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Connectivity, costs and congestion indicators

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DELIVERABLE 4.2

Connectivity, costs and congestion indicators

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DELIVERABLE 4.2

Connectivity, costs and congestion indicators

Abstract

This deliverable explains the progress in the development of three types of indicators. First, the maritime RoRo connectivity indicator and the container connectivity indicator. The process of RoRo schedule data collection is presented, with the description of the rationale for the choice of variables and the explanation of calculation of each separate variable that forms the RoRo connectivity indicator. Furthermore, the interpretations on obtained connectivity indicator are given, with the association to other port performance indicators. For maritime connectivity, a thorough review of the potential approaches is provided and a calculation method is proposed. Next, the problems regarding data collection are discussed and a way forward is proposed.

Second, the progress regarding the cost indicators in presented. Two indicators are discussed: the THCs charged by shipping lines for the terminal handling services and the port dues per ton charged by the port authorities. Third, progress regarding the development of congestion indicators is presented. The next steps envisaged in PORTOPIA are discussed last.

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Connectivity, costs and congestion indicators

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1 INTRODUCTION

This deliverable explains the progress in the development of three types of indicators. First, the maritime RoRo connectivity indicator and the container connectivity indicator. The process of RoRo schedule data collection is presented, with the description of the rationale for the choice of variables and the explanation of calculation of each separate variable that forms the RoRo connectivity indicator. Furthermore, the interpretations on obtained connectivity indicator are given, with the association to other port performance indicators. For maritime connectivity, a thorough review of the potential approaches is provided and a calculation method is proposed. Next, the problems regarding data collection are discussed and a way forward is proposed.

Second, the progress regarding the cost indicators in presented. Two indicators are discussed: the THCs charged by shipping lines for the terminal handling services and the port dues per ton charged by the port authorities. Third, progress regarding the development of congestion indicators is presented.

2 Connectivity indicators

Ports create value for port users by creating connectivity. Increases in connectivity imply more value creation for port users. The purpose of connectivity indicators is to monitor changes in the connectivity of the EU port system over time. Data are –to the extent possible- collected at the level of individual ports, and next aggregated to the EU level. Three connectivity indicators are being developed:

1. RoRo connectivity
2. Maritime container connectivity
3. Intermodal container connectivity

The choice for these indicators is based on the fact that connectivity is only relevant for *scheduled services*, with fixed departures and schedules and users that book volumes on these services. Most (if not all) bulk shipping is not scheduled but tramp: cargo owners charter a vessel and deliver the cargo at the port of destination. Consequently, the relevance/value of connectivity indicators for bulk shipping is relatively low. The two most important scheduled maritime flows are containers and RoRo services that generally are used by freight trucks as well as passengers. For the container connectivity indicator, we focus on the global (extra-EU) connectivity while the RoRo indicator addresses the intra-EU connectivity.

For inland transport, rail and barge services are scheduled, truck transport generally is not. Therefore, an indicator is developed for intermodal (rail + barge) connections from ports to inland destinations. In the following paragraph the development of these three indicators is further detailed.

2.1 RoRo connectivity

Maritime Ro-Ro shipping is a significant fragment within the EU integration process, contributing vastly to the free movement of goods, capital, services, and people. It is getting even more important for it is undoubtedly the best replacement of the mode that causes fuel expiration, congestion, pollution and noise - the transport by road. Probably this sub-mode of sea transport provides the most value added research when connectivity being the topic. Ro-Ro connectivity is a degree to which ports (nodes) in a network are connected to each other, and there is a long list of models upon which it can be measured. Anyway, the choice for the model in our analysis was to a great extent dependent on the availability of data, as will be explained in the following paragraphs.

Our set up is based on weekly frequencies from port, travel time port to port, number of different connections, and the number of service providers offering the route.

2.1.1 DATA *COLLECTION METHOD - FORMULATION*

The term maritime Ro-Ro connectivity within this project is, as said, narrowed to short sea services in maritime transport. The data were obtained from fixed schedules (timetables) of various European ferry-freight operators.

Intra-country Ro-Ro connections were excluded, in the sense that inter(EU)country performance indicator is what was actually being traced. However, we opted not to exclude routes that are reputable and important linkages, yet inter-territorial (such as the routes from French continent to the French island of Corsica). Generally we established the rule to include such routes where such destination territory, if belonging to the same country, counts no less than 300.000 inhabitants. The ports and countries will be specified in several following exhibits.

Data collection was performed within the period of third quarter of a year with an initial test for the period mid February to mid-March 2014. Both Q1 and Q3 are good periods because they are outside the seasonal mostly holiday-makers oriented Ro-Ro services (e.g. UK-Northern Spain).

How were data gathered? We assumed the webpages of Ro-Ro (ferry) operators show true and actual data for the schedules and timetables on their webpages. Only the operators particularly offering cargo (or freight) services were included in the observation. Furthermore, only short sea services operators were observed. These were traced through search engines for a specific route (e.g. Helsinki - Tallinn), or the real-time Internet ferry finder network portals (e.g. AFerry.co.uk, Directferries.co.uk). Nevertheless the data was always taken from the original source, meaning although the route is suggested with a ferry finder, the schedule is always taken from the operators own web page. Moreover, the existence of the particular route was additionally verified using Google's Maps, whose newest version illustrates actual geographical line movements and names the route as port-to-port. Lastly it will be requested from the port authorities and other relative partners to verify the data.

Which data was gathered? A crucial decision was about which data should be observed and collected. Not only that collecting data in the described way is time consuming, but leaving out variables that are important for measuring connectivity would lead to repeating the whole process again (since the process is done at a fixed period of time). On the other hand, not all of the data are available. The variables which both have best impact to connectivity and were utterly obtainable were the following: frequency, travel time, tier of connection, and the number of service providers.

Frequency is the number of departures from a specific port to a specific port per week. It is typically represented either by dates or weekdays within schedules (timetables) of operators published on their webpages. Travel time is the time in hours the ship travels from the port of departure to port of destination. Tier of connection is the order number of the observed destination port within a route (1, 2, 3…). Number of service providers is the number of different operators (ferry companies) for the same observed route.

When collecting the aforementioned data, there were "anomalies", pertaining mostly to travel time and tier of connection. Since for one same route (e.g. Kotka -Hull, as offered in

Table 1) there were sometimes several different travel times stated from one and the same operator (e.g. Finnlines), which usually and not always means that the route is different or a port is being a different tier on the route, a proper weight should have been used to attain a best representing time. For this a median value of all travel times was calculated. In case there were decimal numbers, median is approximated to the closest round number. The reasons are the following; using mean in a dataset where there are several common smaller values and only one larger value (e.g. 45, 48, 47, 160) would show a distorted travel time (in this case mean=75 vs. median=47,5[1]). As per the relative tier of connection, the applied statistic was mode, to "keep the track" with travel times, and which was best to show which order number is most common for the port, for the very route. Moreover, it is more suitable for datasets with smaller round numbers (e.g. for tier values 1, 1, 1, 4 mode is 1).

[1] This value (47,5) is further approximated to 48 (MS Excel function CEILING (MEDIAN (values); significance =1) to easen further calculations.

Table 1 Median travel time and mode tier of connection (example route Kotka-Hull)

Vessel	Port loading	Departure date	Departure time	Departure weekday	Departure datetime	Port discharge	Arrival date	Arrival time	Arrival weekday	TRAVEL TIME (h)	TIER
MISIDA	Kotka	6-3-2014	22:00:00	Thu	6-3-2014 22:00	Lübeck	8-3-2014	18:00:00	Sat	44,00	
MISIDA	Kotka	6-3-2014	22:00:00	Thu	6-3-2014 22:00	Gdynia	14-3-2014	17:00:00	Fri	187,00	
MISIDA	Kotka	6-3-2014	22:00:00	Thu	6-3-2014 22:00	Hull	16-3-2014	8:00:00	Sun	226,00	3
FINNHAWK	Kotka	7-3-2014	20:00:00	Fri	7-3-2014 20:00	Immingham	11-3-2014	14:00:00	Tue	90,00	
FINNHAWK	Kotka	7-3-2014	20:00:00	Fri	7-3-2014 20:00	Hull	11-3-2014	23:00:00	Tue	99,00	2
MISANA	Kotka	13-3-2014	20:00:00	Thu	13-3-2014 20:00	Immingham	18-3-2014	14:00:00	Tue	114,00	
MISANA	Kotka	13-3-2014	20:00:00	Thu	13-3-2014 20:00	Hull	18-3-2014	23:00:00	Tue	123,00	2
MISIDA	Kotka	21-3-2014	20:00:00	Fri	21-3-2014 20:00	Helsinki	22-3-2014	7:00:00	Sat	11,00	
MISIDA	Kotka	21-3-2014	20:00:00	Fri	21-3-2014 20:00	Immingham	25-3-2014	14:00:00	Tue	90,00	
MISIDA	Kotka	21-3-2014	20:00:00	Fri	21-3-2014 20:00	Hull	25-3-2014	23:00:00	Tue	99,00	3
FINNHAWK	Kotka	28-3-2014	20:00:00	Fri	28-3-2014 20:00	Immingham	1-4-2014	14:00:00	Tue	90,00	
FINNHAWK	Kotka	28-3-2014	20:00:00	Fri	28-3-2014 20:00	Hull	1-4-2014	23:00:00	Tue	99,00	2
										MEDIAN TT	MODE TIER
										99,00	2

As it was mentioned before, some data which could be valuable are for the time being left out from observation. For instance, similar to other relative connectivity indicators such as LSCI[2] we could follow the number of ships (complementary to number of operators) that provide a certain service. Moreover, we could measure the price of the fares for particular routes. However, since the resources for obtaining a complete set of data were scarce, we narrowed the observation to the fore mentioned four parameters.

2.1.2 The ports included in the data analysis

The initially selected ports are all maritime core ports as defined by Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network (TEN-T), Annex II, 2.

For each of the ports we thoroughly searched the Internet for published schedules, as described in the previous chapter. Each core port is observed as the origin port and we traced for all the published connections to all possible destinations. The list of ports is given in Appendix 1.

2.1.3 The collected data

The results of the data collection are given in Appendix 2 For each core port all possible routes stemming from it as a port of origin have been traced. The final data collection set included 73 out of initially 98 ports, yet the throughput realized by those ports makes more than 90% of total throughput in Europe.

[2] UNCTAD's liner shipping connectivity index - LSCI - is generated from five components: (a) the number of ships; (b) the total container-carrying capacity of those ships; (c) the maximum vessel size; (d) the number of services; and (e) the number of companies that deploy container ships on services from and to a country's ports. (UNCTADSTAT 2014 - http://unctadstat.unctad.org/TableViewer/dimView.aspx)

2.1.4 Data validation

The data collection was based on publicly available sources. However, in order to validate the data, a validation process is being developed. This validation process is done as follows:

1. The Ro-Ro connectivity data about a specific port is made available to this port through the 'cloud service'. That requires developing a system where ports can access specific data for their own port (not visible for others) through a password. This system has been developed.
2. The ports are mailed with the request to verify if the data are accurate and in case additional services are being offered, submit either a website or a document with those data.
3. TU/e and UTU contacted the ports to explain relevance and method and re-iterate the importance of validating the data.
4. Additional data in line with the definitions were added to the data.

The data validation process led to some small additions to the database.

2.1.5 The calculation method

The intention behind the port Ro-Ro connectivity index is to compare Ro-Ro connectivity of a certain core port compared to other ports, to track changes in its connectivity over time. Also, one common indicator should express the Ro-Ro connectivity of the EU port system.

As described in the previous chapter, our indicator is limited to the components available online: frequency of services, travel time, number of tiers within connection, the number of different connections, the number of competitors offering the service and maritime distances. Similar to other relative connectivity indicators such as LSCI[3] we could include some other valuable components such as the number of ships (complementary to number of operators) that provide a certain service. Moreover, we could measure the price of the fares for particular routes. Yet obtaining a complete set of data is extremely costly so this item was not included. Nevertheless we were able to offer several options for to incorporate these variables into the connectivity indicator.

2.1.5.1 Ro-Ro connectivity indicator - variant one

[3] UNCTAD's liner shipping connectivity index - LSCI - is generated from five components: (a) the number of ships; (b) the total container-carrying capacity of those ships; (c) the maximum vessel size; (d) the number of services; and (e) the number of companies that deploy container ships on services from and to a country's ports. (UNCTADSTAT 2014 - http://unctadstat.unctad.org/TableViewer/dimView.aspx)

One essential perspective is the viewpoint of the eventual user of the port's Ro-Ro service i.e. the shipper. In this sense we further assess the available variables, as follows:

The *number of connections* implies an opportunity to select from a variety of connected ports, thus providing the shipper a possibility to choose in favour of e.g. minimized land transport.

The *frequency of service* is important for the shipper by contributing to lean production (minimizing inventories etc.).

Travel time is naturally an important aspect for a shipper, and particularly in the case of time sensitive cargoes (e.g food and other perishables), which are often an object of Ro-Ro freight shipping.

The *number of service providers* offering a port to port service implies competition, thus being beneficial to the shipper from potentially decreasing freight rates.

As regards the collected variable of the *tier of connection*, one viewpoint could be that the higher tier means "weaker" connectivity. In this sense the value of tier can be used to weight the connectivity. When the observed port has several services (routes), the connected port can have different tier value as dependent to its order in these routes. In these cases, the smallest tier (direct connection) may be seen as providing the best available "connectivity" for a shipper (example in figure 1).

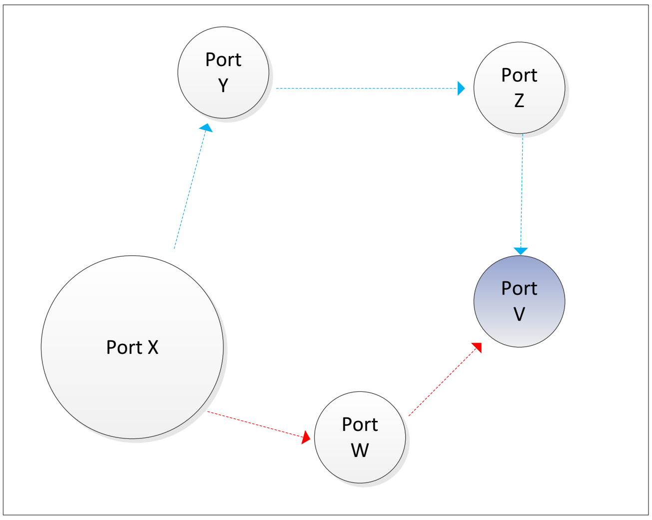


Figure 1. Connection port X to Port V is tier 2 (2 < 3).

Furthermore, Ro-Ro *vessel capacity* (lane meters) seems an obvious quality factor in port connectivity. However, considering the shippers perspective, the lane capacity is not an essential dimension since in open market that is always adapted to the demand. Shipping companies are nowadays very flexible in changing the vessels in different routes and redundant capacity is not available a long time if there are not enough users. Other variables have more inertia than vessel capacity. Therefore, Ro-Ro capacity was not included as an indicator component. The other pragmatic reason is difficulty of data collection, already argued above. To summarize, the following components are included into the first option for the Ro-Ro connectivity indicator:

- Number of connections weighted by tier (more connected ports, more connectivity)
- Frequency of service (number of departures/week; more frequency more connectivity)
- Travel time (the longer the average travel time, the weaker the connectivity)
- Number of service providers (more service providers, more connectivity)

First of all, we have to address the sensitive matter of weighting applied to different components in the proposed indicators. Weighting is always more or less subjective and depends on the perception of the user on the importance of different parameters. In this case, the proposed weights (that, in our view, represent fairly reasonable weighting of components) can be used in initial calculation, however they can be amended with an agreement with users. From the shippers' perspective, we argue that the number of existing connections, in general, is more important than the other aspects. Similarly, the frequency of Ro-Ro service is more important than the travel time or the number of service providers. It is finally up to the user set the weights and observe the impact in connectivity indicator. This kind of sensitivity analysis can be made when data is collected from different time periods in order to make comparisons over the weight value impact.

After performing several tests on the above calculation principle, we observed the following facts. The variable of tier of connection correlates with travel time since the higher value of tier implies inevitably a longer travel time. From the shipper's perspective the information on specific route and actual tiers of connections of the vessel as such may seem irrelevant, whereas the shipper is only interested in the estimated time of arrival of his shipment. The tier would be a more relevant variable if only the number connections variable were used as an indicator for connectivity.

An additional problem related to the concept of tiers is data availability. Most of the Ro-Ro traffic is point-to-point traffic (1st tier). For routes having several ports the schedules are mainly published on the shipping company web sites, from which the tiers on routes could be extracted. However, there are shipping companies who do not publish route schedules. Also, the longer routes including several ports are subject to changes more often than the common point-to-point traffic.

A further problem is related to the variable of travel time, which has same data collection challenges as the tier data. As was discussed before, different travel data could be shown for one and the same route. This would demand resources from the validators of data (port authorities) and poses a risk of incoherent data and data gaps. Also, the travel times from a port can be perceived as a variable which is given by the physical location of the port (distance to markets/other ports), and which the human actions cannot change, while others - the number of connections, frequency and the number of service providers - are dependent on human decisions. On the other hand, the latter are all robust concepts, and supposedly many port authorities as well as data collectors directly from the web can with little effort update this data regularly.

Thus, by eliminating those variables that are ambiguous (tier of connection and travel time), we formulated the second variant for the connectivity indicator, as presented below.

The components are expressed as follows

K_i – Number of connections from port i to different ports

$$K_i = \sum_{i=1}^{N}$$

F_i – Number of weekly departures from port i in total

$$F_i = \sum_{i=1}^{N} f_i$$

S_i - Number of service providers (shipping companies) per departure on average

$$S_i = \sum_{i=1}^{N} \frac{s_i}{N}$$

where N is the number of ports.

Equation 1 (roro connectivity development over time in individual port)

$$C_{i\,=\,w_k} K_i + w_f F_i + w_n S_i$$

where

C_i is the connectivity indicator for port i.

The tentative weights are $w_k = 0.5, w_f = 0.3, w_n = 0.2$

The C_i value obtained of the first time dataset can represent value 100 (normalization), thus making comparisons easily feasible against the following years values.

Equation 2 (roro connectivity of individual port compared with other ports)

$$C_{iN} = w_k (K_i^{\ N}) + w_f(F_i^{\ N}) + w_n(S_i^{\ N})$$

where

C_{iN} – Normalized composite value of roro connectivity for port i. The maximum value is 1. In this case the port has highest values in all three components.

$(K_i^{\ N})$ – Normalized value of connections in port i. K_i is divided with the maximum value in connections dataset.

$(F_i^{\ N})$ - Normalized value of weekly departures from port i. $F_i$is divided with the maximum value in weekly departures dataset.

$(S_i^{\ N})$ - Normalized value of average number of service providers from port i. S_i is divided with the maximum value in average number of service providers dataset.

The C_{iN} value obtained of first time dataset can represent value 100 (normalization), thus making comparisons easily feasible against the following years values.

The weights are adjustable by the users, as in the previous version. Finally, the updated version provides a roro connectivity indicator where the changes in component values and their consequent impact to the indicator are comprehensible to users.

Both indicators can be used for individual or group of ports in benchmarking over time (horizontal dimension) of on a set of other ports (vertical dimension) to observe the development on roro connectivity.

2.1.5.2 Ro-Ro connectivity indicator - variant two

This version of the Ro-Ro connectivity indicator also emphasizes a shipper as an influential actor in Ro-Ro shipping. However it does not exclude any of the variables, and uses methodologies which does not involve weighting, in order to minimize subjectivity.

Firstly, all origin-destination pairs were traced individually. For example, for the port of Helsinki, which is one of the most frequently appearing origin ports within the data set, the following data was retrieved, as presented in **Erreur ! Nous n'avons pas trouvé la source du renvoi.**.

