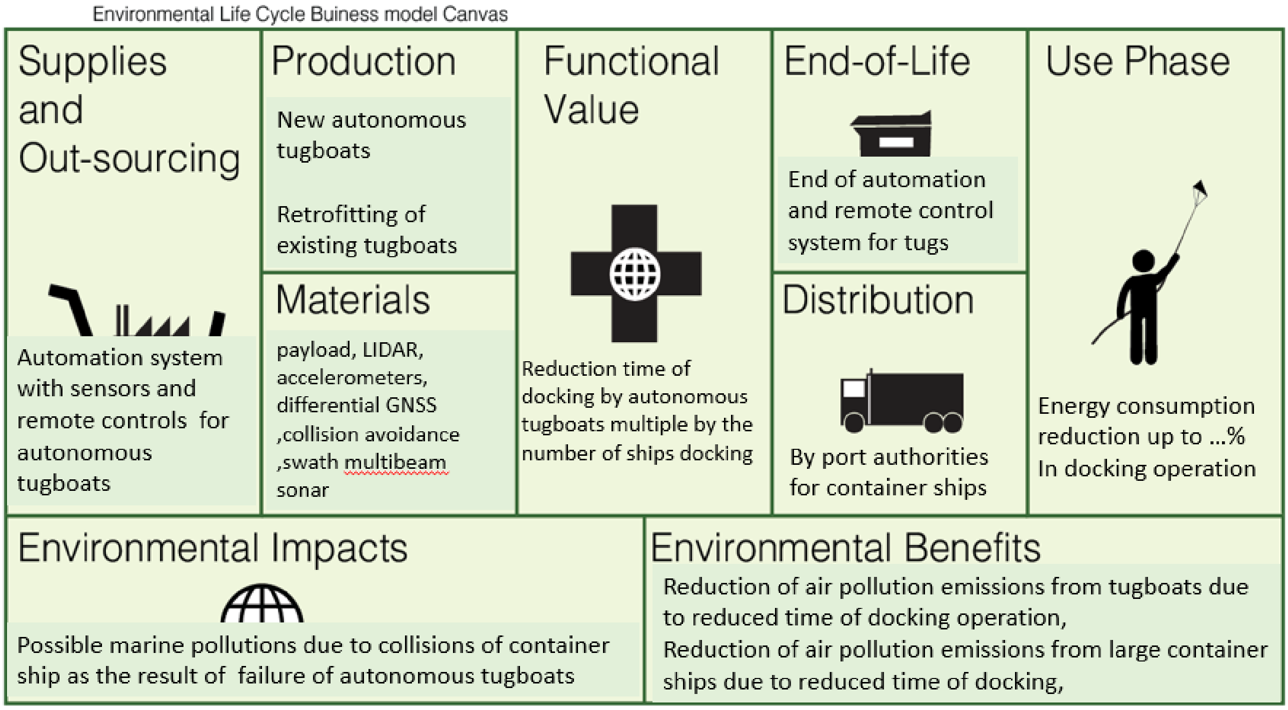
Economic Business model Canvas





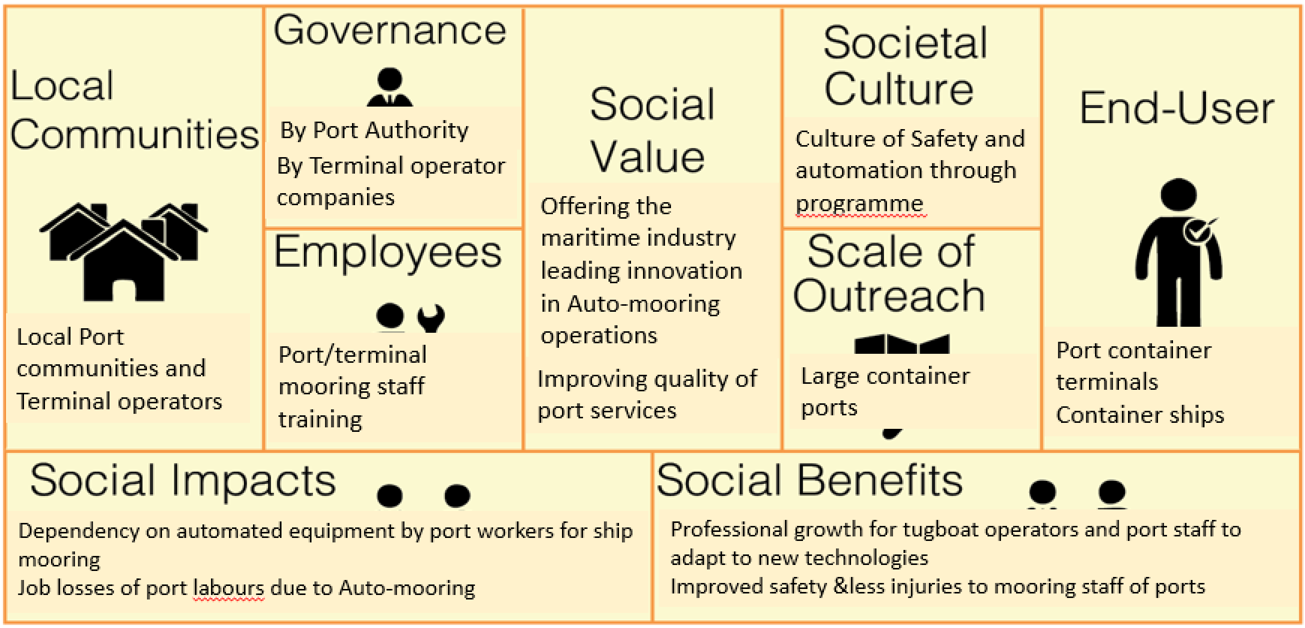
Preliminary MOSES Business Canvass Models for Autonomous Tugboats


Economic Business model Canvas
Partners
Port authorities, large container terminals, and tugboat operators
Activities
Remote operations, and local maintenance of autonomous tugs
Resources
Current port infrastructures
Value Proposition
High quality of Tugboat services
Improving the port profile and competitiveness
Customer Relationship
Channels
Port website platform
Port VTS centre
Customer Segments
Tugboat operators
Port Vessel Traffic control
Costs
Cost of production of autonomous tugs,
Cost of maintenance,
Cost of operations
Revenues
Main revenue is to purchase autonomous tugboats
Or retrofitting the existing ones to autonomous tugboats

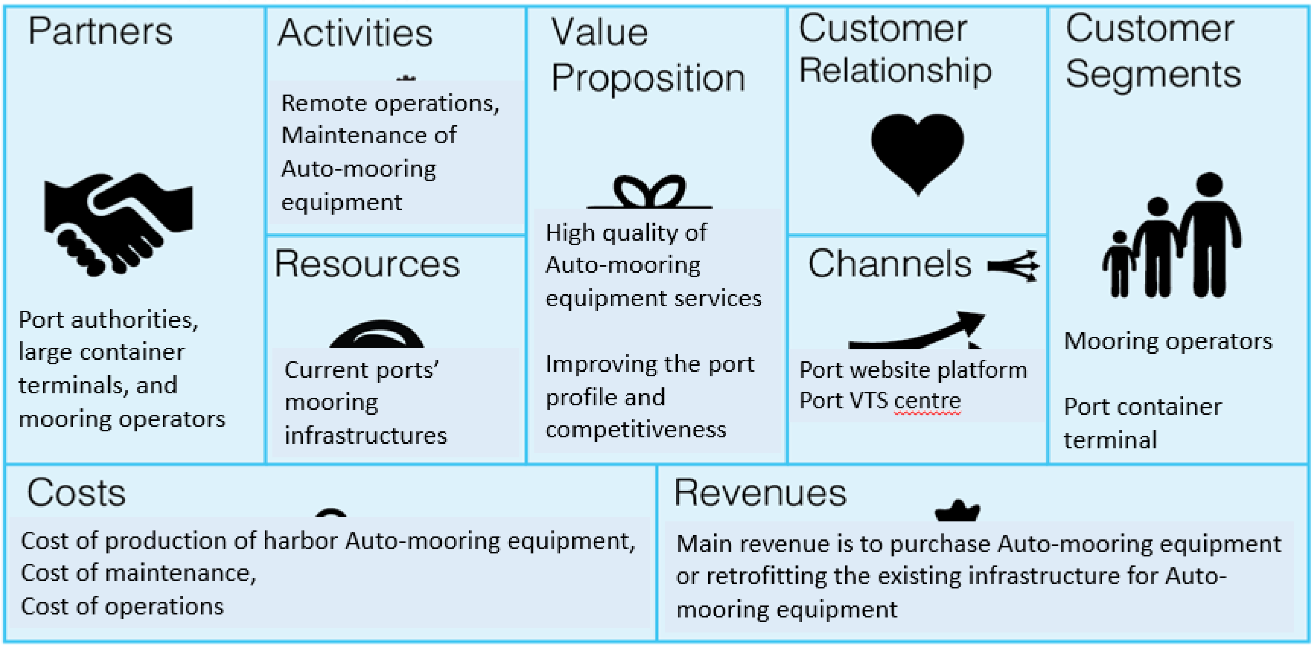

Environmental Life Cycle Buiness model Canvas
Supplies and Out-sourcing
Automation system with sensors and remote controls for autonomous tugboats
Production
New autonomous tugboats
Retrofitting of existing tugboats
Materials
payload, LIDAR, accelerometers, differential GNSS ,collision avoidance ,swath multibeam sonar
Functional Value
Reduction time of docking by autonomous tugboats multiple by the number of ships docking
End-of-Life
End of automation and remote control system for tugs
Distribution
By port authorities for container ships
Use Phase
Energy consumption reduction up to ...%
In docking operation
Environmental Impacts
Possible marine pollutions due to collisions of container ship as the result of failure of autonomous tugboats
Environmental Benefits
Reduction of air pollution emissions from tugboats due to reduced time of docking operation,
Reduction of air pollution emissions from large container ships due to reduced time of docking,

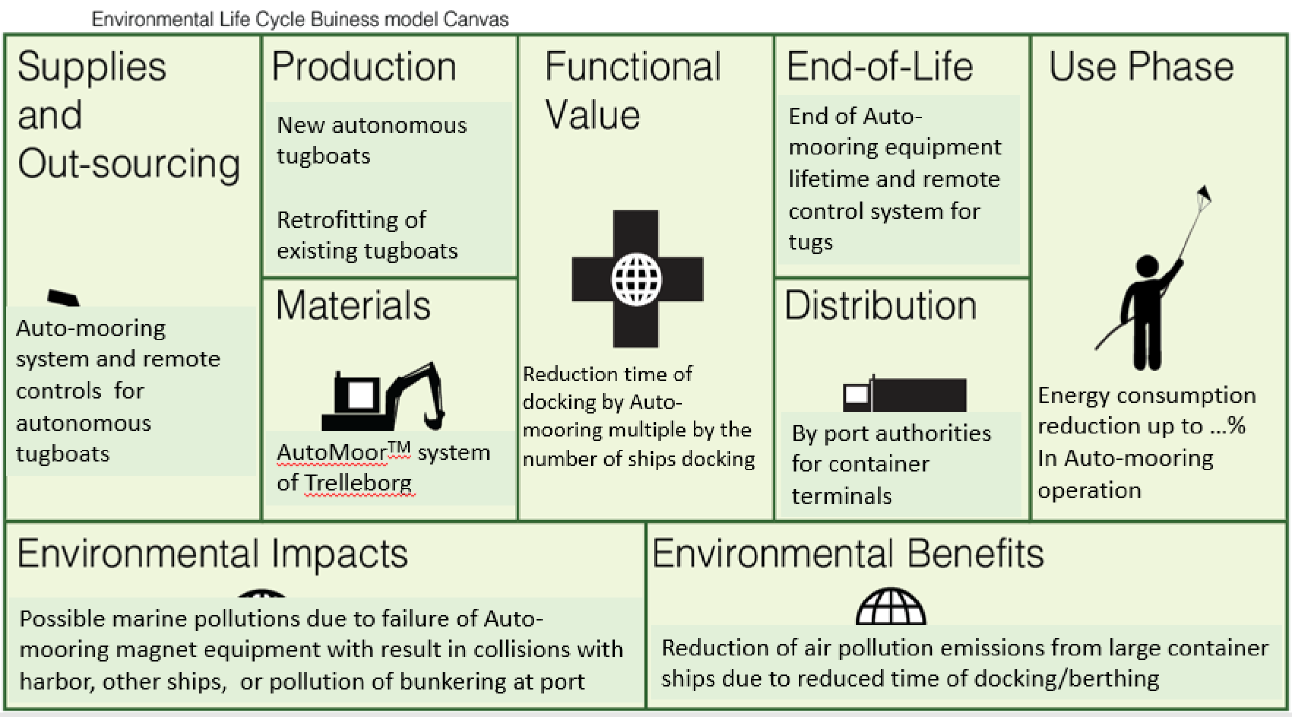
Preliminary MOSES Business Canvass Models For Auto-Docking