Table 2 Collected values for Ro-Ro connectivity variables for the port departure: Helsinki

ORIGIN PORT	ROUTE NAME	FREQ (dep/week)	TRAVEL TIME (h)	TIER OF CONN	DISTANCE nm	NO OF DIFF SER
HELSINKI	HELSINKI-GDYNIA	2	27	1	480	1
HELSINKI	HELSINKI-IMMINGHAM	1	64	1	1509	1
HELSINKI	HELSINKI-MARIEHAMN-STOCKHOLM	11	12	2	267	2
HELSINKI	HELSINKI-RAUMA	1	43	1	187	1
HELSINKI	HELSINKI-ROSTOCK	3	37	1	712	1
HELSINKI	HELSINKI-ST PETERSBURG	2	11	1	179	1
HELSINKI	HELSINKI-TALLINN	62	2	1	39	3
HELSINKI	HELSINKI-TRAVEMÜNDE	7	28	1	754	1
HELSINKI	HELSINKI-UST LUGA	1	10	1	128	1

O*n one route (port pair)*, let this be Helsinki - Stockholm, we find that there are 11 departures within one week within in the observed quarter (frequency column). The median travel time that the ship takes to get from Helsinki to Stockholm along the both weekly routes is 12 h. There is one stop in between the ports, meaning Helsinki connects two ports on this route. Also, there are two companies found that provide Ro-Ro service for this route, so the number of different service providers for the route is two.

After obtaining single values for each of the components per route, the next step is to obtain a common value inherent to a particular route for each of the five variables.

Based from what we are able to obtain, we build the following indicator. The first part of the indicator relates to the time-range of the port. This part is proportional to the distance covered by the route and the number of times the route is passed (frequency), and inversely proportional to the travel times along the route. By summing up the values per each route originating from the evaluated port, we obtain the "time-range" of the port, the total distance realized by all routes from the port within the observed period.

The idea is summarized in the following equation:

Equation 3

$$R_i = \sum_j \frac{F_{ij} \cdot D_{ij}}{TT_{ij}}$$

where

R_i - time range of the evaluated port i

F_{ij} - number of weekly departures from port i to port j

D_{ij} - maritime distance in nm from port i to port j

TT_{ij} - travel time along the route from port i to port j

The results for the ten top ports in terms of range are given in **Erreur ! Nous n'avons pas trouvé la source du renvoi.**.

Table 3 Top ten ports by evaluation of time range

ORIGIN PORT	RANGE	NORM RANGE
CALAIS	3.294,00	1,0000
DOVER	2.830,80	0,8594
BELFAST	2.230,91	0,6773
ALGECIRAS	2.078,40	0,6310
HELSINKI	1.808,81	0,5491
OLBIA	1.646,79	0,4999
LIVORNO	1.551,09	0,4709
TRELLEBORG	1.548,00	0,4699
LUBECK/TRAVEMÜNDE	1.481,89	0,4499
DUBLIN	1.418,55	0,4306

Although Calais is connected only to Dover, and Dover is connected to the two ports, Calais and Dunkirk, which all less than 30 nm away, have such high frequencies that the total range realized on routes from Dover ranks very high.

However, the other two collected components allow us to establish a fairer measure when it comes to the diversity of routes from the port. This means we want to observe the multidimensional range one port realizes, or how many different ports the evaluated port connects. For every route stemming from the evaluated port (the same route as in range calculation), we express the abundance of the route as the number of ports the evaluated port connects, and the number of service providers that offer services on the particular route. In this sense the term "abundance" could be envisioned as "competitive abundance". All such route values are then summed up to one, port value. This is expressed in the following equation.

Equation 4

$$A_i = \sum_j TC_{ij} \cdot NSP_{ij}$$

where

A_i - abundance of the evaluated port i

TC_{ij} - number of ports the evaluated port connects (tiers of connection) along the route from port i to port j

NSP_{ij} - number of different service providers for the route from port i to port j

The results for the competitive abundance of the top ports is provided in the following table.

Table 4 Top ten ports by evaluation of abundance

ORIGIN PORT	ABUND	NORM ABUND
LUBECK/TRAVEMÜNDE	15	1,0000
HELSINKI	14	0,9333
STOCKHOLM	14	0,9333
LIVORNO	13	0,8667
TURKU	13	0,8667
GENOVA	11	0,7333
BARCELONA	10	0,6667
MARSEILLE	10	0,6667
PATRAS	10	0,6667
TILBURY	10	0,6667

For both of the parts of the indicator (range and abundance), we applied normalization, by dividing each part with the maximum value within the list. The normalized values reflect the share of each connectivity component of a port within the observed set of ports. Normalization by the maximum values for the year 2014 (initial period) should be continued for all the forthcoming evaluation periods, which would allow us to track the changes (growth or decrease) in connectivity in the next periods.

Finally, the composite value for the Ro-Ro port connectivity indicator is calculated as the geometrical average of both parts. We used geometric average to correct for the cases where one component is much higher than the other (as in the example of Calais, range 1, abundance 0,2), where arithmetic average would assign much higher value. The final measure for Ro-Ro connectivity is expressed in the following equation.

Equation 5

$$IRRC_i = \sqrt{R_i^N \cdot A_i^N}$$

The results for the indicator for top 20 ports are presented in table 5 below.

Table 5 European Ro-Ro Connectivity indicator - two parts and the result for 20 highest ranked

RANK	ORIGIN PORT	RANGE	NORM RANGE	ABUND	NORM ABUND	IRRC
1	HELSINKI Total	1808,808	0,5491	14	0,9333	0,7159
2	LUBECK/TRAVEMÜNDE Total	1481,886	0,4499	15	1,0000	0,6707
3	LIVORNO Total	1551,092	0,4709	13	0,8667	0,6388
4	STOCKHOLM Total	1142,989	0,3470	14	0,9333	0,5691
5	TURKU Total	896,3684	0,2721	13	0,8667	0,4856
6	DOVER Total	2830,8	0,8594	4	0,2667	0,4787
7	GENOVA Total	952,2955	0,2891	11	0,7333	0,4604
8	PATRAS Total	1031,958	0,3133	10	0,6667	0,4570
9	CALAIS Total	3294	1,0000	3	0,2000	0,4472
10	OLBIA Total	1646,788	0,4999	6	0,4000	0,4472
11	BARCELONA Total	898,914	0,2729	10	0,6667	0,4265
12	TRELLEBORG Total	1548,003	0,4699	5	0,3333	0,3958
13	BELFAST Total	2230,912	0,6773	3	0,2000	0,3680
14	ALGECIRAS Total	2078,4	0,6310	3	0,2000	0,3552
15	DUBLIN Total	1418,548	0,4306	4	0,2667	0,3389
16	ROTTERDAM Total	922,6678	0,2801	6	0,4000	0,3347
17	ZEEBRUGGE Total	665,0149	0,2019	8	0,5333	0,3281
18	TILBURY Total	529,151	0,1606	10	0,6667	0,3273
19	PORTSMOUTH Total	655,2948	0,1989	8	0,5333	0,3257
20	TALLINN Total	1021,95	0,3102	5	0,3333	0,3216

The results can be interpreted in the following way. The port whose connectivity value is closest to 1 has both parts (range and abundance) as close to 1 as possible. This setup is valid only for the first year of observation, since the normalization of each part will be continued against the starting year (2014). In this way the value of the indicator will be changing, and fortunately increasing for all ports, and in time it will surpass 1.

To test validity of the indicator, we first compared the obtained values with throughput, as reported by Eurostat in 2013 for the year 2012 (the most recent period we were able to obtain). We tested the two variables for correlation, and obtained significant correlation of 0,586 (Pearson product-moment coefficient).

Additionally we made a retrospective for the top-ranked, one mid-ranked and one bottom-ranked port. These are Helsinki, Liverpool, and Trieste. The rationale was to choose from the port that all high throughput. The summary is presented in

Table 6.

Table 6 Route data for the top, mid and bottom ranked ports

ORIGIN PORT	ROUTE NAME	FREQ (dep/week)	TRAVEL TIME (h)	DISTANCE nm	RANGE
HELSINKI	HELSINKI-GDYNIA	2	27	480	35,5556
HELSINKI	HELSINKI-IMMINGHAM	1	64	1509	23,5781
HELSINKI	HELSINKI-MARIEHAMN-STOCKHOLM	11	12	267	244,75
HELSINKI	HELSINKI-RAUMA	1	43	187	4,34884
HELSINKI	HELSINKI-ROSTOCK	3	37	712	57,7297
HELSINKI	HELSINKI-ST PETERSBURG	2	11	179	32,5455
HELSINKI	HELSINKI-TALLINN	62	2	39	1209
HELSINKI	HELSINKI-TRAVEMÜNDE	7	28	754	188,5
HELSINKI	HELSINKI-UST LUGA	1	10	128	12,8
HELSINKI Total					**1808,81**
LIVERPOOL	LIVERPOOL-BELFAST	16	9	193	343,111
LIVERPOOL	LIVERPOOL-DUBLIN	18	7	178	457,714
LIVERPOOL Total					**800,825**
TRIESTE	TRIESTE-DURRES	2	36	455	25,2778
TRIESTE Total					**25,2778**

ORIGIN PORT	ROUTE NAME	TIER OF CONN	NO OF SER PROV	ABUND
HELSINKI	HELSINKI-GDYNIA	1	1	1
HELSINKI	HELSINKI-IMMINGHAM	1	1	1
HELSINKI	HELSINKI-MARIEHAMN-STOCKHOLM	2	2	4
HELSINKI	HELSINKI-RAUMA	1	1	1
HELSINKI	HELSINKI-ROSTOCK	1	1	1
HELSINKI	HELSINKI-ST PETERSBURG	1	1	1
HELSINKI	HELSINKI-TALLINN	1	3	3
HELSINKI	HELSINKI-TRAVEMÜNDE	1	1	1
HELSINKI	HELSINKI-UST LUGA	1	1	1
HELSINKI Total				**14**
LIVERPOOL	LIVERPOOL-BELFAST	1	1	1
LIVERPOOL	LIVERPOOL-DUBLIN	1	1	1
LIVERPOOL Total				**2**
TRIESTE	TRIESTE-DURRES	1	1	1
TRIESTE Total				**1**

The values confirm the consistency of the indicator results; higher values for the two parts (range and abundance) produce higher port rankings.

However the data collection part could potentially be under a lot of critique, since in this example the port of Trieste reports very large throughputs, but only one scheduled route is found from the port.

The issue of data validity has to be solved for the first year of observation, because all further index calculations will be void (unless rebooted against a different year). We expect this to be significantly improved with the support from the ports (see section 2.1.4).

Another test for validity in terms of sensitivity is performed by using a fictional case. We wanted to check the changes in connectivity indicator if a port would obtain one additional route, while all other routes remaining the same. We have chosen the example of Dover, which currently has enormous throughput reported, but still is ranked sixth by connectivity index. Currently Dover has two very short but very frequently realized routes to Calais and Dunkirk.

We inserted an additional route and obtained the result as presented below.

Table 7 Fictional route and the indicator result

ORIGIN PORT	ROUTE NAME	FREQ (dep/week)	TRAVEL TIME (h)	DISTANCE nm	RANGE
DOVER	DOVER-CALAIS	161	2,5	27	1738,8
DOVER	DOVER-DUNKERQUE	78	2	28	1092
DOVER	DOVER-ANTWERP (FI	7	10	110	77
DOVER Total					2907,8

ORIGIN PORT	ROUTE NAME	TIER OF CONN	NO OF SER PROV	ABUND
DOVER	DOVER-CALAIS	1	3	3
DOVER	DOVER-DUNKERQUE	1	1	1
DOVER	DOVER-ANTWERP (FICT)	1	1	1
DOVER Total				5

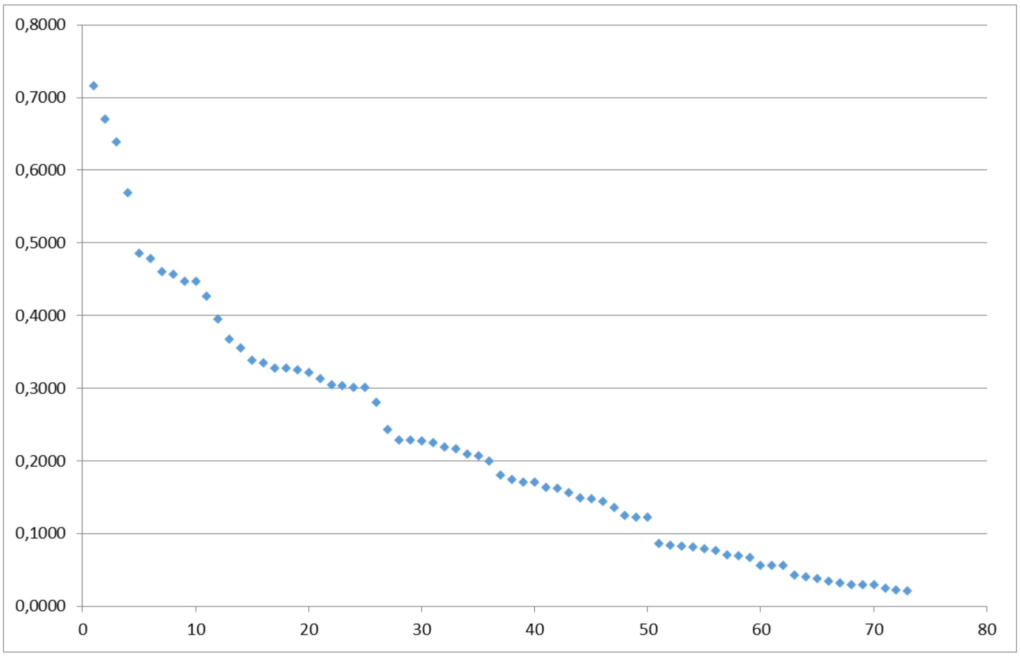
RANK	ORIGIN PORT	RANGE	NORM RANGE	ABUND	NORM ABUND	IRRC
1	HELSINKI Total	1808,808	0,5491	14	0,9333	0,7159
2	LUBECK/TRAVEMÜNDE Total	1481,886	0,4499	15	1,0000	0,6707
3	LIVORNO Total	1551,092	0,4709	13	0,8667	0,6388
4	STOCKHOLM Total	1142,989	0,3470	14	0,9333	0,5691
5	DOVER Total	2907,8	0,8828	5	0,3333	0,5425
6	TURKU Total	896,3684	0,2721	13	0,8667	0,4856
7	GENOVA Total	952,2955	0,2891	11	0,7333	0,4604
8	PATRAS Total	1031,958	0,3133	10	0,6667	0,4570
9	CALAIS Total	3294	1,0000	3	0,2000	0,4472
10	OLBIA Total	1646,788	0,4999	6	0,4000	0,4472

The range consequently increased by very little, however an increased abundance score pushed Dover one position up along the list (compare with table 5).

We have performed similar test with other ports, and the indicator shows to be more responsive to changes in the part of abundance, because the abundance values have low range (maximum-minimum difference). This may be corrected by including other variables into the competitive abundance part of the equation. Primarily the best such variable would be the costs per each route.

Additionally, to track the progress of the connectivity of the whole set of core ports in time, a European Ro-Ro connectivity indicator is developed. We first analysed how the indicator values are distributed against the ranking, and found the power law curve typical for scale free networks such as maritime network, where many ports have only few links and large hubs have many (Kaluza et al, 2010). This supports the methodology of the indicator.

Figure 1 The Ro-Ro connectivity value against the rank, 2014



To obtain a single value on the basis on this form of distribution, we used discrete integration, which is a simple sum of all indicator values. This is expressed in the final equation, for the European Ro-Ro connectivity indicator.

Equation 6

$$IRRC^E = \sum_{i=1}^{n} IRRC_i$$

where

$IRRC^E$ - index or European maritime Ro-Ro connectivity

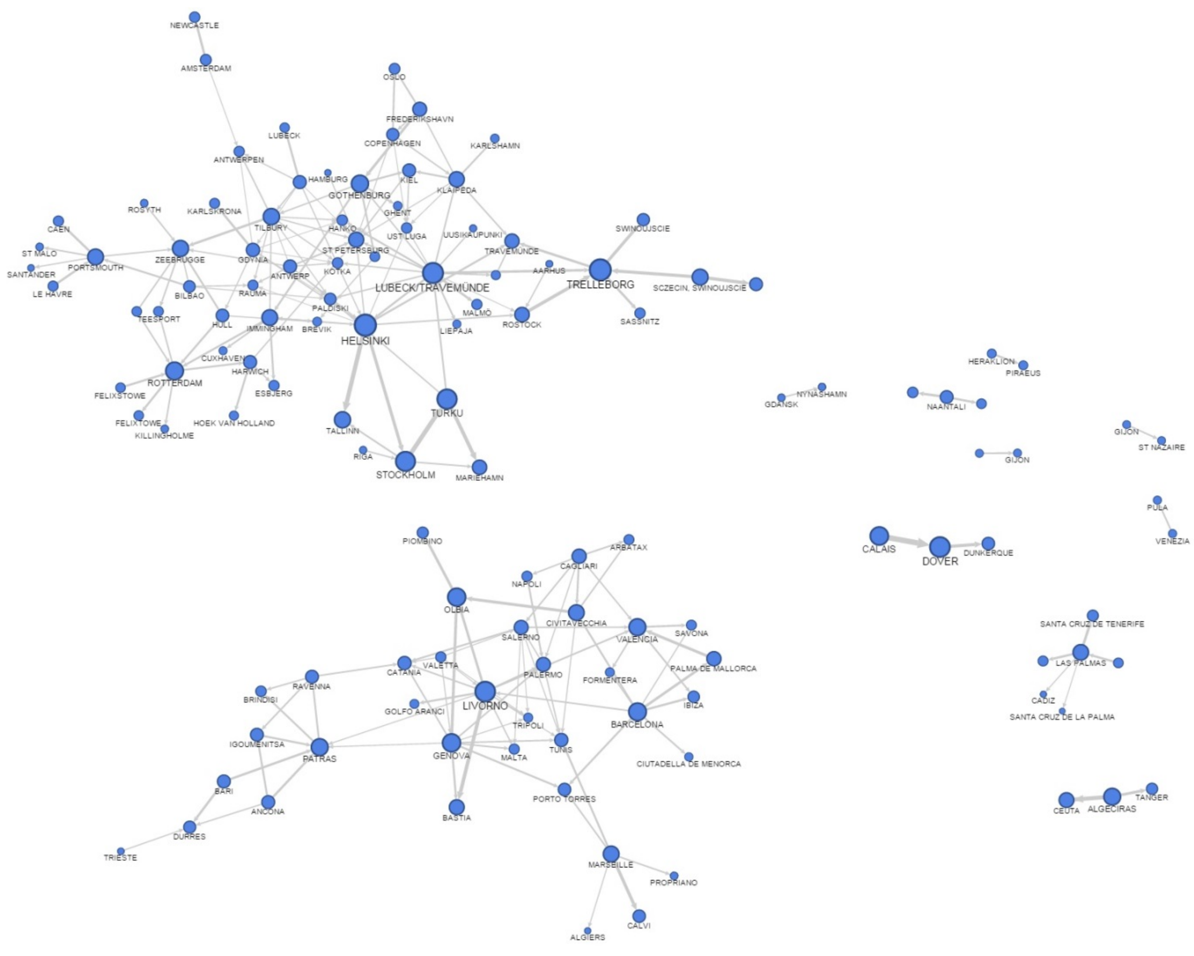
$IRRC_i$ - the value of the Ro-Ro connectivity indicator per port i

For the first period of observation the value of the European connectivity indicator is 16,2425. However, this value only becomes meaningfull in a time series.

Connectivity graph based on route connectivity

We formed a network graph based on the obtained data where the weights of the links are "route connectivities", which are calculated in the same manner as for the ports (Figure 2. The graph provides an insight into the existence of several communities. It may be viable to establish a new policy to connect these communities, encouraging stakeholders in developing new services. In terms of graph theory, a service from the well connected hubs would be most beneficial. This means we should aim at connecting the two (or more) ports who have the highest score from the different clusters. However the land infrastructure, congestion, population and other factors should be examined in parallel for the final design.