Social Stakeholder Buiness model Canvas



Economic Business model Canvas

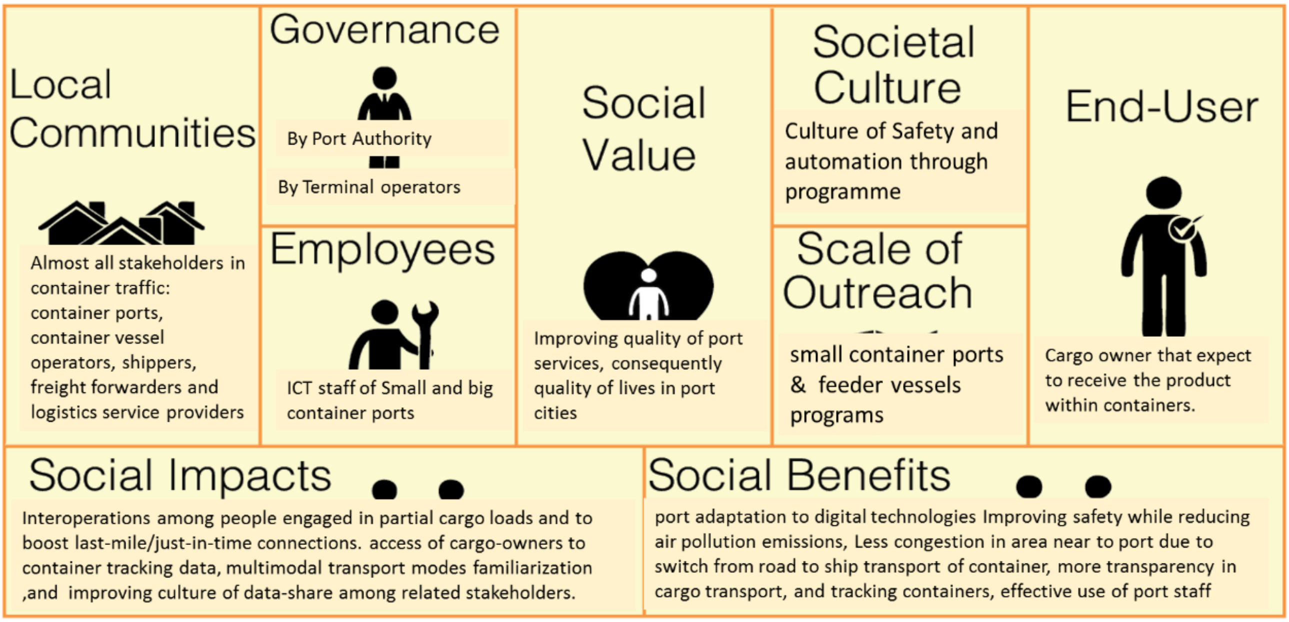




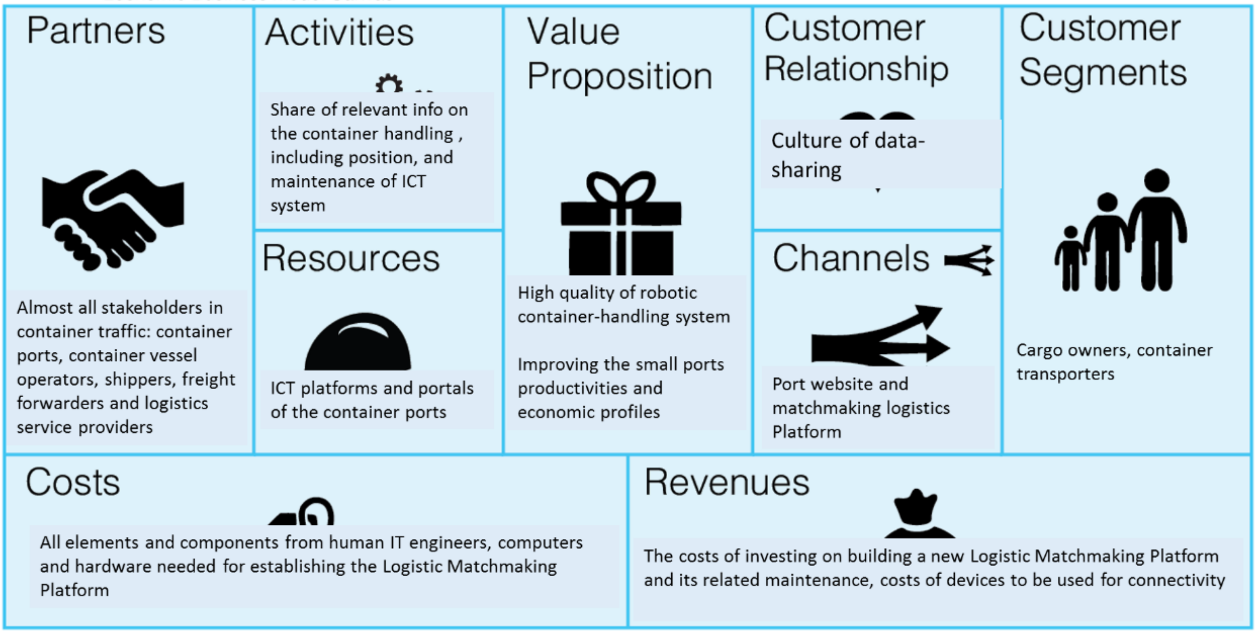
<u>Preliminary MOSES Business Canvass Models for Matchmaking Logistics Platform</u>