Figure 2 Ro-Ro graph based on route connectivity



2.1.6 Ro-Ro connectivity and policy objectives

Maritime Ro-Ro connectivity is a significant fragment within the EU integration process and the free movement of goods, capital, services, and people. The indicator of Ro-Ro maritime connectivity belongs to port performance indicators which, besides measuring port performance, serves to bring in the information on the position of the segment in Europe as a whole. Sustainable means for data collection in a harmonized way still need to be developed, together with summoning the participation of port authorities and other port stakeholders in providing or inspecting data. However, we believe the system of both data collection and index calculation presented in this paper can be practically and relatively easily implemented. In this way it is more easily adopted by participants within the port life and wider, serving many purposes, of which most fitting is that it disseminates status information.

2.1.7 Benchmarking Ro-Ro connectivity and other port performance indicators

Maritime Ro-Ro connectivity is made in such way that the values reflect both vertical and horizontal changes. Meaning, it already has a component of comparison within the chosen set of ports (vertical) but it allows also to benchmark the development of single port over the years (horizontal). Moreover, it also allows (central) benchmarking with the EU indicator (port's Ro-Ro connectivity indicator vs European Ro-Ro connectivity indicator).

Exploring connectivity of a port within a set of ports allows better insights when comparing with other performance indicators of a port. De Langen, Nijdam and van der Horst (2006), consolidate a set of performance indicators which could be used for relating the obtained Ro-Ro connectivity indicator. Such are the value added to the seaports, logistics space, investment level, ship waiting time, value of goods passing through the port, and many others. Each of these PPIs, which could be of greater importance than only throughput, could be correlated to the obtained Ro-Ro connectivity indicator. If there would be firm correlations to a PPI, we could also forecast the development of port performance by using connectivity indicator (which is relatively easily obtained for each period), which may be of the crucial contribution to the whole sector.

2.1.8 Conclusions and propositions for future research

The development of Ro-Ro connectivity indicator that we performed here still lies on shaky ground, and this is mostly because the data collection relies on a relatively uncertain territory, and that is internet. Not only that, but it is the only source of data. Other uncertainty is that, no matter how clearly and methodically the data collection process is explained and trailed, a part of it always stays subjective and highly reliant on what data the collector deems are important and how skillful the collector is with browsing for the aimed route. Therefore, with the help of Portopia frontrunners it is desirable to develop either a cluster of shipping lines or ask ports themselves to provide correct and up to date schedules. We think the first option enables firsthand information, and if such partners would (even unsistematically, but firsthand) provide data, the indicator would be more reliable and accurate. Even better, the project would increase the number of participants.

2.2 A MARITIME CONNECTIVITY INDICATOR

For maritime connectivity, a thorough review of the potential approaches is provided and a calculation method is proposed. Next, the problems regarding data collection are discussed and a way forward is proposed.

2.2.1 A CALCULATION METHOD FOR MARITIME CONTAINER CONNECTIVITY

There is a large portion of literature dedicated to the analysis of structures of transportation networks. The studies include a set of graph theoretical measures for overall network structures (e.g. modularity, density, clustering) and measures for highlighting particular nodes for their importance (e.g. centrality, eccentricity, Shimbel index). Guimerá et al (2005) apply these measures to study the worldwide air transport network. Kaluza et al (2010) use them to describe worldwide maritime transport network. Numerous other analyses have been performed for sea transport networks at a regional level (e.g. Veenstra 2005 for the Caribbean, Cisic et al 2005 for the Mediterranean, Lam and Yap 2011 for China). However there is a subset of literature that produces hybrid measures of connectivity which relate specifically to the nodes, declared as port or country connectivity indices. These measures are universal attempts of quantifying node connectivity and creating a standard metric and ranking of nodes within the specific transportation mode. Our aim is to identify the motives behind these measures, describe their functionality in various transport modes and identify the next steps in the development of such connectivity indicator for seaports.

With regards to the scale of transport networks, the two networks that have a worldwide coverage are air and sea transport network. Compared with other networks (rail, road, inland waterways, pipelines), the two networks have an advantage in terms of economics and technology, and have highest importance for the international exchange of goods and people. For these two networks we also noted the majority of attempts to develop the connectivity indices. The node connectivity indices for the worldwide air and sea transport network are summarized in

Table *8*.

Table 8 Up to data developed air and sea connectivity indicators

ONo.	Authors and indicator name (if stated in original text)	Equation	More on components/calculation method
	Air transport		
1	Pearce (2007), Aviation connectivity (AC)	∑ (Frequencies * Available Seats per Flight * Weighting of destination airport) / 1000	The index is based on the number of available seats to each destination served for the first week in July in each year between 1996 and 2005. The number of available seats to each destination is then weighted by the size of the destination airport (in terms of number of passengers handled in each year). The weighted totals are then summed for all destinations (and divided by a scalar factor of 1000) to determine the connectivity indicator.
2	Arvis and Shepperd (2011), Airline Connectivity Index (ACI)	$\bar{C_i} = \sqrt{\frac{X_i/A_i + B_i}{\sum_j B_j}} \cdot \sqrt{\frac{X_i/B_i + A_i}{\sum_j A_j}}$	$\bar{C_i}$ - connectivity of an origin country X_i- total outflows from node i B_i - attractive potentials of the origin country B_j - attractive potentials of all destination nodes A_i - repulsive potentials of origin country A_j - repulsive potentials of all destination countries (A more thorough explanation is provided in the further text.)
3	Wittman and Swelbar (2013), Airline connectivity quality index (ACQI)	$ACQI_a = \sum_{h \in H} f_{a,h} d_{a,h} w_h + \alpha \sum_{h \in H} d'_{a,h'} w_{h'}$	$f_{a,h}$ - average number of daily scheduled flights per destination from airport a to airport type h, $d_{a,h}$ - the number of nonstop destinations of type h served from airport a, $d'_{a,h'}$ - the number of online or codeshare connecting destinations of type h served from airport a, w_h - a weighting factor based on the quality of airport type h, α - a scaling factor that weights the importance of nonstop destinations vs. one-stop destinations. Airports served via both nonstop and connecting service are counted as nonstop destinations only. Weights for the quality of airport type are: Large Hub 1.0, Medium Hub 0.21, Small Hub 0.05, Non-Hub/Essential Air Service 0.01 and International 1.0.
	Maritime transport		
4	Hoffman (2005) Liner shipping connectivity index (LSCI)	$LSCI_n^{yyyy} = \frac{\frac{\sum_{i=1}^{5} \frac{C_i^{yyyy}}{C_i^{max2004}}}{5}}{\max_n \sum_{i=1}^{5} \frac{C_i^{2004}}{C_i^{max2004}}} \cdot 100, \forall n$	C_i- the five index components: 1) deployment of container ships on the liner services from and to country's ports (number of) 2) deployment of container carrying capacity in TEU (of the ships in 1) 3) maximum vessel size (TEU) 4) the number of services 5) the number of companies that deploy container ships on services from and to a country's ports. $C_i^{max2004}$- maximum value of ith component in 2004 C_i^{2004} - value of ith component in 2004 n - countries, excluding landlocked
5	Bartholdi et al (2014) Container Port Connectivity Index (CPCI)	Same as in (6), extended by HITS algorithm.	For each pair of ports LSCI is calculated in the similar manner, only C_i calculated for the route port-port. LSCI becomes the weight for the link per each node and the Web search HITS algorithm is further used to determine hubs and authorities in terms of inbound and outbound value of weighted links. The equations for HITS algorithm are not presented for its extensiveness (see Kleinberg 1999 for exact calculation).

The Aviation connectivity index by Smyth and Pearce was the first attempt to provide a systematic ranking of countries in the global airline network, on a sample of 47 countries. It was published in International Air Transport Association briefing from July 2007 as a connectivity indicator for the sampled countries for the year 2005. The index is based on the number of available flights and seat capacities to each destination airport from the observed country's airport. The data for the calculation are taken for the first week of July, in each year between 1996 and 2005. The product of the two components of the index, flights capacities and frequencies, are further multiplied by the weighting factor, which represents the throughput of the destination airport normalized by the throughput of the largest airport in the network. All products of the three components are summed for all destinations, and finally divided by a scalar factor of 1000. In short, the aviation connectivity index gives a highest rank to the origin countries whose airports have frequent, large-capacity connections to the destination countries' airports having highest yearly passenger enplanement levels. Smyth and Pearce dedicate a large part of their publication to finding the statistically significant and positive relationships between several variables - labour productivity, capital investments, R&D, education expenditure - and connectivity. In this sense we outline the underlying purpose of the majority of the developed indicators of connectivity in the literature, and that is correlating the connectivity with other variables, particularly those relating to economics.

Arvis and Shepperd (2011) develop the Air connectivity index, as an extension to the Aviation connectivity index, offering ``a more systematic model with a larger sample of countries (over 200)''. ACI is developed as an analytical tool for policy makers and researchers working on trade integration. The connectivity is presumed to be a determinant of country competitiveness and the improvements in connectivity is presumed to reduce international trade transaction costs. The methodology of ACI is based on the gravity model, where each origin-destination interaction is proportional to the size or potential of the two nodes, and inversely proportional to the cost of movement between them. In the empirical implementation of their model, the proxy for potentials is outflows and inflows, and the cost is expressed in a (shifted logarithmic) function of distance. However authors leave open the possibility of using economic variables such as GDP or population for potentials, and approximating costs other variables such as time, or any other quantifiable variable representing the disutility of movement between the two interacting nodes. The empirical implementation is based on the data for the month of June 2007, including both cargo and passenger direct flights per week among the sample of over 200 countries. Arvis and Shepperd test their index for statistical significance in correlation with air liberalization and trade. They find significant correlations especially with the segment of trade in parts and components.

Wittman and Swelbar (2013) develop the latest measure of connectivity in air transport, the Air connectivity quality index, as the only standard metric to measure an airport connectivity. The model is tested on the 462 US airports, based on the data for the period from 2007 to 2012, where the index is calculated separately for each year. Their study is focused at developing a new ``intuitive metric'' for connectivity, without attempts to find correlations with economic indicators. Authors are primarily interested in the connectivity changes with regards to the different airport types. Airports are sorted at different hub levels, based on the level of enplanement in the previous year: large hub, medium hub, small hub, non-hub (Essencial Air Service), and international hubs. This typology is based on the classification of Federal Aviation Association (FAA) of the United States. Authors estimate that the typology can serve as a proxy for the economic, social cultural and political importance of each destination, and the different types underlie different weights for each of the destination airports. The index is generally based on two characteristics: the quality of non-stop services to different destinations, and the quality of codeshare services to different destinations. The quality of non-stop services is represented by the average number of daily scheduled flights and the number of different non-stop destinations, while the quality of codeshare services is represented by the number of different codeshare destinations. An arbitrary scaling (reducing) factor is applied only at the side of codeshare services, and it is based on the different suggestions coming from the airline literature on the value of the codeshare itineraries compared to non-stop itineraries.

In maritime transport, the connectivity indices have not been a frequent topic of research for years. The Liner shipping connectivity index (LSCI) developed by the United Nation Conference on Trade and Development in 2005 (Hoffmann, 2005), has for almost a decade been the only index of connectivity, measuring connectivity of countries as nodes in the worldwide container network. The two additional attempts to develop a new index of connectivity of ports emerged during writing this review paper.

LSCI is a well-established index, published by UNCTAD and the World Bank each year from it starting year of 2004. It is developed to measure countries' competitiveness in terms of access to regular and frequent liner services. The authors suggest that the index could be used to identify the causalities between transport costs, trade and connectivity. The index also provides insights to policy makers on where to promote cheaper transport services, to facilitate trade. LSCI is constituted of five components: the number of ships that national and international liner shipping companies deploy on the liner services from and to the country’s ports, deployment of container carrying capacity (number of slots for 20 foot equivalent units (TEU)) of the ships used in these services, maximum vessel size that calls a country's port (TEU), the number of different services provided by the shipping lines and the number of liner companies providing services to the country's ports. All of the components are calculated on a yearly basis, and each of the components is normalized by the value of the highest component in 2004. The obtained values are then averaged and once again normalized by the maximum average for 2004 and multiplied by 100. The methodology of LSCI is different from other connectivity indices because it does not observe each node-to-node connection, but calculates the data locally, only at the observed node.

A recent study producing another maritime connectivity index has been pursued by Bartholdi et al, resulting in a paper submitted for publication, in 2014. Their Container port connectivity index (CPCI) is based on the same components as the LSCI but the components' data is collected per each port to port link. After establishing the LSCI value per each link, a web search algorithm (HITS) is applied to quantify inbound and outbound connectivity of each port. HITS algorithm (Kleinberg, 1999) assigns a higher authority value (inbound connectivity) when the port's inbound links come from ports with high hub values. At the same time a higher hub value (outbound connectivity) occurs if the port's outbound links are directed to ports with higher authority values. In this way the two values should reflect how well the port stands in terms of imports and exports, or in other words they represent port's trade connectivity. The index is tested using the data on the scheduled container shipping services in September 2011.

Besides the described port/country connectivity indices in air and maritime transport network, there are several other measures that emerged in the transport literature as part of case studies, labelled as connectivity indices. For instance Mishra et al (2012), extending the work of Park and Kang (2011), developed an index of connectivity of transit nodes in public transportation. The components of the index include average vehicle (train or bus) capacities, frequencies, daily hours of operation, speed and distance on each of the lines passing through the stations. The index assesses the quality of train or bus stops as passenger transit nodes. In air transport literature, Kim and Park (2012), adding to the work of Veldhuis (1997), formulate an airfreight connectivity index based on the frequencies and time differences between arrival and departure flights. In maritime transport, Tang et al (2011) and Low et al (2009) extend the graph theoretical measure of degree centrality, defining the container port connectivity index as a fraction of the number of origin-destination pairs served by the evaluated port to the total number of port pairs.

Based on the summary of indicators, we may draw a couple of conclusions. All of the indicators deal with regular, scheduled services. The regularity of services is highest in airline industry, where flight schedules are arranged months in advance and strictly followed, without allowing for much delay or rerouting. Regularity is also characteristic for the container segment, to which pertain all of the developed maritime connectivity indices. Schedules of shipping lines are published at their websites.

There are indications that the connectivity focus is moving from countries to a smaller unit of analysis, that is, ports. It is more appropriate to observe networks as they naturally exist, as sets of interlinked ports. For example, LSCI does not at all include the landlocked countries, and yet some landlocked countries are high users of ports for the realization of trade (e.g. Austria in de Langen, 2007). This trend is followed by the different index methodologies. The ambition is to include as much of the interaction between all the nodes in the network. For example, LSCI incorporates local data on ships, their sizes and the number of services that passed through the country's ports within a year, and it does not include separate country-to-country interactions. On the other hand its successor, the CPCI includes each node-to-node connection, and by using a different methodology authors try to incorporate indirect connectivity (connectivity between neighbours of neighbours and further). In the same manner, ACI builds on AC, to better reflect the hub and spoke airline network structure.

Considering the different components and methodologies of the described indicators and considering the limitations with regards to current unavailability of container shipping data (see following chapter), in the following part we propose a feasible method of calculating maritime container connectivity.

The maritime container connectivity indicator is designed with the same rationale as the RoRo connectivity indicator (as presented in part 2.1.). Again there are two parts of the indicator: range and abundance. However in this case the time-range as in the example of RoRo connectivity is expanded with the component of total vessels available capacity (number slots for TEU) per each route. All the route values are then summed up for the origin port.

The calculation method for the (volume) time-range is presented in the following equation.

Equation 7

$$R_i = \sum_j \frac{F_{ij} \cdot D_{ij}}{TT_{ij}} \cdot C_{ij}$$

where

R_i - volume time range of the evaluated port i

F_{ij} - number of weekly departures from port i to port j

D_{ij} - maritime distance in nm from port i to port j

TT_{ij} - travel time along the route from port i to port j

C_{ij} - total vessels available capacity (number slots for TEU) travelling the route from port i to port j

All further steps (calculation of abundance, normalization against the maximum values in starting year, geometrical average calculation and summing up all the values to obtain one value at the European level), are calculated in the same way as in RoRo connectivity indicator:

Equation 1

$$ICC_i = \sqrt{R_i^N \cdot A_i^N}$$

Equation 8

$$ICC^{E} = \sum_{i=1}^{n} ICC_{i}$$

2.2.2 PROBLEMS REGARDING DATA COLLECTION

The collection of empirical data for calculating maritime connectivity has proven to be problematic. There are two potential methods to calculate connectivity:

1. Based on the services as provided by the shipping lines
2. Based on the actual ship movements of container vessels

Within the first approach, two data collection methods have been explored. First, the first-hand data collection by the research partners (in this case TU/e). However, various complexities make this impossible:

- The number of services is too large to collect all data manually from websites
- Various shipping lines offer slots on services that are not operated by them, leading to duplications.
- Some carriers have insufficient quality of data publicly available.

Second, a partnership has been sought with a specialised company that has these data. We managed to reach an agreement with Linescape, however, data tests show that they do not have a sufficiently large and representative coverage of all liner services. We approached all other companies that collect data (Sea-Intel, Journal of Commerce, and American Shipper) but did not manage to reach an agreement given the insufficient value that could be offered to them (no budget to purchase the data). See appendix 3 for the letters we have send after initial phone contact. Overall, the approach of getting published data on schedules has not led to a result. We can use existing data providers but in that case would not be able to track the exact transit times between two ports and have to make some other limitations to make data collection feasible.

The second potential approach is to look at actual ship movements of container vessels. This is more complex as it involves more data (at the level of individual ships) but has as advantage that not the promised but the actual call patterns are collected. These two differ in case of a by-pass of a port because of strikes, bad weather, delays in previous ports and similar reasons. However, first hand data collection is not possible so we would have to work with data providers, with the limitation that we a request without budget for buying the data. We have initiated contacts with a European company Marine Traffic that has relevant data. However these contacts revealed that there are too many missing variables, and the number of observations is too large to allow straightforward tracing connectivity on the basis of the Marine Traffic data. While this may be an option for the future, this currently (Q4 2015) is not an option. Another potential data provider is Alphaliner. We have established contacts, getting to a deal would be the first best option. In short the next steps are:

1. First best: aim for a partnership with Alphaliner.
2. Second best: develop calculations for a more limited set of ports based on available data.

The pros and cons of both options will be analysed in the coming months, and a decision on how to pursue this further will be made.

2.2.3 THE LINK BETWEEN MARITIME CONNECTIVITY DATA AND POLICY OBJECTIVES

The indicator allows us to have a consistent record on the network constitution, dependent on the interval we choose for data collection. Supporting the indicator ranking with maps and graph presentations, we are able to spot the fragmentation of the total network to clusters. In this way the decision makers have an insight into the possible existing links that could be fortified, or missing links that could be established in the system.

The optimal period for data extraction would be each quarter end, in order to be able to monitor the fluctuations throughout a year. We expect that, after the indicator is incorporated into performance dashboard of each port, there would be a higher willingness of ports and stakeholders to share data.

2.2.4 BENCHMARKING OPPORTUNITIES

Depending on the data collection method that is feasible, we will in any case collect data for the EU core ports on connections with a set of leading international ports. Therefore, once data collection has been secured, benchmarks between ports as well as over time are feasible.

2.2.5 THE LINK BETWEEN MARITIME CONNECTIVITY AND OTHER PORT PERFORMANCE INDICATORS

The links with the following other port performance indicators is relevant:

- Container volumes of the ports. It is not by definition the case that the port with the highest volumes also has the highest connectivity (Bartholdi et al, 2014). Thus, empirical analysis is relevant.
- Intermodal connectivity. As ports are not 'end destinations' most port users would ideally be interested in the connectivity of a nearby inland terminal, via ports. Combining maritime connectivity data with inland port connectivity data allows this.
- Terminal handling charges (see later). Rich data on both would allow for understanding the effect of THC in/decreases on connectivity of a port.

2.3 An intermodal connectivity indicator

For the intermodal connectivity indicator, the method was presented in D.4.1. The data collection effort is currently (Q1 2015) under way. The PORTOPIA cloud service is used to ask ports to provide their connectivity data for 2014. This will enable an analysis of the evolution of intermodal connectivity. The results will be communicated as soon as they are ready through the PORTOPIA website and communicated at the relevant ESPO committees.

3 COST INDICATORS

One of the complicated challenges in this work package is to develop indicators on costs of ports. The principal challenge is that cost / price data are confidential and generally not released. Furthermore, even if they are released, they cannot be validated. No academic or other study on ports has managed to collect reliable and verifiable cost data. Thus, our approach has been to focus on publicly available data on port costs. However, this implies no overall cost data are analysed.

3.1 Monetary vs. non-monetary costs

First, it is relevant to mention that the cost indicators only deal with monetary costs. However, these are not the only relevant costs for cargo owners. Indirect cost components include:

- Time costs of the goods (opportunity costs linked to the capital tied up in the transported goods and costs linked to the economic or technical depreciation of the goods);
- Inventory costs linked to the holding of safety stocks;
- Costs caused by damage and delays that may occur in ports. Such costs have been estimated in the case of strikes, but not with a method that can be replicated structurally.

- Transaction costs, including costs of searching services providers, developing contracts with these service providers, costs of monitoring the service provider and the costs of exchanging the relevant information for the transaction.

Even though there are no sound empirical investigations of the relative importance of all these parts of the overall generalized port costs, some indications suggest non-monetary costs are significant:

- Time costs are high as demonstrated by revealed preferences, for instance on the use of road vs. slower barge transport, or air vs. maritime transport.
- Transaction costs are high as demonstrated by the significant (joint) investments in port community systems.
- Damage costs are significant as indicated by the substantial insurance costs for transport.

These points are relevant for the interpretation of cost data: out-of-pocket costs in ports alone do not explain why cargoes are routed through different ports.

3.2 Port costs vs. door-to-door costs

Second, it is relevant at the start to highlight that port costs are only one element in the total door-to-door costs. The 'user' of a transport chain, in most cases the exporter or importer, is not interested in the prices of different parts of a transport chain, but only in minimising the costs of the total transport chain. The port is in many cases not the most important component of the total transport costs. The relative importance of port costs as a percentage of total transport costs differs for different commodities. As one example: the transport of one 20-feet container from Singapore to the Ruhr district. The total transportation costs of one container are about 1,000 Euro, including all port costs. This total is based on:

The port costs (apart from handling charges)	25 Euro
Loading and discharging in the port:	150 Euro
Hinterland transportation using a truck:	325 Euro
Sea transport between Singapore and Rotterdam/Antwerp/Hamburg	500 Euro

Only 175 Euro of the 1,000 are related to the port. Thus, if the port fits well in the transportation system, shippers are willing to pay the higher prices. Again, this is an important disclaimer for the relevance of cost data. Unless one understands the whole value creating process, cost data cannot be easily interpreted. Costs are a price for a service, and when the service is better, higher costs can be justified. As one example, Singapore's costs are significantly higher than those of regional competitors, but Singapore remains the largest hub of the region; quality aspects thus must enable higher costs.

3.3 Components of port costs

Next, the costs that ultimately are relevant for cargo owners consist of various components:

1. Harbour dues, paid by the shipping line to the port authority

2. Towage, paid by the shipping line to the service provider
3. Pilotage, paid by the shipping line to the service provider
4. Mooring/unmooring, paid by the shipping line to the service provider
5. Terminal handling costs, paid by the shipping line or cargo owner to the service provider.

The relative weights of these five components differ between ports, but generally:

1. The terminal handling costs are the most important component, ranging from around €15-20 per ton for containers & break bulk to €3-5 per ton for bulk cargoes.
2. Of the other costs, port dues are generally the highest ones, while mooring costs are generally very low. Pilotage and towage costs depend on regulation as well as geographical / climatological conditions.

Table 9 shows the indicators for which publicly available has been collected, and a justification of this selection.

Table 9: Indicators for which publicly available data was collected

Component of port costs	**Data collection & argumentation**
Port dues	Average port dues per ton are collected (see details later on).
Towage	No data collection; Tariffs are generally privately negotiated and not publicly available.
Pilotage	No data collection; Pilotage costs are generally publicly available[4], but often complex, subject to exemptions and hard to compare for vessels that are representative in all European (core ports).
Mooring	No data collection; Tariffs are generally privately negotiated and not publicly available. Furthermore. Costs are a very small component for overall costs
Terminal handling costs	Collected for the only segment where they are publicly available: containers (see details below).

In addition to the above table. For pilotage it is important to mention that pilotage is not in all ports considered as a service that is provided by a commercially operating entity. In many ports government owned organisations provide pilotage services, and often not on a transparent cost recovery basis. Furthermore, it is important to note that pilotage exemptions may be as important for port users as pilotage costs. The exemptions cannot be meaningfully expressed in terms of port costs. Finally, it is important to note the huge regulatory influence on the pilotage services. Monitoring pilotage costs is for these reasons not deemed a priority.

3.4 Port dues

[44] See PwC (2013) Study on Pilotage Exemption Certificates, Final Report, available at http://ec.europa.eu/transport/modes/maritime/studies/doc/2012-09-18-pec.pdf

The port dues charged by the port authority are a relevant component of the total 'out-of-pocket' port costs. Port dues are publicly available in most ports. These dues generally vary based on the size and type of ships and the cargo it carries. There are two potential methods to collect data on port dues:

1. Collecting and analysing the published port dues.
2. Collecting the revenues from port dues as reported in annual reports.

We have opted for option 2, for the following reasons:

- Structures of port dues vary with ship size. Thus, they can only be collected for 'idealtype' ships. However, such ideal types differ per port. While for Hamburg a deep sea container vessel may be relevant, for Dover a large RoRo vessel is, and for Amsterdam a bulk vessel is. The only way to proceed would be to develop a complex 'basket' of ships and identify which one is relevant in which port. This is very laborious and will require arbitrary choices.
- Many port authorities have the freedom to give reductions to give rebates on port dues, either transparently or confidentially. Thus, there is a difference between the dues on paper and the dues that are actually collected. For this reason, the 'official tariffs' reveal only part of the reality.
- The central aim of the indicator is to be able to trace the evolution of port dues over time. This is very hard based on official tariffs, as tariff structures change and cannot be translated in a straightforward way into price increases (or decreases).
- For a port user, it is not the port dues per ship that ultimately matter, but the port dues per ton. These will change also because of the composition of the fleet that is calling a port is changing. Such changes are not captured in published tariffs per ship.

Option 2 is much more simple, as it only involves tracing the port dues as reported in the annual accounts. These are related to the total throughput volumes of a port, resulting in an indicator *'port dues per ton'.* This indicator has a clear intuitive logic, and allows for monitoring the evolution of port dues over time. However, this indicator also has some shortcomings that must be acknowledged:

- Not all ports publish revenues from port dues, so the indicator will have to be based on a sample of ports.
- The underlying commodity structure is changing, which influences port dues per ton. However, from a helicopter view, this is not truly a shortcoming. On the assumption that port dues are charges for the services of a port authority, the evolution of the port dues per ton informs about the extend to which port authorities assist in reducing real transport costs (with 'real' in the sense of corrected for inflation).
- Port authorities also charge port dues for passenger vessels. Therefore, the port dues per ton may not be relevant for all ports.

Notwithstanding these disadvantages, this approach allows for an overall view on the evolution of port dues in Europe's port system.

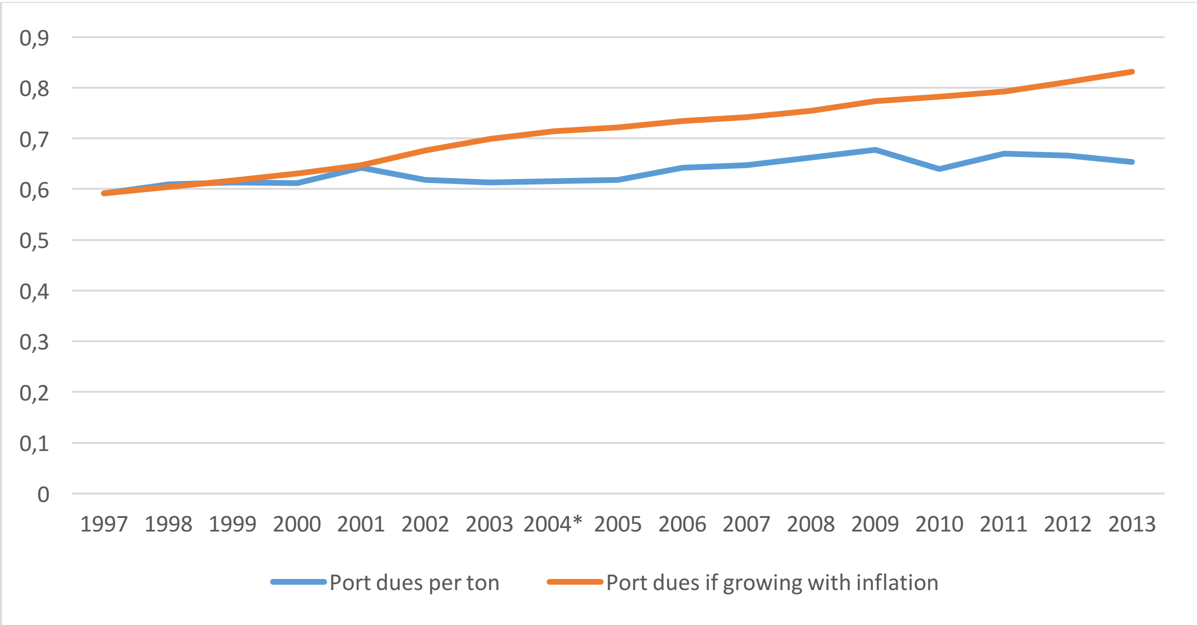
3.4.1 Calculation method

For the ports that report revenues from port dues as well as total tons throughput, both the revenues and the throughput is aggregated. Next, the ratio is calculated. The only methodological issue is that these figures can only be compared year-to year if:

- an index is used or;
- in the case the sample of ports is kept constant (and continues to publish the required data). In this case, absolute values can be used.

Which of these options is more attractive is to be decided next year, when new data have been collected. In the case of absolute data are used, the sample could be renewed say once every five years and an index could be used that allows for tracing the historic evolution. As an example, we show the port dues per ton for the port of Rotterdam, which already for a long period of time publishes these figures in an annual report. The figure also shows a fictitious line showing the evolution had the port dues grown each year with inflation.

Figure 3: Real development of port dues per ton vs. port dues per ton assuming growth with inflation; case Rotterdam



This example shows roughly constant port dues per ton from 2002-2013, while there was inflation in this period. This means that the 'real port dues' in Rotterdam have declined; positive for port users.

Within a couple of years, PORTOPIA will be able to provide a similar analysis for the EU port system as a whole, and potentially also for port ranges. However, this analysis will be based on a sample of ports, as not all ports have publicly available revenues from port dues.

Table 10 provides an overview of the data collected for 2014.

Table 10: Number and volume handled by ports with publicly available port dues per ton.

Result	Number of ports	Total volume of ports in these categories
Annual report has not been found	32	No estimate
Annual report provides revenues from port dues	29	About 1.5 billion ton
Annual report does not provide revenues from port dues	34	About 1 billion ton

This table shows that revenues from port dues are available for about one third of all EU core ports. The total volume of these ports represents more than 40% of the total throughput of the EU core ports. Thus, this sample is sufficiently large to be able to show a trend concerning the development of port dues per ton in the EU port system. Thus, once data for 2014 are available (probably only Q3 or Q4 of 2015), the data can be compared and turned into an index.

The average port dues per ton for the ports in the sample in 2013 was €0.98 per ton. Note that the trend for the coming years is more important than the absolute number, given the concerns raised above.

Given the sensitivity of the data, the underlying data per port, although they are publicly available, are not provided in this report. The main reason is that the revenues from port dues have not been verified by the port authorities, and some port authorities may include charges that are not included in other ports. Thus an ongoing conversation is required with the ports to further develop this indicator.

3.5 Terminal handling charges

Terminal Handling Charges (THCs) are important components of the cost of transporting containerized cargo. THCs are defined by shipping lines as ancillary charges and represent the additional increase in costs that are associated with the operation of moving containers (loading and discharging of containers).

Terminal handling charges (THC) are essentially charges collected by shipping lines to recover from the shippers the cost of paying the container terminals for the loading or unloading of the containers, and other related costs borne by the shipping lines at the port of shipment or destination[5]. The practice of charging THC is common worldwide.

THCs were introduced to increase the transparency of shipping charges, and to protect the shipping lines from the fluctuation of currencies, since terminal handling costs charged by terminal operators are usually paid in local currencies, while freight rates are calculated in US dollars.

[5] For containers shipped on FOB (Free-On-Board) terms the shippers are responsible for paying the THC in the origin port, while the buyers (consignees) are responsible for paying the freight rate and the THC of the port of destination.

Prior to 18th October 2008 the level of terminal handling charges varied across the different trade routes within individual ports. However, they were consistent across individual members of Liner Conferences.[6]

A Liner Conference can be defined as "a group of two or more vessel operating carriers which provide international liner services for the carriage of cargo on a particular route or routes within specific geographical limits and which has an agreement or arrangement within the framework of which they operate under uniform or common freight rates and any other agreed conditions with respect to the provisions of the liner services"[7].

However, by treaty of the European Commission Liner Conferences are abolished since 18th October 2008. In response to the abolition of the conferences, carriers introduced new THCs across most of their terminals. The major factors of change were:

1. The abolition of trade route related THCs
2. THCs more closely aligned with costs
3. For some carriers, the introduction of "country" THCs as a means of simplification
4. Publication of charges on carriers' websites by a significant number of carriers.[8]

As a result, THCs now vary between ports and carriers and can thus be used as an indicator for port related supply chain costs.

Methodology

The analysis of the feasibility of the indicator has been carried out by comparing the THCs of the 98 TEN-T Core Ports, where publically available THCs were available. We collected THCs based on data from the 20 largest container liner carries in 2013.[9] This selection of carriers is representative for the whole industry because they form around 90 percent of the world liner fleet in TEU. However, due to the fact that THCs were not publically available for each of the carries the number of analyzed carriers was reduced to 17.

Table 11 illustrates the list of analyzed carriers and the number of ports for which THCs were publically available (from the 98 TEN-T Core Ports) in 2013 as well as 2015.

Table 11: Overview of analyzed carriers and the number of ports with publically available THCs in 2013 and 2015[10]

Carrier	Number of ports called	Change

[6] http://ec.europa.eu/competition/sectors/transport/reports/terminal_handling_charges.pdf, p. 14.
[7] http://www.jus.uio.no/english/services/library/treaties/08/8-03/code-conduct.xml
[8] http://ec.europa.eu/competition/sectors/transport/repor31ts/terminal_handling_charges.pdf, p. 19.
[9] http://www.alphaliner.com/top100/.
[10] Fraunhofer CML (2015).

		2013	2015	
1.	APM Maersk	64	38	26
2.	Mediterranean Shg Co	24	15	-9
3.	CMA CGM Group	73	69	-4
4.	Evergreen Line	55	46	-9
5.	COSCO Container L.	17	22	+5
6.	Hapag Lloyd	56	65	+9
7.	APL	83	79	-4
8.	Hanjin Shipping	71	71	0
9.	CSCL	50	25	-25
10.	MOL	84	69	-15
11.	OOCL	27	27	0
12.	NYK Line	81	78	-3
13.	Hamburg Süd Group	34	34	0
14.	Yang Ming Marine Transport Corp.	51	No data available	-
15.	K Line	83	83	0
16.	UASC	25	No data available	-
17.	CSAV Group	31	Merger with Hapag Lloyd	-

As can be taken from the above table, THCs were not available for all container liner carries in 2013 and in 2015. This is due to the fact that carriers e.g. merged or made the access to the THCs subject to a charge (i.e. the data are no longer publicly available).

The variation in the number of ports called results from the carriers' different shipping routes. Due to the fact that different carriers call different ports THCs could be found for all ports but one in 2013 (Valetta) and two in 2015 (Valetta and Marsaxlokk).

Further, 2013 THCs were compared to 2009 THCs and the development between 2013 and 2015 was observed. Research was in most cases done on the basis of information given on the carriers' websites (e.g. website of Hamburg Süd[11]).

3.5.1 Results:

In a first step, the average THCs per port were calculated across all carriers and the results were ranked according to the average THCs in 2013.

Table 12 gives an overview over the results of this calculation:

[11] Hamburg Süd THC Kalkulator.

Table 12: Ranking of Ports according to their average THCs in EUR in 2013[12]

Rank	Country	Core Port	Average THCs		Number of Carriers	
			2013	2015	2013	2015
1	DE	Bremen	272	280	12	7
2	DE	Lübeck	271	282	10	6
3	DE	Rostock	271	282	10	6
4	DE	Wilhelmshaven	271	282	10	6
5	DE	Bremerhaven	269	275	16	13
6	DE	Hamburg	268	277	17	13
7	FR	Calais	231	242	8	7
8	FR	Nantes - St Nazaire	231	242	8	7
9	FR	Rouen	229	239	9	8
10	FR	Dunkerque	229	238	9	8
11	FR	Le Havre	228	236	15	12
12	FR	Marseille	227	240	10	8
13	ES	Barcelona	225	213	10	9
14	ES	La Coruna	225	206	6	4
15	ES	Cartagena	225	206	6	4
16	ES	Gijon	225	196	7	5
17	ES	Huelva	225	206	6	4
18	ES	Palma de Mallorca	225	206	6	4
19	ES	Sevilla	225	206	6	4
20	NL	Rotterdam	225	237	16	13
21	ES	Valencia	224	212	10	9
22	FR	Bordeaux	224	240	8	7
23	ES	Algeciras	222	207	8	7
24	ES	Tenerife	222	209	8	5
25	ES	Tarragona	222	205	7	6
26	ES	Las Palmas	220	208	9	6
27	NL	Amsterdam	219	236	11	10
28	ES	Bilbao	218	199	10	8
29	NL	Moerdijk	215	235	10	8
30	NL	Vlissingen + Terneuzen	215	235	10	8
31	IT	Cagliari	205	208	11	10
32	IT	Gioia Tauro	205	207	12	9
33	IT	Taranto	204	208	9	8
34	IT	Augusta	204	208	8	7
35	IT	Ancona	204	207	10	8
36	IT	Napoli	204	207	10	8
37	IT	Palermo	204	207	10	8
38	IT	Ravenna	204	207	10	8
39	IT	Trieste	204	207	10	8
40	BE	Antwerp	204	214	17	14
41	IT	Bari	204	207	9	7
42	IT	Genoa	204	206	15	11
43	IT	Livorno	203	206	12	10
44	IT	Venezia	202	204	11	9
45	IT	La Spezia	202	205	12	9
46	BE	Zeebrugge	199	215	13	11

[12] Fraunhofer CML (2015).

47	BE	Ghent	195	213	11	10
48	BE	Oostende	195	213	11	10
49	SI	Koper	185	189	6	3
50	PT	Leixoes	184	195	13	10
51	PT	Lisbon	183	195	12	9
52	PT	Sines	182	187	11	7
53	UK	Belfast	179	199	14	11
54	UK	Glasgow	178	200	11	10
55	UK	Southampton	178	199	14	13
56	UK	London Gateway Tilbury	178	199	11	10
57	UK	Edinburgh	177	199	12	11
58	UK	Teesport	177	198	13	12
59	UK	Cardiff-Newport	176	199	10	9
60	UK	Dover	176	199	10	9
61	UK	Harwich	176	199	10	9
62	UK	Milford Haven	176	199	10	9
63	UK	Bristol	176	198	11	10
64	UK	Liverpool	176	198	14	12
65	UK	Grimsby / Immingham	176	198	11	10
66	UK	Felixtowe	175	198	14	12
67	PL	Gdansk	172	161	3	3
68	PL	Sczecin, Swinoujscie	172	158	3	2
69	SE	Goteborg	161	157	14	11
70	IE	Dublin	159	168	13	8
71	DK	Copenhagen	158	155	14	10
72	DK	Aarhus	158	155	14	10
73	PL	Gdynia	156	148	4	4
74	IE	Cork	154	168	12	8
75	SE	Malmo	154	152	11	8
76	SE	Lulea	151	153	7	6
77	SE	Trelleborg	151	153	7	6
78	IE	Limerick	150	164	7	4
79	SE	Stockholm	150	150	11	9
80	LV	Riga	143	136	10	8
81	FI	Kotka-Hamina	141	159	13	9
82	FI	Helsinki	138	155	12	8
83	LT	Klaipeda	137	128	10	8
84	LV	Ventspils	134	141	5	4
85	GR	Pireaus	133	64	3	2
86	EE	Tallin	132	144	10	6
87	FI	Turku naantali	127	149	10	6
88	RO	Constantza	118	91	3	3
89	CY	Lemesos	118	112	3	3
90	GR	Thessaloniki	116	42	2	1
91	RO	Galati	98	91	2	3
	MT	Marsaxlokk	260	-	1	0
	BG	Burgas	152	200	1	2
	HR	Reijka	128	164	1	3
	GR	Igoumetsina	42	42	1	1
	GR	Iraklion	42	42	1	1
	GR	Patras	42	42	1	1
	MT	Valetta	-	-	0	0

As can be taken from the above table, the ranking has only been carried out for 91 ports. This is due to the fact that seven of the ports are only called by one or less carriers which made it impossible to validate the identified THCs by comparing them to at least one alternative value for the THCs in a port. Note that the remaining seven ports handle a very small percentage of the total EU container handling.