Even though the cargo has been successfully transported to its destination, the continuity and sustainability of the feeder service require the necessary adaptation of the existing port operations and the balance between demand and supply. To this end, the MOSES concept is supported by the MOSES Matchmaking Platform to effectively handle the changing of the freight flows, to increase the cost-effectiveness of partial cargo loads and to boost last-mile/just-in-time connections among transport modes and backhaul traffic.

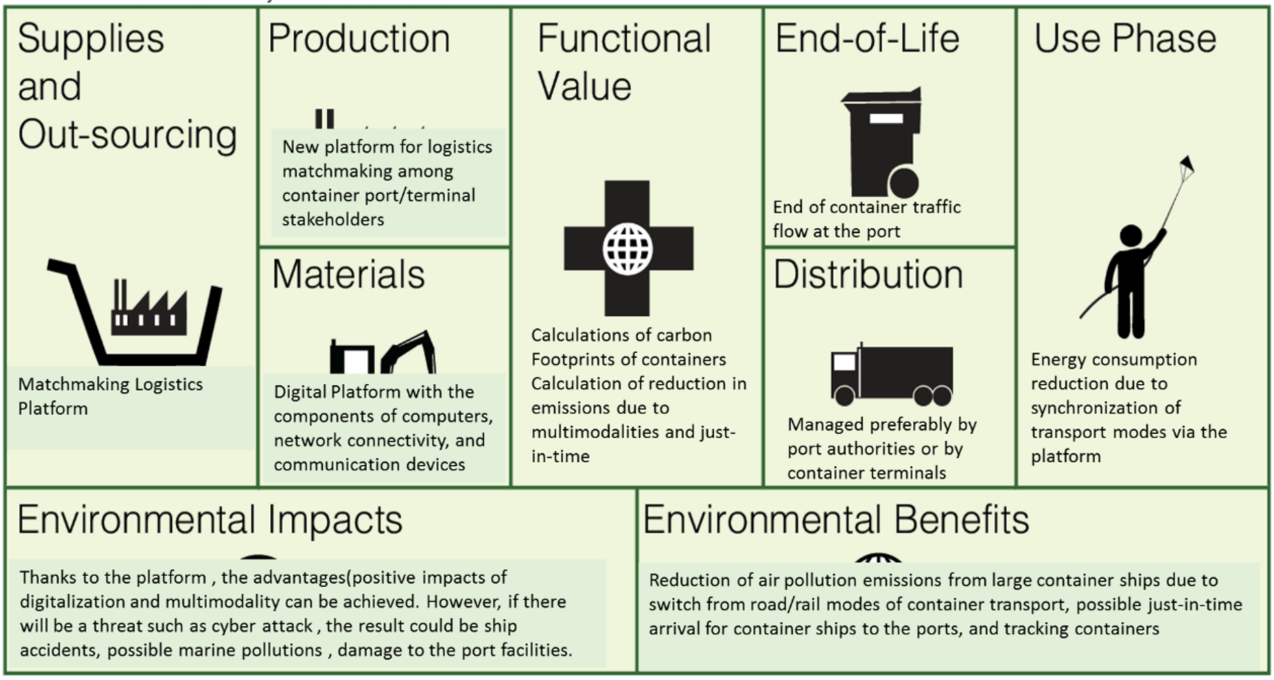
Social Stakeholder Buiness model Canvas



Economic Business model Canvas



Environmental Life Cycle Buiness model Canvas



10. Conclusion

As discussed at the beginning of this document, ports play a decisive role in the EU's external and internal trade. Although ports and especially Deep Sea Shipping (DSS) ports are integral nodes within multimodal logistic flows, Short Sea Shipping (SSS) and inland waterways are not so well integrated. Short Sea Shipping made up around 59 % of the entire sea transport of cargo to and from the main EU ports in 2018 and 2019. Geographical considerations, such as long coastlines or many inhabited islands play a part in the explanation of the high share of Short Sea Shipping in most EU countries. A large volume of feeder services to or from hub ports explains the high degree of Short Sea Shipping transport in countries that function as regional trans-shipment points. However, the share of Short Sea Shipping is lower than 50 % in countries with major ports focused on intercontinental trade, such as Spain. The development of the trans-European networks concept along rising worries about the externalities impacts by transport, have made possible an increasing interest of the EU to promote SSS. For such promotion particularly for containers, it is encouraged to involve all stakeholders involved in logistic chains and to approach innovative solutions to make the container transport in viable for ports with no or low container traffic. The information in the Chapters two to eight served as input to the MOSES innovation analyses in the Chapter 9, where the focus was more on the innovative feeder vessel innovation.

In the context of the MOSES project, a two-fold strategy to reduce the total time to berth for TEN-T Hub Ports, and also to stimulate the use of SSS feeder services to small ports that have limited or no infrastructure, have been followed in this document. In this respect, this Deliverable explored the market opportunities and business cases for the defined MOSES innovations. In this Deliverable, for each of the MOSES innovations developed in D2.1 and D2.2, twenty EU core ports have been selected (mostly) near small ports or islands where in most cases there is not regular and/or frequent container shipping between those core ports and their small ports. In this way, a typology of the ports was suggested for the Innovative Feeder vessel and Robotic Container Handling System innovations.