THCs of the analyzed ports vary between 98 EUR in the Port of Galati and 272 EUR in the Port of Bremen. Further, THCs are very comparable for ports of the same country. This is especially true for Germany, France, Spain, Italy, Portugal and Great Britain.

Table 13 summarizes the country level of THCs in 2013 as well as 2015 in a country ranking. Malta, Bulgaria and Croatia are not included into the ranking because of the reasons explained above.

Table 13: Country level of THCs in EUR in 2013 and 2015[13]

Rank	Country	Average THCs		Variance (Min – Max)			
		2013	2015	2013		2015	
1	Germany	270	280	-1%	1%	-2%	1%
2	France	228	240	-2%	1%	-2%	1%
3	Spain	223	206	-2%	1%	-5%	3%
4	Netherlands	218	236	-1%	3%	0%	0%
5	Italy	204	207	-1%	0%	-1%	1%
6	Belgium	198	214	-2%	3%	0%	0%
7	Slovenia	185	189	0%	0%	0%	0%
8	Portugal	183	192	-1%	1%	-3%	2%
9	UK	177	199	-1%	1%	0%	1%
10	Poland	167	155	-7%	3%	-5%	3%
11	Denmark	158	155	0%	0%	0%	0%
12	Ireland	154	166	-3%	3%	-2%	1%
13	Sweden	153	153	-2%	5%	-2%	3%
14	Latvia	138	138	-3%	4%	-2%	2%
15	Lithuania	137	128	0%	0%	0%	0%
16	Finland	135	154	-6%	4%	-4%	3%
17	Estonia	132	144	0%	0%	0%	0%
18	Cyprus	118	112	0%	0%	0%	0%
19	Romania	108	91	-9%	9%	0%	0%
	Malta	260	-	0%	0%	-	-
	Bulgaria	152	200	0%	0%	0%	0%
	Croatia	128	164	0%	0%	0%	0%
	Greece	75	-	-	-	-	-

As shown in the above table the highest average THCs can be found in Germany, which amount to 270 EUR in 2013. With reference to the ports' individual THCs, the THCs in Germany vary by -/+ 1 percent between 268 EUR in Hamburg and the already mentioned 272 EUR in Bremen. Also in 2015 German

[13] Fraunhofer CML (2015).

ports have the highest average THCs. A similar observation can be made for the majority of the analyzed port regions. The average variation is between -4 percent to +5 percent in 2013. In 2015 the average variance is reduced to -/+ 1 percent. Greece is also highlighted in red because of low degree of data availability for Greek ports.

The differences in (country) THCs result from the costs of terminal operations. These costs are influenced by a number of different factors, including:

- Handling technology and productivity.
- Labor costs and labour productivity.
- Cost of lease fees to the port authority.
- Energy costs (container terminals are substantial energy users).
- Other drivers of terminal cost e.g. regulations regarding safety, security, noise and others.

THCs for types of containers

In a third step the THCs for different types of containers were analyzed. This analysis comprised the following types of containers: Dry containers, reefer containers, import containers and export containers. A distinction between 20-foot- or 40-foot-containers was not necessary, because their THCs are the same. The results of this analysis can be taken from Table 14.

Table 14: Comparison of different types of containers' THCs in EUR in 2013[14]

Country	Import		Export		Average	Difference Import - Export		Difference Dry - Reefer	
	Dry	Reefer	Dry	Reefer		Dry	Reefer	Import	Export
Germany	217	323	217	324	270	0%	0%	49%	49%
France	191	266	191	266	228	0%	0%	39%	39%
Spain	185	261	185	262	223	0%	0%	41%	41%
Netherlands	188	249	189	248	218	0%	0%	32%	31%
Italy	168	237	171	239	204	2%	1%	41%	40%
Belgium	164	232	164	232	198	0%	0%	41%	41%
Slovenia	142	229	141	229	185	-1%	0%	61%	63%
Portugal	153	207	153	221	183	0%	6%	36%	45%
UK	145	209	145	209	177	0%	0%	44%	44%
Poland	122	211	122	211	167	0%	0%	73%	73%
Denmark	127	190	127	190	158	0%	0%	50%	50%
Ireland	121	187	123	187	154	1%	0%	54%	52%
Sweden	137	169	137	172	153	0%	2%	23%	25%
Latvia	118	158	118	158	138	0%	0%	34%	34%
Lithuania	110	163	110	163	137	0%	0%	47%	47%
Finland	109	166	99	166	135	-9%	0%	52%	67%
Estonia	104	152	120	152	132	16%	0%	47%	27%
Cyprus	105	130	105	130	118	0%	0%	24%	24%
Romania	97	140	97	140	108	0%	0%	44%	44%
Malta	-	-	290	230	260	-	-	-	-21%

[14] Fraunhofer CML (2015).

Bulgaria	152	-	152	-	152	0%	-	-	-
Croatia	128	-	128	-	128	0%	-	-	-
Greece	73	198	47	-	75	-36%	-	169%	-

As shown in the above table in almost all countries the THCs for import and export containers are the same. This is true for dry containers as well as reefer containers. Further, the THCs of reefer containers are in all ports (except for the ports highlighted in red) significantly higher than the THCs of dry containers. The below table compares different types of containers' THCs in Euro for the year 2015:

Table 15: Comparison of different types of containers' THCs in EUR in 2015[15]

Country	Import		Export		Average	Difference Import - Export		Difference Dry - Reefer	
	Dry	Reefer	Dry	Reefer		Dry	Reefer	Import	Export
Germany	224	336	224	335	280	0%	0%	50%	50%
France	193	286	193	286	240	0%	0%	48%	48%
Spain	172	239	172	239	206	0%	0%	39%	39%
Netherlands	197	274	197	274	236	0%	0%	39%	39%
Italy	172	241	173	241	207	0%	0%	40%	39%
Belgium	175	252	175	252	214	0%	0%	44%	44%
Slovenia	150	228	150	228	189	0%	0%	52%	52%
Portugal	160	225	160	225	192	0%	0%	41%	41%
UK	163	235	163	235	199	0%	0%	44%	44%
Poland	160	225	160	225	192	0%	0%	41%	41%
Denmark	125	183	125	187	155	0%	2%	47%	50%
Ireland	132	200	132	200	166	0%	0%	52%	52%
Sweden	135	171	135	171	153	0%	0%	26%	26%
Latvia	123	154	123	154	138	0%	0%	25%	25%
Lithuania	111	136	119	144	128	7%	6%	22%	20%
Finland	125	183	125	183	154	0%	0%	46%	46%
Estonia	126	154	138	157	144	9%	2%	22%	14%
Cyprus	93	130	95	130	112	2%	0%	39%	37%
Romania	104	78	104	78	91	0%	0%	-25%	-25%
Malta	-	-	-	-	-	-	-	-	-
Bulgaria	130	260	150	260	200	15%	0%	101%	74%
Croatia	141	188	141	188	164	0%	0%	33%	33%
Greece	45	-	47	-	46	4%	-	-	-

The comparison of different types of containers shows, that the ranking of the port regions in terms of the average THCs is (in most cases) also valid for the different container types.

Last, an analysis of the development of THCs has been carried out by comparing the 2013 THCs with the 2009 THCs (first year after abolition of Liner Conferences) and the 2015 THCs with the 2013 THCs.

[15] Fraunhofer CML (2015).

The 2009 values were taken from the European Commission's paper "Terminal handling charges during and after the liner conference era" from 2009. The analysis came to the following results:

Table 16: Development of THCs on country level between 2009 and 2013 as well as 2013 and 2015[16]

Country	Average THCs in 2009	Average THCs in 2013	Total increase (2009-2013)	Average THCs in 2015	Annual increase (2009-2015)
Germany	197	270	38%	280	6%
France	180	228	27%	240	5%
Spain	170	223	32%	206	3%
Netherlands	174	218	26%	236	5%
Italy	147	204	38%	207	6%
Belgium	150	198	32%	214	6%
Slovenia	-	185	-	189	-
Portugal	-	183	-	192	-
UK	124	177	43%	199	8%
Poland	-	167	-	155	-
Denmark	-	158	-	155	-
Ireland	-	154	-	166	-
Sweden	110	153	40%	153	6%
Latvia	-	138	-	138	-
Lithuania	89	137	54%	128	6%
Finland	-	135	-	154	-
Estonia	-	132	-	144	-
Cyprus	-	118	-	112	-
Romania	147	108	-26%	91	-8%
Malta	-	260	-	-	-
Bulgaria	-	152	-	200	-
Croatia	-	128	-	164	-
Greece	112	75	-33%	46	7%

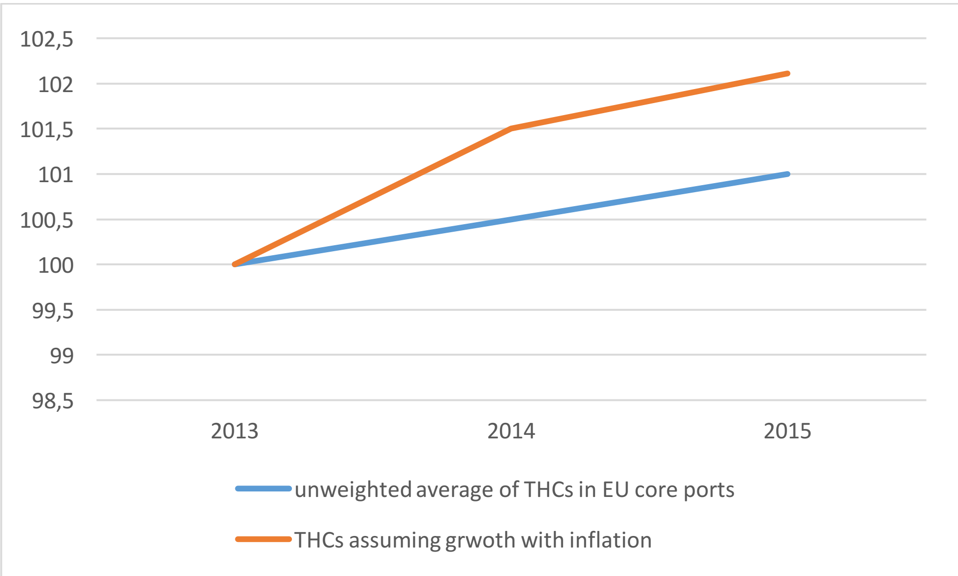
As shown in Table 16 country THCs increased significantly between 2009 and 2013. Romania and Greece form the only exceptions. This increase can be explained by an overall increase of costs of terminal operations. Further, it can be summarized from the analyses carried out that the average annual growth rate of THCs amounts to 5 percent between 2009 and 2015.

[16] Fraunhofer CML (2015).

3.5.2 Summary:

There is not one publicly available rate of handling containers in ports; the contracts between shipping lines and terminals are confidential, but carriers do publish THCs. There are different THCs for different carriers in a port. Many carriers apply the same THCs for all ports in a country (country THCs), in almost all cases THCs are the same for import and export containers, but they are higher for reefer containers. THCs are a critical part of port costs for port users. Ongoing collection of THCs allows for monitoring these costs over time. The figure below provides such an analysis for the two available years. Like port dues per ton, they are benchmarked for inflation. As with the port dues, THCs have grown less than inflation. This is a signal terminal operators manage to reduce real operating costs and pass these cost reductions on to port users.

Figure 4: Real THC growth vs. assumed growth with inflation



4 CONGESTION INDICATORS

The final type of indicator on which we report progress in this deliverable is an indicator on congestion. Here we make a distinction between landside and seaside congestion.

4.1 Landside congestion

On the landside, data availability is key problem. Congestion can occur on port access roads and on rail and inland waterway systems. However, for the last two hinterland modes, relevant data at a European scale is not publicly available. Furthermore, industry conversations confirm that congestion is not a key issue in general. For inland barge transport, the current capacity is generally sufficient, while for rail transport, there may be a shortage of rail paths at certain peak periods. However, shortage of train paths does not lead to congestion. Therefore, we have focused our efforts on developing an indicator for road transport. We have approached a leading provider of road speed patterns (TomTom) and have had lengthy discussions with them, but were unable to reach an agreement. This process took until November 2014. The second best option that is publicly available is through traffic information provided by GOOGLE (under the name WAZE, see www.waze.com). They provide information on road congestion based on historical data. This data shows the severity of road congestion. In line with the interaction with the European Seaports, we test the usefulness of this data for specific case, in this case two ports. Provisional test results are provided below.

Oslo

For Oslo, three road corridors have been selected, all connecting an important port area with an inland node outside the congestion area:

Kolleveien – Tusenfreid (south corridor)

Sorengkaia – Lillestrom (Central /North corridor)

Filipstadkaia – asker (West corridor)

If ESPO members (and other PORTOPIA partners) regards these results as relevant, similar corridors can be selected for all EU core ports, in cooperation with the relevant port authorities.

For each of these corridors, the travel profiles to and from the port were collected, for hourly intervals in the period 07.00 until 20.00, as well as for 24.00, to verify the 'freeflow' time along the corridor. The time period until 20.00 captures the peak hours in the relevant port areas.

Travel profile

Time	Travel time to port	Travel time from port
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
24 (freeflow)		

Travel profiles to be collected from www.waze.com

Travel profile

Time	Travel time to port	Travel time from port
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
24 (freeflow)		

The results for the Olso data collection are provided below:

Filipstadkaia – Asker

Time	Travel time to port	Travel time from port
7	26	16
8	36	17
9	33	16
10	22	17
11	19	16
12	17	16
13	17	16
14	18	17
15	22	24
16	26	33
17	25	27
18	18	18
19	16	17
20	15	16
24	15	15

Data extracted Thursday 8th of January, 2015

Sorengkaia – Lillestrom

Time	Travel time to port	Travel time from port
7	16	15
8	17	17
9	16	15
10	16	15
11	15	15
12	16	15
13	16	16
14	15	17
15	16	22
16	16	28
17	16	22
18	16	17
19	16	16
20	16	15
24 (freeflow)	15	15

Data extracted Friday the 16th of January 2015.

Kolleveien – Tusenfreid (south corridor)

Time	Travel time to port	Travel time from port
7	16	29
8	16	21
9	16	21
10	15	18
11	16	17
12	16	17
13	15	17
14	17	17
15	18	16
16	22	17
17	20	17
18	16	17
19	16	18
20	16	17
24 (freeflow)	16	16

Data extracted Monday the 26th of January 2015.

The data show some congestion on important corridors to/from the port.

Provisional results for Lisbon

For Lisbon, two corridors were identified:

Rua gen Gomes Araujo (container terminal)- Alhandra (North corridor)

Avenida Infante Dom Henrique – Volta de Pedra (South corridor)

Rua gen Gomes Araujo (container terminal)- Alhandra (North corridor)

Time	Travel time to port	Travel time from port
7	27	30
8	33	32
9	38	35
10	32	35
11	29	33
12	29	32
13	28	31
14	29	31
15	29	33
16	31	34
17	30	35
18	30	36

19	32	40
20	33	41
24	27	31

Data extracted Monday the 26th of Januari 2015.

Avenida Infante Dom Henrique – Volta de Pedra (South corridor)

Time	Travel time to port	Travel time from port
7	26	24
8	29	25
9	31	24
10	26	25
11	26	24
12	27	26
13	26	25
14	26	24
15	26	24
16	27	23
17	27	25
18	26	25
19	27	24
20	27	47
24 (freeflow)	26	25

Data extracted Monday the 26th of January 2015.

These data also show some congestion on both corridors. An intuitive and simple method to quantify the congestion is to calculate the average transport time and divide it by the minimum (freeflow) transit time. In the table below, this is done for the five corridors and aggregated to one indicator per port (to and from the port, leading to an average per corridor, which is then averaged to an average per port).

Corridor	**congestion indicator to port**	**congestion indicator from port**	**total congestion along corridor**
Kolleveien – Tusenfreid (south corridor)	1,14	1,26	1,20
Sorengkaia – Lillestrom (Central /North corridor)	1,21	1,25	1,23
Filipstadkaia – asker (West corridor)	1,59	1,36	1,48
Total Oslo			**1,30**
Rua gen Gomes Araujo (container terminal)- Alhandra (North corridor)	1,23	1,12	1,17
Avenida Infante Dom Henrique – Volta de Pedra (South corridor)	1,12	1,06	1,09
Total Lisbon			**1,13**

Three remarks are relevant regarding these results:

1. These results are especially relevant when monitored over time. By taking the average congestion along corridors next year, trends can be established.
2. In this phase, the corridors were not selected together with the ports. This needs to be improved if this indicator is developed for all EU core ports.
3. The data collection was done at different days of the week, probably leading to outcomes that are not fully comparable. This is due to the limited amount of data requests that can be made. This issue also needs to be addressed moving forward[17].

4.2 The seaside: maritime fluidity

One element of Portopia's Work Package 4 is the development of an indicator to monitor levels of maritime congestion from a seaside perspective. This proved to be a controversial issue. In order to setup a meaningful and generally applicable approach for quantifying maritime congestion valid for most or even all European core ports and all ship types requires problem simplification. In general, congestion is difficult to define and measure, there are different regional perceptions and reasons are diverse. Additionally, carriers, shippers, terminals etc. all have different demands. A new approach has been developed which considers this complexity as well as controversy by utilizing already available ship traffic data to enable subsequent port-specific congestion analysis. Therefore, the proposed approach can be better described as a process to visualize 'maritime fluidity' with a port-independent data source as a starting point for individual maritime congestion analysis.

4.2.1 Note on port congestion and maritime fluidity

There is much literature available which aims at calculating and explaining queuing phenomena and delays on transport infrastructure, however mostly related to road, rail and passenger mobility disregarding the maritime shipping phenomena of congestion. According to the European Conference of Ministers of Transport (2007) among port and terminal operators a general understanding and consensus exists regarding the congestion issue, but mainly at terminal and hinterland level.[18]

As a first attempt to clarify port congestion, it can be stated that:

"Congestion arises when demand levels approach the capacity of a facility and the time required to use it (or travel through it) increases well above the average under low demand conditions".[19]

In this context, demand levels could be, e.g. voyage time, berthing window, moves/hour, truck throughput time, or handling time. Capacity can be broken down into capacity of, e.g. port access, berth, crane, personnel, equipment and yard handling. The accessibility from the sea is, e.g. the shipping route, a river channel, the berth, the terminal (quay, yard, hinterland hand-over); and the average time is either fixed in contracts, or undefined/experienced. Thus, a starting point for the

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17 All data collection will have to be done on the same day of the week. The best day would be Monday (normal traffic pattern). This requires either cooperation of the data provider (where we face similar problems as with TomTom) or a decentralized data collection approach, as Waze limits the amount of data retrievals that can be done.