Furthermore, the market opportunities have been exploited for the MOSES innovations in the context of the SSS part of the container supply chain and develop the MOSES Business Cases: Western MED-Spain and Eastern MED-Greece, in view of the MOSES Transferability Business Case. The focus was on a preliminary analysis to evaluate the viability for container feeder lines, with some innovations in the feeder vessel, versus the current transport system for the case of the port of Piraeus, and also for the case of the port of Valencia. As regards the port of Piraeus, the scope of work concerns a potential feeder line between the port of Piraeus, Mykonos, and some nearby Greek islands. In the current situation, all the general cargo traffic between Piraeus and Mykonos and nearby islands is handled by Ro-Ro or Ro-pax vessels. On the other case, for the port of Valencia, the scope of the work concerns a potential feeder line between three ports managed by the Valencia Port Authority: Valencia, Sagunto, and Gandia. For our case, the containers that reach Sagunto and Gandia hinterlands are loaded/unloaded in Valencia port.

For the case of Piraeus, it concluded that nowadays, the whole general cargo traffic between Mykonos and nearby islands is Ro-Ro traffic, composed of trucks and trailers. Therefore, to develop a container feeder line, the cargo should not only be transferred from the Ro-Ro logistic chain to the Lo-Lo logistic chain but should also be consolidated/unconsolidated in a different way, which will be a significant added difficulty. For the case of Valencia, the analysis showed that despite the longer land distances to the Sagunto and Gandia hinterlands, the shortage or absence of container lines in Sagunto and Gandia port has as a result that most of the traffic is handled through the port of Valencia and carried to the hinterland by truck or rail depending on the case. To evaluate the possibility of developing a container feeder line that links the three ports managed by APV (Valencia, Sagunto, and Gandia), it has been proposed a feeder service with a frequency of three weekly services, with geared ships. And it has been observed that the feeder line would be competitive around Sagunto and Gandia.

Later, the analyses followed by using the business Canvas model to include preliminary indications on the benefits of implementing the MOSES innovations. It ensured that business models create, deliver, and capture multiple forms of values by adding a second-environmental layer and a third-social layer of analyses to the economic layer. It provides in-depth insight into the business cases for MOSES innovations and offers a higher opportunity in exploiting the market. The discussed business Canvas model for the MOSES innovations, as a preliminary analysis, showed high potential for all the innovations. It identified more in detail the stakeholders involved in each innovation besides societal impacts and benefits for port cities at the Social Stakeholder Business Canvas layer. The economic business model gives generally the concept of the costs for the innovations both in ports and on ships and identifying the related value propositions, resources, and activities. And interestingly, significant environmental impacts and benefits are expected for each of the MOSES innovations according to the environmental layer of the canvas model.

In short, Deliverable D2.3 paves the way for the further exploitation of the different MOSES innovations. Specifically, the feeder vessel concept has been deeply analysed for the two different MOSES business cases. A preliminary business model has been released for all the MOSES innovations. All these elements together with a broad analysis of the Short Sea Shipping market in Europe and the Med specifically, constitute the main elements that will be further use in the project to successfully exploit the big potential of such innovations.

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Appendix 1

Structure of maritime traffic in European sea basins

Table 60: Maritime cargo traffic by major sea basins, 2018

sea basin	Total cargo volume handled (mln tonnes) CNC ports	other core ports	comprehensive ports	Total	of which short sea million tonnes	share of total
Baltic Sea	355	16	183	554	470	(85%)
North Sea	1.386	89	118	1.593	912	(57%)
of which UK	167	89	58	314	232	(74%)
Atlantic	213	154	109	477	287	(60%)
of which UK	61	44	41	146	106	(72%)
Western Mediterranean	522	45	144	712	477	(67%)
Eastern Mediterranean	249	0	55	305	225	(74%)
Black Sea	58	0	12	69	51	(74%)
Outermost regions	0	29	14	43	26	(61%)
Total EU maritime ports	3.011	466	735	4.213	2.786	(58%)
of which short sea	1.734	216	500	2.449		
	(58%)	(46%)	(68%)	(58%)		

Note: UK ports are no longer part of the TEN-T network after the UK left the EU. The presented figures are for 2018, hence still including the UK. Source: ISL based on Eurostat[1], 2019

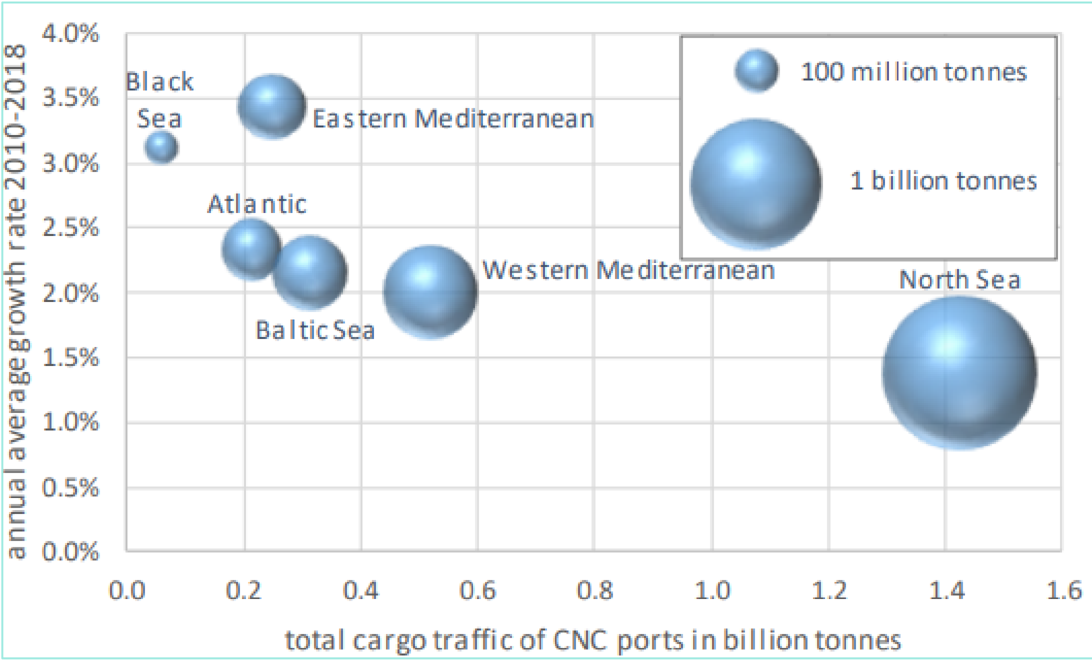

Figure 49: Average annual growth of CNC ports by sea basins, 2010-2018

Source: ISL based on Eurostat[1], 2019

Western Mediterranean Sea

Table 61: Maritime cargo traffic of CNC ports in the Western Mediterranean by cargo, 2018

	Share of cargo segment in %						
country/port	dry bulk	liquid bulk	container	ro-ro	other general cargo	million tonnes	av. annual growth 2008-2018
Spain							
Algeciras	2%	36%	57%	1%	4%	88,6	4,0%
Cartagena	20%	77%	3%	0%	1%	33,5	2,8%
Valencia	4%	3%	76%	0%	16%	62,0	2,1%
Tarragona	31%	59%	1%	0%	8%	31,8	-0,3%
Barcelona	8%	28%	51%	0%	13%	54,5	2,8%
France							
Marseille	20%	60%	14%	3%	4%	75,7	-2,0%
Italy							
Genoa	4%	34%	42%	20%	0%	51,6	1,0%
La Spezia	5%	7%	88%	0%	0%	16,0	-0,6%
Livorno	4%	24%	35%	32%	4%	30,4	0,6%
Napoli	7%	35%	33%	24%	0%	15,5	5,5%
Gioia Tauro	0%	3%	93%	1%	2%	28,5	-1,0%
Palermo/Termini Imerese	1%	18%	2%	77%	3%	9,7	5,0%
Augusta	4%	93%	0%	0%	2%	21,4	-2,2%
Malta							
Valletta	39%	9%	2%	36%	14%	1,4	-4,2%
Marsaxlokk	0%	3%	97%	0%	0%	29,7	3,6%
Total West Med. CNC ports	9%	37%	42%	7%	6%	550,4	1,1%

Source: ISL based on Eurostat, 2019

Eastern Mediterranean and Black Sea

Table 62: Maritime cargo traffic of CNC ports in the Eastern Mediterranean, 2018

	Share of cargo segment in %						
country/port	dry bulk	liquid bulk	container	ro-ro	other general cargo	million tonnes	av. annual growth 2008-2018
Croatia							
Rijeka	9%	0%	76%	0%	15%	2,7	-0,3%
Slovenia							
Koper	32%	16%	40%	0%	11%	23,1	3,4%
Italy							
Trieste	6%	56%	15%	12%	9%	57,5	4,5%
Venezia	35%	31%	20%	7%	7%	26,3	-1,3%
Ravenna	51%	23%	9%	10%	8%	31,1	0,3%
Ancona/Falconara Marittima	8%	5%	28%	52%	7%	5,9	1,1%
Bari	31%	6%	12%	37%	15%	5,3	7,8%
Taranto	58%	26%	0%	12%	4%	20,3	-8,5%
Greece							
Igoumenitsa	2%	0%	0%	98%	0%	3,6	0,0%
Patras	6%	7%	1%	85%	1%	3,3	-2,0%
Piraeus	1%	2%	88%	9%	1%	50,9	19,2%
Heraklion	8%	2%	7%	81%	1%	2,2	-5,1%
Thessaloniki	24%	47%	26%	0%	4%	14,0	-1,0%
Cyprus							
Limassol	0%	0%	79%	4%	17%	3,0	-1,8%
Bulgaria							
Burgas	22%	61%	5%	0%	12%	16,7	0,4%
Romania							
Constanța	64%	15%	13%	0%	7%	39,5	-1,5%
Galați	66%	7%	0%	0%	28%	1,3	-2,5%
Total East Med/Black Sea CNC ports	28%	26%	28%	11%	7%	306,8	1,0%

Source: ISL based on Eurostat, 2019

Baltic Sea

Table 63: Maritime cargo traffic of CNC ports in the Baltic Sea by cargo type, 2018

	Share of cargo segment in %						
country/port	dry bulk	liquid bulk	container	ro-ro	other general cargo	million tonnes	av. annual growth 2008-2018
Denmark							
København	36%	35%	20%	4%	5%	6,4	-1,2%
Sweden							
Göteborg	0%	58%	17%	22%	3%	40,6	-0,4%
Malmö	8%	31%	2%	50%	9%	8,3	-2,8%
Trelleborg	0%	0%	0%	99%	0%	11,2	-1,0%
Stockholm	19%	11%	8%	50%	13%	4,9	0,8%
Finland							
Naantali	9%	65%	0%	26%	1%	7,8	-1,1%
Turku	2%	7%	1%	71%	20%	2,2	-4,0%
Helsinki	12%	1%	25%	55%	8%	14,7	2,2%
Hamina/Kotka	29%	18%	28%	5%	20%	15,9	-0,2%
Estionia							
Tallinn	19%	42%	9%	26%	3%	20,4	-3,5%
Latvia							
Rīga	68%	12%	11%	0%	9%	34,4	1,9%
Ventspils	36%	54%	0%	7%	3%	19,2	-3,5%
Lithuania							
Klaipėda	46%	24%	16%	7%	6%	42,8	4,6%
Poland							
Gdańsk	26%	37%	34%	1%	2%	42,4	9,5%
Gdynia	34%	11%	33%	12%	11%	21,0	5,0%
Świnoujście	33%	26%	0%	38%	2%	16,8	6,6%
Szczecin	50%	15%	5%	0%	30%	9,4	1,9%
Germany							
Rostock	33%	15%	0%	43%	10%	19,6	-0,8%
Lübeck	6%	0%	12%	76%	6%	16,5	-2,5%
Total Baltic Sea CNC ports	28%	27%	15%	22%	7%	354,7	1,1%