18 European Conference of Ministers of Transport (2007): Congestion: A Global Challenge the Extend of and Outlook for Congestion in Inland, Maritime and Air Transport. http://www.internationaltransportforum.org/IntOrg/ecmt/cm/pdf/ITF200706e.pdf

19 Dios Ortúzar, J. de, Willumsen, L. G. (2011): Modelling transport. Chichester: Wiley, p.5

development of a maritime congestion indicator regarding the accessibility from the sea could be to decide on measureable variables and data sources for:

- Demand,
- Capacity,
- Facility, and
- Average time.

A bottom-up approach would include selecting, evaluating and weighting different variables and sub-parts and collecting data to apply the proposed indicator or index. But instead of selecting a bottom up-approach, in this research project a top-down approach from a data availability perspective is chosen. Controversies regarding the indicators output value for a broad range of stakeholders lead to the rejection of two previously proposed approaches:

- To measure maritime congestion through port turnaround time. Main reason to abandon this indicator is that it appears to be too closely related to port and terminal productivity issues.
- To measure maritime congestion through a quay utilization degree. This could result in bias if the indicator is low in times were vessel sizes tend to increase and the number of vessel calls decrease.

Data confidentially issues additionally supported a top-down approach. For instance terminal operators are not willing to provide essential time-series on ship arrivals and corresponding berth occupation. On the other hand, maritime transport analysis has the unique opportunity to be confronted with an extensive amount of available traffic information which is not confidential and available for all ports, namely, vessel positions tracking based on AIS data (Automatic Identification System).

As a pragmatic result, it was agreed to develop a maritime fluidity indicator which uses AIS data for basic analysis of general ship movements in geographical pre-defined port areas. Major advantage of this indicator named 'maritime fluidity' is the utilisation of an available data source independent of ports. The main goal is the visualisation and pre-analysis of vessel movements in port areas overtime. The result may serve as a decision base for specific and detailed statistical maritime congestion analysis.

4.2.2 Development of a maritime fluidity indicator

The following part of the deliverable describes and proposes a first version of the maritime fluidity indicator with focus on its development approach. This indicator is still prone to change after discussion with stakeholders.

The indicator gives an insight into waterborne traffic flows in port areas. Information on vessel positions with time reference is derived from AIS data. The outcome indicates the distribution of arriving vessels in a spatially restricted area. Major assumption for the indicator is that a continuous fluid journey to a port will always take the same transition time (with less variation) from a certain distance. A discontinuous journey leads to more fluctuating transition times. But this doesn't necessarily mean that there is any congestion in a port. There are several possible reasons for a low level of traffic flow in ports which are of high importance for additional congestion analysis.

In the next four sections AIS data as main data source is defined, the developed approach is introduced and applied to two ports, and to close, the approach and its possible extensions are discussed.

4.2.3 Vessel position tracking based on AIS data

The ship borne Automatic Identification System (AIS) provides information about vessels automatically. Initial idea of the introduction of AIS was to avoid ship collisions. It has been made a carriage requirement by the International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS). The system became effective in 2004 and is fitted aboard of all ships of 300+ gross tonnage engaged on international voyages, cargo ships of 500+ gross tonnage not engaged on international voyages and all passenger ships irrespective of size.[20] Information that should be entered at the first installation of the AIS on board includes:[21]

- Maritime Mobile Service Identity (MMSI) number;
- IMO vessel number;
- Radio call sign;
- Name of ship;
- Type of ship;
- Dimension/reference for position of the electronic position fixing device (EPFD); and
- Antenna.

In addition to information exchange between ships and public authorities for surveillance and collision avoidance purposes, AIS data is collected and further processed by some commercial organisations.[22] Their possible information services include publication of shipping route histories or online maps displaying the present ship location. Data output is made available online, by mobile apps or email. These commercial organisations usually pick up the broadcasted AIS data by land-based receivers. The receivers send the AIS data via an Internet connection and the data is further processed. For the PORTOPIA project AIS data was supplied free of charge by the company "Marine Traffic" for two pre-selected ports and a time period of one month.

4.2.4 Setting up an approach to measure maritime fluidity

Maritime fluidity shall be identified applying a port-independent data source. Restrictions are that the approach needs to be transferable to all European core container ports, and that data analysis needs to be automated - which distinguishes it from a comprehensive statistical analysis. Thus, prior to receiving AIS data several restrictions are captured by the following assumptions:

- **AIS data time interval: August 2014**
  The month August serves as the initial time interval with sufficient data complexity to set up the approach; weekly differences can be captured; it is assumed that August is not a peak month, e.g. due to the Christmas trade or holiday seasons affecting shipping.
- **Data provider: Marine Traffic**
  Agreement could be reached to share initial data free of charge; in parallel discussion on post-project cooperation started.
- **Port area: max. 50 km radius with potential waiting zones**
  The distance of 50 km is chosen to make sure that a sufficient transition distance is covered to reduce the impact of irregularities in vessel speed. However, the section must be defined in a

[20] Imo (2015): AIS transponders. Online: http://www.imo.org/OurWork/Safety/Navigation/Pages/AIS.aspx. Last accessed: 13 January 2015
[21] IMO (2003): Guidelines for the installation of a ship borne Automatic Identification System (AIS), International Maritime Organization: London, p.7
[22] Examples of commercial AIS service providers are: www.fleetmon.com, www.marinetraffic.com, www.shipfinder.co, www.vesselfinder.com, www.vesseltracker.com

size that a fairway to a port can be identified as clearly as possible, e.g. in river ports like Antwerp or Hamburg

- **Vessel travel behaviour: Vessels sail continuously to a port**
  It is anticipated that vessels are not laid up or anchored for several days on purpose; only vessels entering a port area are included.
- **Vessel category: All types, then filtered for container vessels**
  For this first analysis container vessels are chosen due to market dependencies on fixed liner shipping routes and estimated arrival and departure times.

The maritime fluidity indicator approach is based on AIS data as input, which is further processed. The input for the maritime fluidity indicator is provided in Table 17 containing vessels as rows. The column MMSI displays the vessel identification number called Maritime Mobile Service Identity. Longitude and latitude are both position information in Cartesian coordinates. Timestamp combines date and time, and ship type is set to container vessel.

Table 17: AIS Data Sample (made anonymous)

MMSI	Longitude	Latitude	Timestamp	Ship type
211591071	8,14914	53,51345	01.08.2014 01:46	Container

The methodology is subdivided into several steps (Figure 5):

1. AIS data is filtered by vessel type.
2. AIS data is visualized by Geographic Information Systems (GIS) software. A port-specific finishing and starting line or other geometric figure for transition time calculation is defined depending on visible navigational routes. The line (or another geometric figure) definition helps to determine coordinates where all vessels usually cross to call a port.
3. For each vessel the first AIS data point after crossing the start, and the first AIS data point after crossing the finish have to be determined (loop to AIS data visualization to decide on navigational channel).
4. The time difference between these two AIS data points is calculated and this transitions time is displayed as a time/frequency plot.

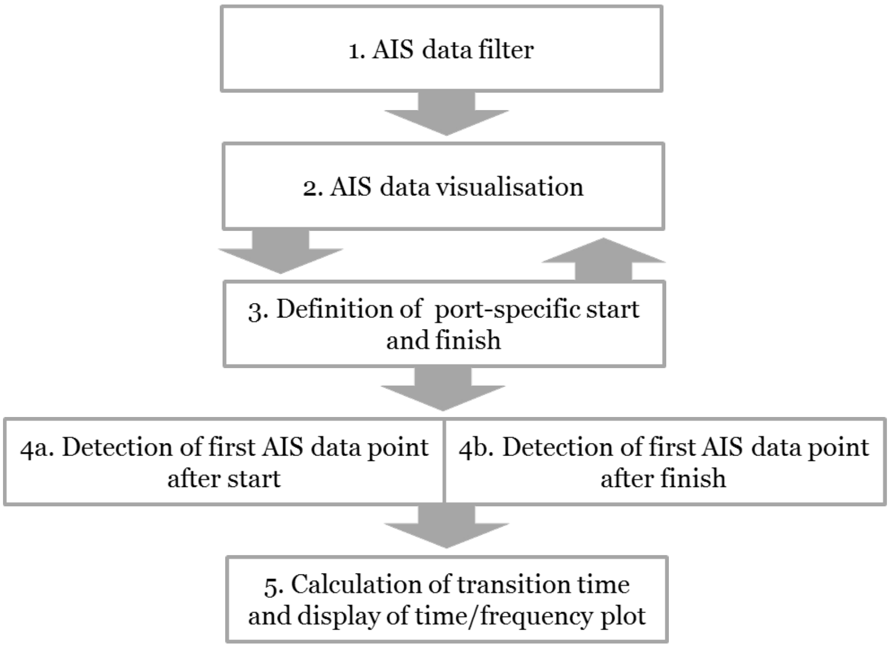


Figure 5 Maritime fluidity indicator approach

4.2.5 Application of the maritime fluidity approach

The approach for the maritime fluidity indicator is applied to the Port of Bremerhaven, Germany and the Port of Valencia, Spain with AIS data for August 2014.

Port of Bremerhaven

AIS data for a square area of 50 x 50km around the Port of Bremerhaven is filtered and displayed in Figure 6. Vessels on their way to the ports of, e.g. Wilhelmshaven, Cuxhaven or Hamburg are also included.

Figure 6: AIS data visualisation for the Port of Bremerhaven

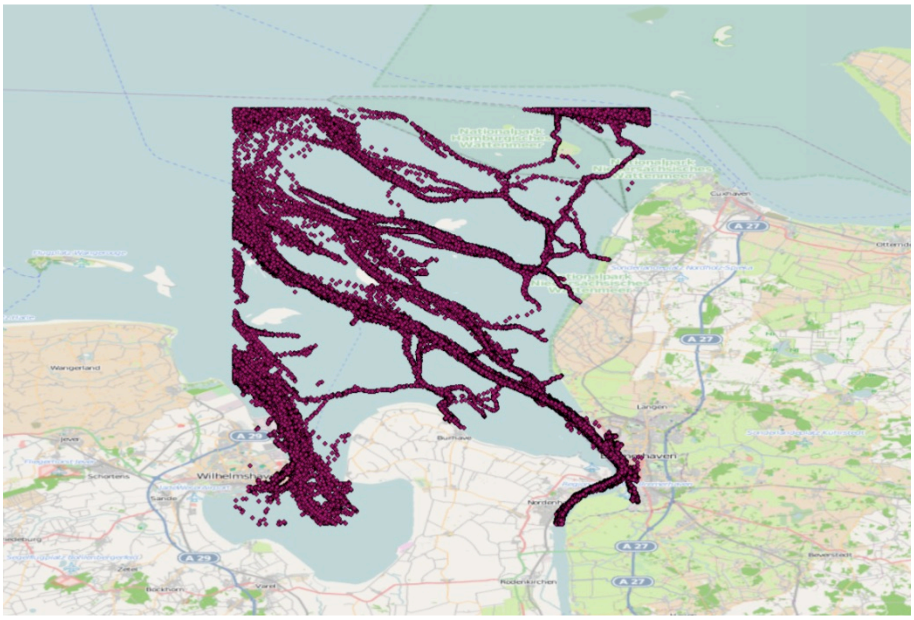
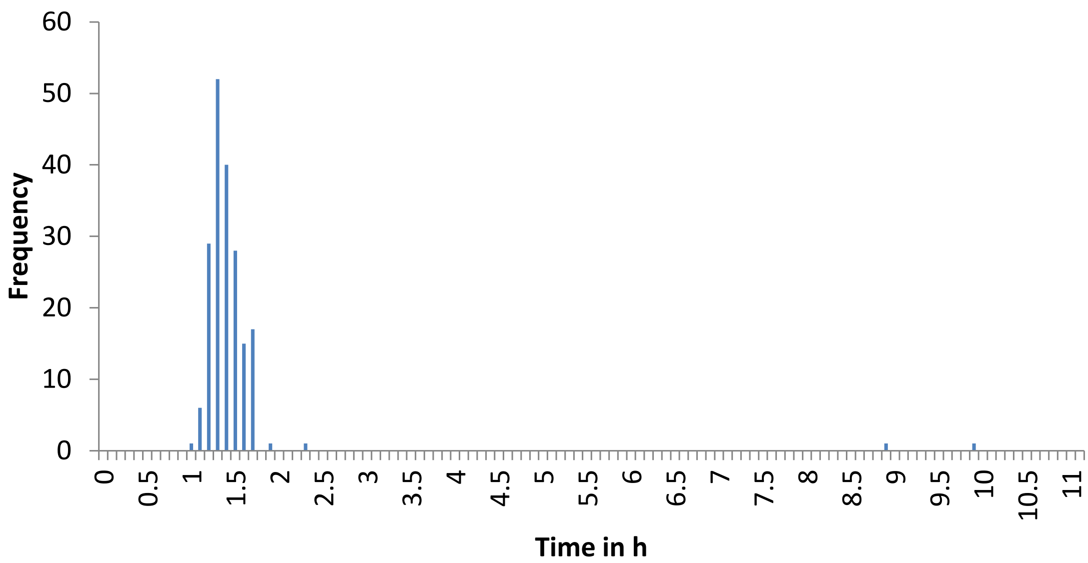


Figure 7 shows AIS data for container vessels. The fairway to the Port of Bremerhaven can be identified. In addition, the figure illustrates the imaginary starting and finishing line for the calculation of the transition time. Due to a rather straight navigational channel this can be realized by using two boundary segments.

Figure 7: AIS data visualisation for the Port of Bremerhaven, ship type: container

Finally, the distribution of transition times for container vessels in the Port of Bremerhaven area is highlighted in Figure 8. The y-axis named “frequency” stands for the cumulated number of ships per time interval. The x-axis named “time in h” displays pre-defined time bins of 0.1 hours width.

Figure 8: Port of Bremerhaven - Distribution of container ship transition time in August 2014

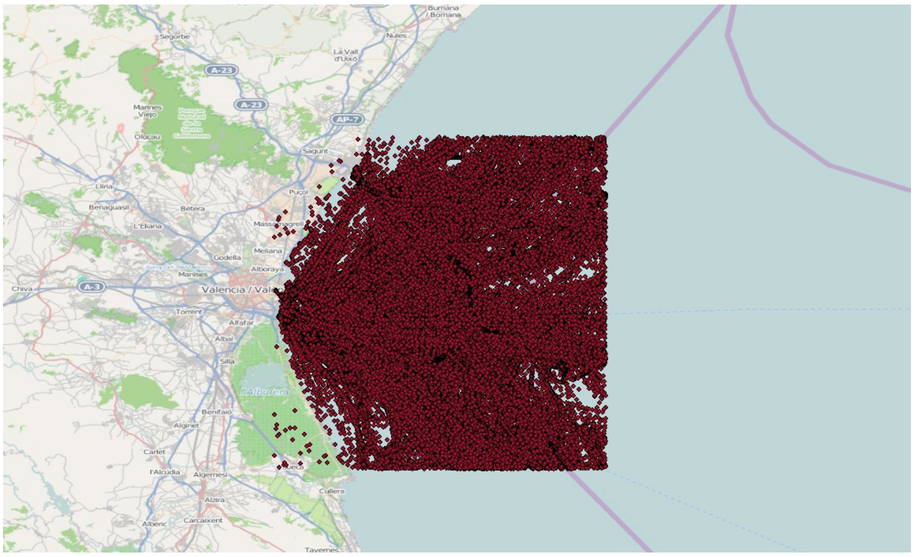


As a first very basic analysis step, it can be stressed that the transition time distribution looks rather homogeneous and almost bell-shaped. It has its peak at approximately 1.3 hours. The variance seems fairly small. There are just a few higher transition time values visible between 8.8 and 10 hours.

Port of Valencia

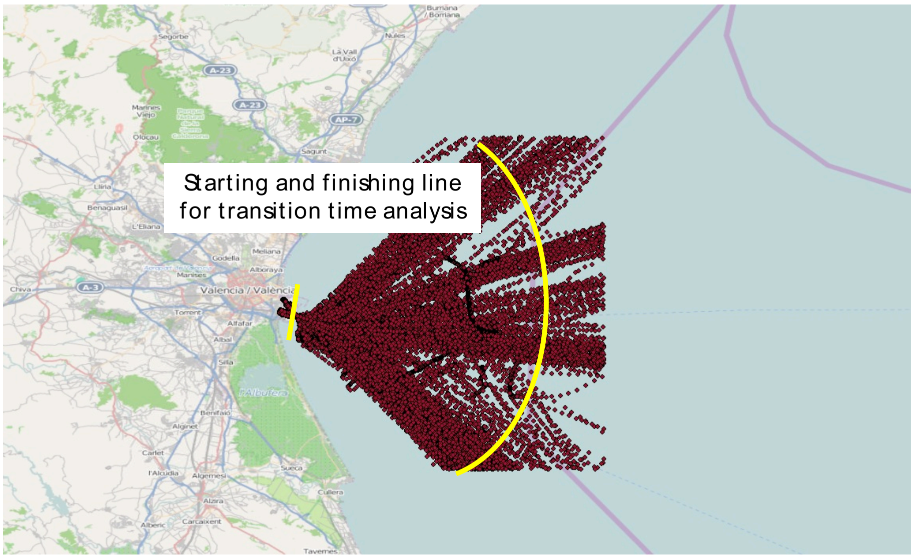
AIS data for a square area of 50 x 50 km around the Port of Valencia is filtered and displayed in Figure 9. The situation looks quite different to the Bremerhaven area. In Bremerhaven it was possible to recognize the major fairway. In Valencia vessels call the port from the majority of eastern directions.

Figure 9: AIS data visualisation for the Port of Valencia



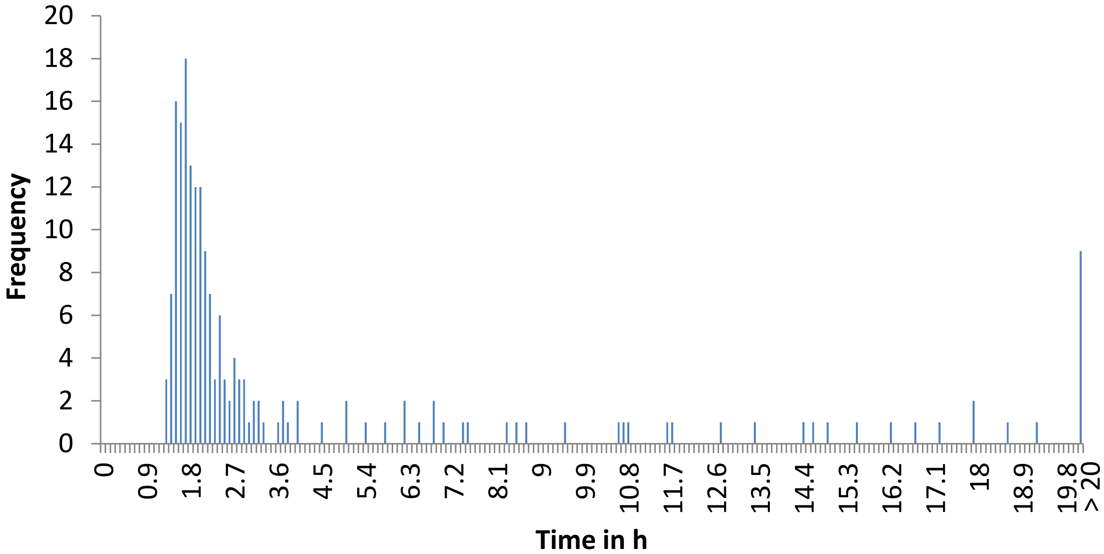
The next Figure 10 shows AIS data for container vessels. One fairway to the Port of Valencia cannot be identified. Thus, in this case it is not possible to use a simple segment as starting line. A semicircle seems to be a more appropriate choice to detect all vessels which are calling at the port. But as in the Port of Bremerhaven case the finishing line can indeed be a short segmenting line based on higher ship density closer to the port terminals.

Figure 10: AIS data visualisation for the Port of Valencia, ship type: container



Finally, the distribution of transition times for container vessels in the Port of Valencia area for August 2014 is highlighted in Figure 11.

Figure 11: Port of Valencia - Distribution of container ship transition time in August 2014



The transition time distribution is depicted at a broader range than in the case of Bremerhaven. The peak for container vessel transition time at the port of Valencia is at about 1.7 hours. The variance seems much higher compared to Bremerhaven. There are some vessels with a transition time above 20 hours.

4.2.6 Discussion of the maritime fluidity approach

The approach for maritime fluidity measurement has been developed and applied as highlighted in this deliverable. It finishes after the calculation and display of transit time distribution. In this way the approach remains simple and flexible enough to be transferred to a variety of different ports. Only small adjustments are needed to correspond to different geographical conditions.

The main idea is that the maritime fluidity indicator can be used for further port-specific and detailed statistical analysis on maritime congestion and other influencing factors. Outlier detection is a logical starting point for identification of non-normalities. But many factors may influence non-normality of vessel travel behaviour. Data could be enriched by further details on potentially influencing factors such as ship size, weather, tide times, day of the week, or vessel course interactions. Initially, we propose to undertake simple descriptive analysis to generate estimates of the vessel transit time distribution such as expected value, variance or standard deviation and then search for outliers. Based on this we suggest to apply inferential statistics methods. Aim is to identify correlation of transit time with additional predictor variables such as ship size, or weather. A final outcome could be predictions on port congestion depending on changes of the influencing factors.

To sum up, port performance indicators are usually confronted with a lack of publicly available data. AIS data is an often under-valued exception. The automated vessel tracking has transformed the problem of data gaps into a challenge of data analysis. Therefore, the main goal is to analyse available information to detect non-normalities and to apply more sophisticated statistical learning techniques to derive predictions on port congestion and correlating variables.

5 Next steps in PORTOPIA

Deliverable 4.2 has delivered various new indicators for port performance. The table below summarises the status of each of the indicators and proposed next steps.

Table 18: Summary of indicators

Indicator	Development in 4.2	Suggested next steps
RoRo connectivity of Europe's core ports	Method established, data for 2014 collected, validation of data underway.	Finish validation.
Maritime connectivity of Europe's core ports	Method established, data not available.	Develop an empirical calculation based on data availability.
Average Port dues per ton in EU core ports	Method established, data collected.	Repeat yearly for PORTOPIA project period. Data validation by ESPO subject to further discussion.
THCs per container in EU core ports.	Method established, data collected.	Repeat yearly for PORTOPIA project period.
Road congestion in EU's core ports	Method established, data collected for two test ports.	Broaden data collection to all EU core ports, subject to ESPO support for this indicator.
Maritime fluidity of EUs core ports	Method established, data collected for two test ports.	Broaden data collection to all EU core ports, subject to ESPO support for this indicator.

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7 APPENDIX 1: LIST OF CORE PORTS FOR RORO DATA COLLECTION

Country	**Core ports**
Belgium	Antwerp
Belgium	Ghent
Belgium	Oostende
Belgium	Zeebrugge
Bulgaria	Burgas
Croatia	Reijka
Cyprus	Lemesos
Denmark	Aarhus
Denmark	Copenhagen
Estonia	Tallin
Finland	Helsinki
Finland	Kotka-Hamina
Finland	Turku naantali
France	Bordeaux
France	Calais
France	Dunkerque
France	Marseille
France	Le Havre
France	Nantes - st nazaire
France	Rouen
Germany	Bremen
Germany	Bremerhafen
Germany	Hamburg
Germany	Lubeck
Germany	Rostock
Germany	Wilhelmshafen
Greece	Pireaus
Greece	Igoumetsina
Greece	Heraklion
Greece	Patras
Greece	Thessaloniki
Ireland	Cork
Ireland	Dublin
Ireland	Limerick
Italy	Ancona

Italy	Augusta
Italy	Bari
Italy	Cagliari
Italy	Genova
Italy	Gioio Tauro
Italy	La Spezia
Italy	Livorno
Italy	Napoli
Italy	Palermo
Italy	Ravenna
Italy	Taranto
Italy	Trieste
Italy	Venezia
Latvia	Riga
Latvia	Ventspils
Lithuania	Klaipeda
Malta	Marsaxlokk
Malta	Valetta
Netherlands	Amsterdam
Netherlands	Moerdijk
Netherlands	Rotterdam
Netherlands	Vlissingen + terneuzen
Poland	Gdansk
Poland	Gdynia
Poland	Sczecin, Swinoujscie
Portugal	Lisboa
Portugal	Leixoes
Portugal	Sines
Romania	Constantza
Romania	Galati
Slovenia	Koper
Spain	La coruna
Spain	Algeciras
Spain	Barcelona
Spain	Bilbao
Spain	Cartagena
Spain	Gijon
Spain	Huelva
Spain	Las Palmas
Spain	Palma de Mallorca
Spain	Sevilla

Spain	Tenerife
Spain	Valencia
Spain	Tarragona
Sweden	Lulea
Sweden	Goteborg
Sweden	Malmo
Sweden	Stockholm
Sweden	Trelleborg
UK	Belfast
UK	Bristol
UK	Cardiff-Newport
UK	Dover
UK	Edinburgh (Forth, Grangemouth, Rosyth and Leith)
UK	Felixtowe
UK	Harwich
UK	Glasgow (Clydeport, King George V dock, Hunterston and Greenock)
UK	Grimsby / immingham
UK	Liverpool
UK	London gateway Tilbury
UK	Milford haven
UK	Southampton
UK	Teesport

8 APPENDIX 2: DATA COLLECTED

PORTOFDEP	dep CODE	COUNTRY OF DEP	PORT OF DEST	dest CODE	COUNTRY OF DEST	ROUTE NAME	FREQ	TRAVEL TIME (h)	TIER OF CONN	DATE RETRIEVED
AARHUS	DKAAR	DENMARK	HELSINKI	FIHEL	FINLAND	AARHUS-ROSTOCK	2	13,5	1	11-9-2014
ALGECIRAS	ESALG	SPAIN	TANGER	MATNG	MOROCCO	ALGECIRAS-TANGER	30	1,5	1	14-9-2014
ALGECIRAS	ESALG	SPAIN	CEUTA	ESCEU	SPAIN	ALGECIRAS-CEUTA	25	1,5	1	14-9-2014
ALGECIRAS	ESALG	SPAIN	CEUTA	ESCEU	SPAIN	ALGECIRAS-CEUTA	63	1	1	24-9-2014
AMSTERDAM	NLAMS	NETHERLANDS	ANTWERPEN	BEANR	BELGIUM	AMSTERDAM-ANTWERPEN	1	18	1	11-9-2014
AMSTERDAM	NLAMS	NETHERLANDS	NEWCASTLE	GBNCS	UNITED KINGDOM	AMSTERDAM-NEEWCASTLE	7	15,5	1	11-9-2014
ANCONA	ITAOI	ITALY	IGOUMENITSA	GRIGO	GREECE	ANCONA-IGOUMENITSA	6		1	14-9-2014
ANCONA	ITAOI	ITALY	DURRES	ALDRZ	ALBANIA	ANCONA-DURRES	2	22	1	14-9-2014
ANCONA	ITAOI	ITALY	PATRAS	GRGPA	GREECE	ANCONA-IGOUMENITSA-PATRAS	6	25	2	24-9-2014
ANTIRIO	GRANT	GREECE				ANTIRIO -				
ANTWERP	BEANR	BELGIUM	HELSINKI	FIHEL	FINLAND	ANTWERP-HELSINKI	1	69	1	11-9-2014
ANTWERP	BEANR	BELGIUM	ST PETERSBURG	RULED	RUSSIAN FEDERATION	ANTWERP-ST PETERSBURG	1	106	1	11-9-2014
ANTWERP	BEANR	BELGIUM	ZEEBRUGGE	BEZEE	BELGIUM	ANTWERP-ZEEBRUGGE	1	8,5	1	14-9-2014
ANTWERP	BEANR	BELGIUM	KOTKA	FIKTK	FINLAND	ANTWERP-KOTKA	2	119	1	14-9-2014
ANTWERP	BEANR	BELGIUM	RAUMA	FIRAU	FINLAND	ANTWERP-HANKO-RAUMA	1	91	2	14-9-2014
ANTWERP	BEANR	BELGIUM	ST PETERSBURG	RULED	RUSSIAN FEDERATION	ANTWERP-ST PETERSBURG	2	103	1	14-9-2014
ANTWERP	BEANR	BELGIUM	PALDISKI	EEPLA	ESTONIA	ANTWERP-PALDISKI	1	93	1	14-9-2014
ANTWERP	BEANR	BELGIUM	TILBURY	GBTIL	UNITED KINGDOM	ANTWERP-TILBURY	1	19	1	14-9-2014
AUGUSTA	ITAUG	ITALY				AUGUSTA-				
BARCELONA	ESBCN	SPAIN	CIVITAVECCHIA	ITCVV	ITALY	BARCELONA-CIVITAVECCHIA	6	20	1	14-9-2014
BARCELONA	ESBCN	SPAIN	LIVORNO	ITLIV	ITALY	BARCELONA-LIVORNO	4	28	1	14-9-2014

BARCELONA	ESBCN	SPAIN	PORTO TORRES	ITPTO	ITALY	BARCELONA-PORTO TORRES	5	13	1	14-9-2014
BARCELONA	ESBCN	SPAIN	SAVONA	ITSVN	ITALY	BARCELONA-SAVONA	3	39	1	14-9-2014
BARCELONA	ESBCN	SPAIN	FORMENTERA	ESFNI	SPAIN	BARCELONA-FORMENTERA	1	9	1	14-9-2014
BARCELONA	ESBCN	SPAIN	IBIZA	ESIBZ	SPAIN	BARCELONA-IBIZA	2	9	1	14-9-2014
BARCELONA	ESBCN	SPAIN	PALMA DE MALLORCA	ESPMI	SPAIN	BARCELONA-PALMA DE MALLORCA	7	8	1	14-9-2014
BARCELONA	ESBCN	SPAIN	IBIZA	ESIBZ	SPAIN	BARCELONA-IBIZA	5	8,5	1	24-9-2014
BARCELONA	ESBCN	SPAIN	PALMA DE MALLORCA	ESPMI	SPAIN	BARCELONA-PALMA DE MALLORCA	5	7,5	1	24-9-2014
BARCELONA	ESBCN	SPAIN	CIUTADELLA DE MENORCA	ESCMC	SPAIN	BARCELONA-CIUTADELLA DE MENORCA	4	6,5	1	24-9-2014
BARI	ITBRI	ITALY	DURRES	ALDRZ	ALBANIA	BARI-DURRES	7	9	1	14-9-2014
BARI	ITBRI	ITALY	DURRES	ALDRZ	ALBANIA	BARI-DURRES	7	9	1	24-9-2014
BARI	ITBRI	ITALY	PATRAS	GRGPA	GREECE	BARI-IGOUMENITSA-PATRAS	7	17	2	24-9-2014
BELFAST	GBBEL	UK	CAIRNRYAN	GBCYN	UNITED KINGDOM	BELFAST-CAIRNRYAN	39	2	1	14-9-2014
BELFAST	GBBEL	UK	LIVERPOOL	GBLIV	UNITED KINGDOM	BELFAST-LIVERPOOL	16	8	1	14-9-2014
BELFAST	GBBEL	UK	HEYSHAM	GBHYM	UNITED KINGDOM	BELFAST-HEYSHAM	12	8,5	1	14-9-2014
BILBAO	ESBIO	SPAIN	PORTSMOUTH	GBPME	UNITED KINGDOM	BILBAO-PORTSMOUTH	2	35	1	14-9-2014
BILBAO	ESBIO	SPAIN	ZEEBRUGGE	BEZEE	BELGIUM	BILBAO-ZEEBRUGGE	2	59	1	14-9-2014
BILBAO	ESBIO	SPAIN	RAUMA	FIRAU	FINLAND	BILBAO-HANKO-RAUMA	1	156	2	14-9-2014
BILBAO	ESBIO	SPAIN	PALDISKI	EEPLA	ESTONIA	BILBAO-PALDISKI	1	163	1	14-9-2014
BILBAO	ESBIO	SPAIN	PORTSMOUTH	GBPME	UNITED KINGDOM	BILBAO-PORTSMOUTH	1	22,5	1	24-9-2014
BREMEN, BLUMENTHAL	DEBRE	GERMANY				BREMEN, BLUMENTHAL-				
BREMERHAVEN	DEBRV	GERMANY				BREMERHAVEN-				
BRISTOL	GBBRS	UK				BRISTOL-				
CAGLIARI	ITCAG	ITALY	NAPOLI	ITNAP	ITALY	CAGLIARI-NAPOLI	2	13,5	1	24-9-2014
CAGLIARI	ITCAG	ITALY	CIVITAVECCHIA	ITCVV	ITALY	CAGLIARI-CIVITAVECCHIA	7	15	1	24-9-2014
CAGLIARI	ITCAG	ITALY	ARBATAX	ITATX	ITALY	CAGLIARI-ARBATAX	3	4,5	1	24-9-2014
CAGLIARI	ITCAG	ITALY	VALENCIA	ESVLC	SPAIN	CAGLIARI-VALENCIA	3	27	1	14-9-2014

CAGLIARI	ITCAG	ITALY	SALERNO	ITSAL	ITALY	CAGLIARI-SALERNO	3	16	1	14-9-2014
CAGLIARI	ITCAG	ITALY	PALERMO	ITPMO	ITALY	CAGLIARI-PALERMO	1	11,5	1	24-9-2014
CALAIS	FRCQF	FRANCE	DOVER	GBDVR	UNITED KINGDOM	CALAIS-DOVER	68	2,5	1	11-9-2014
CALAIS	FRCQF	FRANCE	DOVER	GBDVR	UNITED KINGDOM	CALAIS-DOVER	161	2,5	1	14-9-2014
CALAIS	FRCQF	FRANCE	DOVER	GBDVR	UNITED KINGDOM	CALAIS-DOVER	76	2	1	25-9-2014
CARDIFF-NEWPORT	GBCDF	UK				CARDIFF-NEWPORT-				
CARTAGENA	ESCAR	SPAIN				CARTAGENA-				
CIVITAVECCHIA	ITCVV	ITALY	BARCELONA	ESBCN	SPAIN	CIVITAVECCHIA-BARCELONA	6	20	1	14-9-2014
CIVITAVECCHIA	ITCVV	ITALY	TUNIS	TNTUN	TUNISIA	CIVITAVECCHIA-TUNIS	1	20	1	14-9-2014
CIVITAVECCHIA	ITCVV	ITALY	ARBATAX	ITATX	ITALY	CIVITAVECCHIA-ARBATAX	3	10	1	24-9-2014
CIVITAVECCHIA	ITCVV	ITALY	OLBIA	ITOLB	ITALY	CIVITAVECCHIA-OLBIA	7	7,5	1	24-9-2014
CIVITAVECCHIA	ITCVV	ITALY	OLBIA	ITOLB	ITALY	CIVITAVECCHIA-OLBIA	7	5,5	1	24-9-2014
CIVITAVECCHIA	ITCVV	ITALY	CAGLIARI	ITCAG	ITALY	CIVITAVECCHIA-CAGLIARI	7	15	1	24-9-2014
CONSTANTZA	ROCND	ROMANIA				CONSTANTZA-				
COPENHAGEN	DKCPH	DENMARK	OSLO	NOOSL	NORWAY	COPENHAGEN-OSLO	7	18	1	11-9-2014
COPENHAGEN	DKCPH	DENMARK	UST LUGA	RUULU	RUSSIAN FEDERATION	COPENHAGEN-UST LUGA	1	87	1	11-9-2014
COPENHAGEN	DKCPH	DENMARK	ST PETERSBURG	RULED	RUSSIAN FEDERATION	COPENHAGEN-ST PETERSBURG	1	71	1	11-9-2014
COPENHAGEN	DKCPH	DENMARK	KLAIPEDA	LTKLJ	LITHUANIA	COPENHAGEN-KLAIPEDA	3	21	1	11-9-2014
CORK	IECOB	IRELAND				CORK-				
DOVER	GBDVR	UK	DUNKERQUE	FRDKK	FRANCE	DOVER-DUNKERQUE	78	2	1	11-9-2014
DOVER	GBDVR	UK	CALAIS	FRCQF	FRANCE	DOVER-CALAIS	68	2,5	1	11-9-2014
DOVER	GBDVR	UK	CALAIS	FRCQF	FRANCE	DOVER-CALAIS	23	2,5	1	14-9-2014
DOVER	GBDVR	UK	CALAIS	FRCQF	FRANCE	DOVER-CALAIS	70	2	1	25-9-2014
DUBLIN	IEDUB	IRELAND	LIVERPOOL	GBLIV	UNITED KINGDOM	DUBLIN-LIVERPOOL	18	7	1	14-9-2014
DUBLIN	IEDUB	IRELAND	HOLYHEAD	GBHLY	UNITED KINGDOM	DUBLIN-HOLYHEAD	28	3,5	1	14-9-2014
DUBLIN	IEDUB	IRELAND	HOLYHEAD	GBHLY	UNITED KINGDOM	DUBLIN-HOLYHEAD	29	3,5	1	24-9-2014
DUBLIN	IEDUB	IRELAND	CHERBOURG	FRCER	FRANCE	DUBLIN-CHERBOURG	1	18	1	24-9-2014

DUNKERQUE	FRDKK	FRANCE	DOVER	GBDVR	UNITED KINGDOM	DUNKERQUE-DOVER	78	2	1	11-9-2014
EDINBURGH (FORTH, GRANGEMOUTH, ROSYTH, AND LEITH)	0	0				EDINBURGH (FORTH, GRANGEMOUTH, ROSYTH, AND LEITH)-				
EMDEN	DEEME	GERMANY				EMDEN-				
FELIXSTOWE	GBFXT	UK	ROTTERDAM	NLRTM	NETHERLANDS	FELIXSTOWE-ROTTERDAM	15	9	1	11-9-2014
FORTH	GBFOR	UK				FORTH-				
FREDERIKSHAVN	DKFDH	DENMARK	COPENHAGEN	DKCPH	DENMARK	FREDERIKSHAVN-COPENHAGEN	2	9	1	11-9-2014
FREDERIKSHAVN	DKFDH	DENMARK	GOTHENBURG	SEGOT	SWEDEN	FREDERIKSHAVN-GOTHENBURG	35	4	1	14-9-2014
FREDERIKSHAVN	DKFDH	DENMARK	OSLO	NOOSL	NORWAY	FREDERIKSHAVN-OSLO	6	9	1	14-9-2014
GDANSK	PLNOW	POLAND	NYNÄSHAMN	SENYN	SWEDEN	GDANSK-NYNÄSHAMN	3	19	1	25-9-2014
GDYNIA	PLGDY	POLAND	HELSINKI	FIHEL	FINLAND	GDYNIA-HELSINKI	2	27	1	11-9-2014
GDYNIA	PLGDY	POLAND	HULL	GBHUL	UNITED KINGDOM	GDYNIA-HULL	1	54	1	11-9-2014
GDYNIA	PLGDY	POLAND	ANTWERPEN	BEANR	BELGIUM	GDYNIA-ANTWERPEN	1	159	1	14-9-2014
GDYNIA	PLGDY	POLAND	PALDISKI	EEPLA	ESTONIA	GDYNIA-PALDISKI	1	95	1	14-9-2014
GDYNIA	PLGDY	POLAND	HANKO	FIHKO	FINLAND	GDYNIA-HANKO	1	64	1	14-9-2014
GDYNIA	PLGDY	POLAND	KOTKA	FIKTK	FINLAND	GDYNIA-KOTKA	1	88	1	14-9-2014
GDYNIA	PLGDY	POLAND	KARLSKRONA	SEKAA	SWEDEN	GDYNIA-KARLSKRONA	14	10,5	1	14-9-2014
GENOVA	ITGOA	ITALY	OLBIA	ITOLB	ITALY	GENOVA-OLBIA	3	13	1	24-9-2014
GENOVA	ITGOA	ITALY	OLBIA	ITOLB	ITALY	GENOVA-OLBIA	14	11	1	24-9-2014
GENOVA	ITGOA	ITALY	PORTO TORRES	ITPTO	ITALY	GENOVA-PORTO TORRES	7	11,5	1	24-9-2014
GENOVA	ITGOA	ITALY	PATRAS	GRGPA	GREECE	GENOVA-PATRAS	1	62	1	14-9-2014
GENOVA	ITGOA	ITALY	TUNIS	TNTUN	TUNISIA	GENOVA-TUNIS	2	72,5	1	14-9-2014
GENOVA	ITGOA	ITALY	TUNIS	TNTUN	TUNISIA	GENOVA-TUNIS	2		1	24-9-2014
GENOVA	ITGOA	ITALY	MALTA	MTMLA	MALTA	GENOVA-MALTA	3	32	1	14-9-2014
GENOVA	ITGOA	ITALY	TRIPOLI	LYTIP	LIBYA	GENOVA-TRIPOLI	1	55	1	14-9-2014
GENOVA	ITGOA	ITALY	CATANIA	ITCTA	ITALY	GENOVA-CATANIA	4	37	1	14-9-2014
GENOVA	ITGOA	ITALY	PALERMO	ITPMO	ITALY	GENOVA-PALERMO	4	25	1	14-9-2014
GENOVA	ITGOA	ITALY	BASTIA	FRBIA	FRANCE	GENOVA-BASTIA	14	7	1	24-9-2014
GENT (GHENT)	BEGNE	BELGIUM	BREVIK	NOBVK	NORWAY	GENT (GHENT)-BREVIK	1	30	1	11-9-2014