Source: ISL based on Eurostat, 2019

North Sea

Table 64: Maritime cargo traffic of CNC ports in the North Sea by cargo type,2018

	Share of cargo segment in %						
country/port	dry bulk	liquid bulk	container	ro-ro	other general cargo	million tonnes	av. annual growth 2008-2018
Sweden							
Göteborg	0%	58%	17%	22%	3%	40,6	-0,4%
Germany							
Hamburg	25%	11%	64%	0%	1%	125,1	0,5%
Bremen	55%	10%	0%	0%	34%	12,2	-1,7%
Bremerhaven	0%	1%	89%	0%	10%	51,2	0,4%
Wilhelmshaven	15%	60%	25%	0%	0%	28,3	-3,5%
Netherlands							
Amsterdam	44%	47%	1%	1%	8%	99,5	0,2%
Rotterdam	17%	47%	28%	3%	5%	441,5	1,4%
Moerdijk	24%	29%	37%	0%	10%	6,5	1,2%
Belgium							
Antwerpen	6%	35%	51%	3%	5%	212,0	2,2%
Gent	66%	16%	0%	7%	11%	33,7	2,3%
Zeebrugge	5%	22%	9%	53%	12%	23,9	-3,7%
France							
Dunkerque	63%	13%	6%	15%	3%	41,1	-2,0%
Calais	2%	1%	0%	97%	0%	18,9	0,1%
Le Havre	2%	61%	35%	1%	1%	64,9	-1,5%
Rouen	52%	43%	1%	0%	4%	22,9	0,2%
United Kingdom							
Felixstowe	0%	0%	87%	13%	0%	28,3	1,2%
London	28%	29%	26%	14%	4%	53,2	0,0%
Dover/Folkestone	0%	0%	1%	98%	1%	24,9	0,2%
Southampton	6%	61%	27%	0%	6%	34,5	-1,7%
Forth	4%	85%	9%	1%	1%	26,6	-3,8%
Total North Sea CNC ports	19%	37%	32%	7%	5%	1389,7	0,4%

Source: ISL based on Eurostat [1], 2019

Atlantic Sea

Table 65: Maritime cargo traffic of CNC ports on the Atlantic Coast by cargo type, 2018

	Share of cargo segment in %						
country/port	dry bulk	liquid bulk	container	ro-ro	other general cargo	million tonnes	av. annual growth 2008-2018
Portugal							
Lisboa	50%	15%	33%	0%	1%	10,4	-1,3%
Sines	12%	46%	42%	0%	0%	44,3	6,0%
Leixoes	15%	44%	30%	5%	6%	17,6	1,8%
Spain							
Sevilla	54%	7%	17%	3%	20%	4,0	-0,5%
Bilbao	14%	60%	16%	1%	8%	33,9	-0,8%
France							
Bordeaux	23%	70%	5%	0%	2%	6,7	-2,8%
United Kingdom							
Liverpool	23%	31%	18%	24%	4%	32,6	0,1%
Clydeport	12%	78%	7%	0%	2%	9,1	-4,5%
Belfast	37%	12%	9%	39%	3%	18,9	3,8%
Ireland							
Dublin	9%	18%	21%	52%	0%	26,3	2,2%
Cork	21%	56%	19%	1%	3%	9,5	-0,2%
Total Atlantic CNC ports	19%	40%	23%	14%	3%	213,4	1,1%

Source: ISL based on Eurostat, 2019

Appendix 2

Table 66: Liner service as of September 2017

LINE	ALLIANCE	ORIGIN	SERVICE	MED PORT 1	MED PORT 2	MED PORT 3	MED PORT 4	MED PORT 5	MED PORT 6	MED PORT 7	MED PORT 8	MED PORT 9
MAERSK	2M	ASIA	AE12	PORT SAID EAST	HAIFA	KOPER	TRIESTE	RIJEKA				
MAERSK	2M	ASIA	AE11	SUEZ CANAL	MALTA	BARCELONA	VALENCIA	LA SPEZIA	GIOIA TAURO	PORT SAID EAST		
MAERSK	2M	ASIA	AE20	PORT SAID EAST	BEIRUT	GIOIA TAURO	LA SPEZIA	GENOA	FOS	BARCELONA		
MAERSK	2M	ASIA	AE15	IZMIT	AMBARLI	TEKIRDAG	PIRAEUS					
MSC	2M	ASIA	DRAGON	PORT SAID EAST	BEIRUT	GIOIA TAURO	LA SPEZIA	GENOA	FOS	VALENCIA	BARCELONA	MALTA
MSC	2M	ASIA	JADE	MALTA	BARCELONA	VALENCIA	LA SPEZIA	GIOIA TAURO	PORT SAID			
MSC	2M	ASIA	PHOENIX	PORT SAID EAST	HAIFA	KOPER	TRIESTE	RIJEKA	GIOIA TAURO	PORT SAID EAST		
CMA	OCEAN ALLIANCE	ASIA	Bosphorus Express	SUEZ CANAL	PORT SAID	BEIRUT	PIRAEUS	IZMIT				
CMA	OCEAN ALLIANCE	ASIA	Mediterranean Club Express 2	PIRAEUS	LA SPEZIA							
CMA	OCEAN ALLIANCE	ASIA	Mediterranean Club Express 1	SUEZ CANAL	MALTA	VALENCIA	BARCELONA	FOS				
CMA	OCEAN ALLIANCE	ASIA	Phoenician Express	PORT SAID EAST	MALTA	KOPER	TRIESTE					
COSCO	OCEAN ALLIANCE	ASIA	AEM1	PIRAEUS	LA SPEZIA	GENOA	FOS	VALENCIA				
COSCO	OCEAN ALLIANCE	ASIA	AEM2	MALTA	VALENCIA	BARCELONA	FOS	GENOA	BEIRUT			
COSCO	OCEAN ALLIANCE	ASIA	AEM3	PORT SAID WEST	BEIRUT	PIRAEUS	IZMIT	AMBARLI	CONSTANTA	ODESSA	ISKENDERUN	
COSCO	OCEAN ALLIANCE	ASIA	AEM5	ASHDOD	HAIFA	ALEXANDRIA	PIRAEUS					
COSCO	OCEAN ALLIANCE	ASIA	AEM6	PORT SAID EAST	MALTA	KOPER	TRIESTE	RIJEKA	VENICE	DAMIETA		
EVERGREEN	OCEAN ALLIANCE	ASIA	FEM	SUEZ CANAL	ASHDOD	HAIFA	DEKHELIA	PIRAEUS				
EVERGREEN	OCEAN ALLIANCE	ASIA	FAL3	SUEZ CANAL	MALTA							
EVERGREEN	OCEAN ALLIANCE	ASIA	FAL1	SUEZ CANAL	ALGECIRAS							
EVERGREEN	OCEAN ALLIANCE	ASIA	MD2	SUEZ CANAL	PIRAEUS	LA SPEZIA	GENOA	FOS	VALENCIA			
EVERGREEN	OCEAN ALLIANCE	ASIA	NE7	PIRAEUS	ANTWERP	HAMBURG	ROTTERDAM	FELIXSTOWE				
EVERGREEN	OCEAN ALLIANCE	ASIA	Phoenician Express	SUEZ CANAL	MALTA	KOPER	TRIESTE	RIJEKA	VENICE	KOPER		
OOCL	OCEAN ALLIANCE	ASIA	LL2	PIRAEUS	ROTTERDAM	HAMBURG	ANTWERP					
OOCL	OCEAN ALLIANCE	ASIA	LL3	PIRAEUS	ANTWERP	HAMBURG	ROTTERDAM	FELIXSTOWE	SOUTHAMPTON			
OOCL	OCEAN ALLIANCE	ASIA	LL4	ALGECIRAS	SOUTHAMPTON	DUNKIRK	HAMBURG	ROTTERDAM	ZEEBRUGE	LE HAVRE		
OOCL	OCEAN ALLIANCE	ASIA	WM1	PIRAEUS	LA SPEZIA	GENOA	FOS	VALENCIA				
OOCL	OCEAN ALLIANCE	ASIA	WM2	MALTA	VALENCIA	BARCELONA	FOS	GENOA				
OOCL	OCEAN ALLIANCE	ASIA	EM1	PORT SAID WEST	BEIRUT	PIRAEUS	ISTANBUL	IZMIT	AMBARLI	CONSTANTA	ODESSA	
OOCL	OCEAN ALLIANCE	ASIA	EM2	ASHDOD	HAIFA	ALEXANDRIA	PIRAEUS					
OOCL	OCEAN ALLIANCE	ASIA	AAS	PORT SAID EAST	MALTA	KOPER	TRIESTE	RIJEKA	VENICE			
YANG MING	THE ALLIANCE	ASIA	MD1	DAMIETA	BARCELONA	VALENCIA	FOS	GENOA				
YANG MING	THE ALLIANCE	ASIA	MD2	GENOA	LA SPEZIA	BARCELONA	VALENCIA					
YANG MING	THE ALLIANCE	ASIA	MD3	PIRAEUS	ISTANBUL	ALIAGA	MERSIN					
KLINE	THE ALLIANCE	ASIA	MD1	DAMIETA	BARCELONA	VALENCIA	FOS	GENOA				
KLINE	THE ALLIANCE	ASIA	MD2	GENOA	LA SPEZIA	BARCELONA	VALENCIA					
KLINE	THE ALLIANCE	ASIA	MD3	PIRAEUS	ISTANBUL	ALIAGA	MERSIN					
MOL	THE ALLIANCE	ASIA	MD1	DAMIETA	BARCELONA	VALENCIA	FOS	GENOA				
MOL	THE ALLIANCE	ASIA	MD2	GENOA	LA SPEZIA	BARCELONA	VALENCIA					
MOL	THE ALLIANCE	ASIA	MD3	PIRAEUS	ISTANBUL	ALIAGA	MERSIN					
MOL	THE ALLIANCE	NTRA ME	ADX	PIRAEUS	KOPER	VENICE						
NYK	THE ALLIANCE	ASIA	MD1	DAMIETA	BARCELONA	VALENCIA	FOS	GENOA				
NYK	THE ALLIANCE	ASIA	MD2	GENOA	LA SPEZIA	BARCELONA	VALENCIA					
NYK	THE ALLIANCE	ASIA	MD3	PIRAEUS	ISTANBUL	ALIAGA	MERSIN					
HMM	VSA - 2M	ASIA	AM1	Port Said East	La Spezia	Genoa	Fos Sur Mer	Valencia	Barcelona			
HMM	VSA - 2M	ASIA	AM2	Barcelona	Valencia	La Spezia	Port Said East					
HAPPAG LLOYD	THE ALLIANCE	ASIA	EAX	DAMIETA	PIRAEUS	MALTA						
HAPPAG LLOYD	THE ALLIANCE	ASIA	MD1	DAMIETA	BARCELONA	VALENCIA	FOS	GENOA				
HAPPAG LLOYD	THE ALLIANCE	ASIA	MD2	GENOA	LA SPEZIA	BARCELONA	VALENCIA					
HAPPAG LLOYD	THE ALLIANCE	ASIA	MD3	PIRAEUS	ISTANBUL	ALIAGA	MERSIN					