GENT (GHENT)	BEGNE	BELGIUM	GOTHENBURG	SEGOT	SWEDEN	GENT (GHENT)-GOTHENBURG	6	33	1	11-9-2014
GIJÓN	ESGIJ	SPAIN	ST NAZAIRE	FRNTE	FRANCE	GIJÓN-ST NAZAIRE	3	16,5	1	14-9-2014
GIOIA TAURO	ITGIT	ITALY				GIOIA TAURO-				
GLASGOW (CLYDEPORT, KING GEORGE V DOCK, HUNTERSTON AND GREENOCK)	GBGLW	UK				GLASGOW (CLYDEPORT, KING GEORGE V DOCK, HUNTERSTON AND GREENOCK)-				
GOTHENBURG	FK116	SWEDEN	GHENT	BEGNE	BELGIUM	GOTHENBURG-GHENT	6	33	1	11-9-2014
GOTHENBURG	FK116	SWEDEN	IMMINGHAM	GBGSY	UNITED KINGDOM	GOTHENBURG-IMMINGHAM	6	27	1	11-9-2014
GOTHENBURG	FK116	SWEDEN	TILBURY	GBTIL	UNITED KINGDOM	GOTHENBURG-TILBURY	2	35	1	11-9-2014
GOTHENBURG	FK116	SWEDEN	FREDERIKSHAVN	DKFDH	DENMARK	GOTHENBURG-FREDERIKSHAVN	34	4	1	14-9-2014
GOTHENBURG	FK116	SWEDEN	KIEL	DEKEL	GERMANY	GOTHENBURG-KIEL	7	14,5	1	14-9-2014
HAMBURG	DEHAM	GERMANY	ST PETERSBURG	RULED	RUSSIAN FEDERATION	HAMBURG-ST PETERSBURG	1	64	1	14-9-2014
HANKO	FIHKO	FINLAND				HANKO-				
HARWICH	GBHRW	UK	ESBJERG	DEEBJ	GERMANY	HARWICH-ESBJERG	3		1	11-9-2014
HARWICH	GBHRW	UK	ST PETERSBURG	RULED	RUSSIAN FEDERATION	HARWICH-ST PETERSBURG-KOTKA	1	96	2	14-9-2014
HARWICH	GBHRW	UK	HOEK VAN HOLLAND	NLHVH	NETHERLANDS	HARWICH-HOEK VAN HOLLAND	14	8	1	14-9-2014
HELSINGBORG	SEHEL	SWEDEN				HELSINGBORG-				
HELSINGØR (ELSINORE)	DKHLS	DENMARK				HELSINGØR (ELSINORE)-				
HELSINKI	FIHEL	FINLAND	GDYNIA	PLGDY	POLAND	HELSINKI-GDYNIA	2	27	1	11-9-2014
HELSINKI	FIHEL	FINLAND	ROSTOCK	DERSK	GERMANY	HELSINKI-ROSTOCK	3	37	1	11-9-2014
HELSINKI	FIHEL	FINLAND	RAUMA	FIRAU	FINLAND	HELSINKI-RAUMA	1	43	1	11-9-2014
HELSINKI	FIHEL	FINLAND	ST PETERSBURG	RULED	RUSSIAN FEDERATION	HELSINKI-ST PETERSBURG	2	11	1	11-9-2014
HELSINKI	FIHEL	FINLAND	IMMINGHAM	GBGSY	UNITED KINGDOM	HELSINKI-IMMINGHAM	1	64	1	11-9-2014
HELSINKI	FIHEL	FINLAND	UST LUGA	RUULU	RUSSIAN FEDERATION	HELSINKI-UST LUGA	1	10	1	11-9-2014
HELSINKI	FIHEL	FINLAND	TRAVEMÜNDE	DETRV	GERMANY	HELSINKI-TRAVEMÜNDE	7	28	1	11-9-2014
HELSINKI	FIHEL	FINLAND	TALLINN	EETLL	ESTONIA	HELSINKI-TALLINN	20	2	1	14-9-2014
HELSINKI	FIHEL	FINLAND	TALLINN	EETLL	ESTONIA	HELSINKI-TALLINN	28	2	1	14-9-2014

HELSINKI	FIHEL	FINLAND	TALLINN	EETLL	ESTONIA	HELSINKI-TALLINN	14	2	1	14-9-2014
HELSINKI	FIHEL	FINLAND	STOCKHOLM	SESTO	SWEDEN	HELSINKI-MARIEHAMN-STOCKHOLM	4	12	2	14-9-2014
HELSINKI	FIHEL	FINLAND	STOCKHOLM	SESTO	SWEDEN	HELSINKI-MARIEHAMN-STOCKHOLM	7	12	2	14-9-2014
HERAKLION	GRHER	GREECE	PIRAEUS	GRPIR	GREECE	HERAKLION-PIRAEUS	7	9	1	14-9-2014
HUELVA	ESHUV	SPAIN				HUELVA-				
HULL	GBHUL	UK	HELSINKI	FIHEL	FINLAND	HULL-HELSINKI	1	71	1	11-9-2014
HULL	GBHUL	UK	ROTTERDAM	NLRTM	NETHERLANDS	HULL-ROTTERDAM	7	12	1	14-9-2014
HULL	GBHUL	UK	ZEEBRUGGE	BEZEE	BELGIUM	HULL-ZEEBRUGGE	7	14	1	14-9-2014
IGOUMENITSA	GRIGO	GREECE	ANCONA	ITAOI	ITALY	IGOUMENITSA-ANCONA	6	17	1	14-9-2014
IGOUMENITSA	GRIGO	GREECE	PATRAS	GRGPA	GREECE	IGOUMENITSA-PATRAS	6	6	1	14-9-2014
IGOUMENITSA	GRIGO	GREECE	ANCONA	ITAOI	ITALY	IGOUMENITSA-ANCONA	6	16,5	1	15-10-2014
IMMINGHAM	GBGSY	UK	TILBURY	GBTIL	UNITED KINGDOM	IMMINGHAM-TILBURY	1	7	1	11-9-2014
IMMINGHAM	GBGSY	UK	BREVIK	NOBVK	NORWAY	IMMINGHAM-BREVIK	2	27	1	11-9-2014
IMMINGHAM	GBGSY	UK	ESBJERG	DEEBJ	GERMANY	IMMINGHAM-ESBJERG	6	19	1	11-9-2014
IMMINGHAM	GBGSY	UK	GOTHENBURG	SEGOT	SWEDEN	IMMINGHAM-GOTHENBURG	6	27	1	11-9-2014
IMMINGHAM	GBGSY	UK	ROTTERDAM	NLRTM	NETHERLANDS	IMMINGHAM-ROTTERDAM	8	13,5	1	11-9-2014
IMMINGHAM	GBGSY	UK	CUXHAVEN	DECUX	GERMANY	IMMINGHAM-CUXHAVEN	5	24	1	11-9-2014
KIEL	DEKEL	GERMANY	ST PETERSBURG	RULED	RUSSIAN FEDERATION	KIEL-ST PETERSBURG	3	61	1	11-9-2014
KIEL	DEKEL	GERMANY	UST LUGA	RUULU	RUSSIAN FEDERATION	KIEL-UST LUGA	3	79	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	UST LUGA	RUULU	RUSSIAN FEDERATION	KLAIPEDA-UST LUGA	1	30	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	ST PETERSBURG	RULED	RUSSIAN FEDERATION	KLAIPEDA-ST PETERSBURG	1	32	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	KARLSHAMN	SEKAN	SWEDEN	KLAIPEDA-KARLSHAMN	7	12	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	KIEL	DEKEL	GERMANY	KLAIPEDA-KIEL	6	21	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	FREDERIKSHAVN	DKFDH	DENMARK	KLAIPEDA-FREDERIKSHAVN	2	31,5	1	11-9-2014
KLAIPEDA	LTKLJ	LITHUANIA	TRAVEMÜNDE	DETRV	GERMANY	KLAIPEDA-TRAVEMÜNDE	3	21	1	11-9-2014
KOPER	SIKOP	SLOVENIA				KOPER-				
KOTKA-HAMINA	FIKTK	FINLAND	HELSINKI	FIHEL	FINLAND	KOTKA-HAMINA-HELSINKI	2	8	1	11-9-2014

KOTKA-HAMINA	FIKTK	FINLAND	LUBECK	DELBC	GERMANY	KOTKA-HAMINA-LUBECK	1	42	1	11-9-2014
KOTKA-HAMINA	FIKTK	FINLAND	ANTWERPEN	BEANR	BELGIUM	KOTKA-HAMINA-ANTWERPEN	2	106	1	14-9-2014
KOTKA-HAMINA	FIKTK	FINLAND	LUBECK	DELBC	GERMANY	KOTKA-HAMINA-LUBECK	4	38	1	14-9-2014
KOTKA-HAMINA	FIKTK	FINLAND	GDYNIA	PLGDY	POLAND	KOTKA-HAMINA-GDYNIA	1	67	1	14-9-2014
KOTKA-HAMINA	FIKTK	FINLAND	ST PETERSBURG	RULED	RUSSIAN FEDERATION	KOTKA-HAMINA-ST PETERSBURG	1	21	1	14-9-2014
KOTKA-HAMINA	FIKTK	FINLAND	TILBURY	GBTIL	UNITED KINGDOM	KOTKA-HAMINA-TILBURY	2	81	1	14-9-2014
LA CORUNA	ESLKN	SPAIN				LA CORUNA-				
LA SPEZIA	ITSPE	SPAIN				LA SPEZIA-				
LAS PALMAS	ESLPA	SPAIN	ARRECIFE	ESACE	SPAIN	LAS PALMAS-ARRECIFE	1	9,5	1	14-9-2014
LAS PALMAS	ESLPA	SPAIN	CADIZ	ESCAD	SPAIN	LAS PALMAS-CADIZ	1	45,5	1	14-9-2014
LAS PALMAS	ESLPA	SPAIN	SANTA CRUZ DE LA PALMA	ESSPC	SPAIN	LAS PALMAS-SANTA CRUZ DE LA PALMA	1	19	1	14-9-2014
LAS PALMAS	ESLPA	SPAIN	SANTA CRUZ DE TENERIFE	ESSCT	SPAIN	LAS PALMAS-SANTA CRUZ DE TENERIFE	1	4	1	14-9-2014
LAS PALMAS	ESLPA	SPAIN	SANTA CRUZ DE TENERIFE	ESSCT	SPAIN	LAS PALMAS-SANTA CRUZ DE TENERIFE	21		1	24-9-2014
LAS PALMAS	ESLPA	SPAIN	ARRECIFE	ESACE	SPAIN	LAS PALMAS-ARRECIFE	7		1	24-9-2014
LE HAVRE	FRLEH	FRANCE	PORTSMOUTH	GBPME	UNITED KINGDOM	LE HAVRE-PORTSMOUTH	7	9	1	11-9-2014
LE HAVRE	FRLEH	FRANCE	PORTSMOUTH	GBPME	UNITED KINGDOM	LE HAVRE-PORTSMOUTH	3	7,5	1	24-9-2014
LEIXOES	PTLEI	PORTUGAL				LEIXOES-				
LEMESOS	CYLMS	CYPRUS	HAIFA	ILHFA	ISRAEL	LEMESOS-HAIFA	1	21	1	14-9-2014
LEMESOS	CYLMS	CYPRUS	LAVRIO	GRLAV	GREECE	LEMESOS-LAVRIO	1	48	1	14-9-2014
LISBOA	PTLIS	PORTUGAL				LISBOA-				
LIVERPOOL	GBLIV	UK	DUBLIN	IEDUB	IRELAND	LIVERPOOL-DUBLIN	18	7	1	14-9-2014
LIVERPOOL	GBLIV	UK	BELFAST	GBBEL	UNITED KINGDOM	LIVERPOOL-BELFAST	16	9	1	14-9-2014
LIVORNO	ITLIV	ITALY	BARCELONA	ESBCN	SPAIN	LIVORNO-BARCELONA	4	28	1	14-9-2014
LIVORNO	ITLIV	ITALY	VALENCIA	ESVLC	SPAIN	LIVORNO-VALENCIA	6	38	1	14-9-2014
LIVORNO	ITLIV	ITALY	PATRAS	GRGPA	GREECE	LIVORNO-PATRAS	1	52	1	14-9-2014
LIVORNO	ITLIV	ITALY	TUNIS	TNTUN	TUNISIA	LIVORNO-TUNIS	2	69,5	1	14-9-2014
LIVORNO	ITLIV	ITALY	MALTA	MTMLA	MALTA	LIVORNO-MALTA	3	48	1	14-9-2014

LIVORNO	ITLIV	ITALY	TRIPOLI	LYTIP	LIBYA	LIVORNO-TRIPOLI	1	102	1	14-9-2014
LIVORNO	ITLIV	ITALY	CATANIA	ITCTA	ITALY	LIVORNO-CATANIA	3	27	1	14-9-2014
LIVORNO	ITLIV	ITALY	PALERMO	ITPMO	ITALY	LIVORNO-PALERMO	4	21	1	14-9-2014
LIVORNO	ITLIV	ITALY	OLBIA	ITOLB	ITALY	LIVORNO-OLBIA	14	7	1	24-9-2014
LIVORNO	ITLIV	ITALY	BASTIA	FRBIA	FRANCE	LIVORNO-BASTIA	14	4	1	24-9-2014
LIVORNO	ITLIV	ITALY	BASTIA	FRBIA	FRANCE	LIVORNO-BASTIA	9	4	1	24-9-2014
LIVORNO	ITLIV	ITALY	BASTIA	FRBIA	FRANCE	LIVORNO-BASTIA	7	4	1	24-9-2014
LIVORNO	ITLIV	ITALY	GOLFO ARANCI	ITGAI	ITALY	LIVORNO-GOLFO ARANCI	8	10	1	24-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	UUSIKAUPUNKI	FIUKI	FINLAND	LUBECK (AND TRAVEMÜNDE)-UUSIKAUPUNKI	2	36	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	MALMÖ	SEMMA	SWEDEN	LUBECK (AND TRAVEMÜNDE)-MALMÖ	21	9	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	HELSINKI	FIHEL	FINLAND	LUBECK (AND TRAVEMÜNDE)-HELSINKI	7	30	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	ROSTOCK	DERSK	GERMANY	LUBECK (AND TRAVEMÜNDE)-ROSTOCK	1	6	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	ST PETERSBURG	RULED	RUSSIAN FEDERATION	LUBECK (AND TRAVEMÜNDE)-ST PETERSBURG	1	103	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	UST LUGA	RUULU	RUSSIAN FEDERATION	LUBECK (AND TRAVEMÜNDE)-UST LUGA	2	139	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	KLAIPEDA	LTKLJ	LITHUANIA	LUBECK (AND TRAVEMÜNDE)-KLAIPEDA	3	21	1	11-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	GOTHENBURG	SEGOT	SWEDEN	LUBECK (AND TRAVEMÜNDE)-GOTHENBURG	2	12	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	PALDISKI	EEPLA	ESTONIA	LUBECK (AND TRAVEMÜNDE)-PALDISKI	3	43	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	KOTKA	FIKTK	FINLAND	LUBECK (AND TRAVEMÜNDE)-KOTKA	2	41	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	HANKO	FIHKO	FINLAND	LUBECK (AND TRAVEMÜNDE)-HANKO	7	33	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	ST PETERSBURG	RULED	RUSSIAN FEDERATION	LUBECK (AND TRAVEMÜNDE)-ST PETERSBURG	2	59	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	LIEPAJA	LVLPX	LATVIA	LUBECK (AND TRAVEMÜNDE)-LIEPAJA	5	28	1	14-9-2014

LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	VENTSPILS	LVVNT	LATVIA	LUBECK (AND TRAVEMÜNDE)-VENTSPILS	2	26	1	14-9-2014
LUBECK (AND TRAVEMÜNDE)	DELBC	GERMANY	TRELLEBORG	SETRG	SWEDEN	LUBECK (AND TRAVEMÜNDE)-TRELLEBORG	23	8	1	14-9-2014
MALMÖ	SEMMA	SWEDEN	LUBECK (TRAVEMÜNDE)	DELBC	GERMANY	MALMÖ-LUBECK (TRAVEMÜNDE)	21	9	1	11-9-2014
MARSAXLOKK	MTMAR	MALTA				MARSAXLOKK-				
MARSEILLE	FRMRS	FRANCE	TUNIS	TNTUN	TUNISIA	MARSEILLE-TUNIS	3	36	1	11-9-2014
MARSEILLE	FRMRS	FRANCE	TUNIS	TNTUN	TUNISIA	MARSEILLE-TUNIS	1	24	1	14-9-2014
MARSEILLE	FRMRS	FRANCE	CALVI	FRAJA	FRANCE	MARSEILLE-AJACIO-BASTIA-PORTO VECCHIO-ILE ROUSSE-CALVI	3		5	14-9-2014
MARSEILLE	FRMRS	FRANCE	ALGIERS	DZALG	ALGIER	MARSEILLE-ALGIERS	1	24	1	14-9-2014
MARSEILLE	FRMRS	FRANCE	PORTO TORRES	ITPTO	ITALY	MARSEILLE-PORTO TORRES	1	5	1	14-9-2014
MARSEILLE	FRMRS	FRANCE	PROPRIANO	FRPRP	FRANCE	MARSEILLE-PROPRIANO	3	14,5	1	15-10-2014
MILFORD HAVEN	GBMLF	UK				MILFORD HAVEN-				
MOERDIJK	NLMOE	NETHERLANDS				MOERDIJK-				
NAANTALI	FINLI	FINLAND	KAPELLSKÄR	SEKPS	SWEDEN	NAANTALI-LÅNGNÄS-KAPELLSKÄR	2	7,5	2	11-9-2014
NAANTALI	FINLI	FINLAND	LÅNGNÄS	FILAN	FINLAND	NAANTALI-KAPELLSKÄR-LÅNGNÄS	2	7,5	2	11-9-2014
NAANTALI	FINLI	FINLAND	KAPELLSKÄR	SEKPS	SWEDEN	NAANTALI-KAPELLSKÄR	1	7,5	1	11-9-2014
NANTES - ST NAZAIRE	FRNTE	FRANCE	GIJON	ESGIJ	SPAIN	NANTES - ST NAZAIRE-GIJON	3	15	1	14-9-2014
NAPOLI	ITNAP	ITALY	CAGLIARI	ITCAG	ITALY	NAPOLI-CAGLIARI	2	13,5	1	24-9-2014
NAPOLI	ITNAP	ITALY	PALERMO	ITPMO	ITALY	NAPOLI-PALERMO	7	11	1	24-9-2014
OLBIA	ITOLB	ITALY	CIVITAVECCHIA	ITCVV	ITALY	OLBIA-CIVITAVECCHIA	7	7,5	1	24-9-2014
OLBIA	ITOLB	ITALY	CIVITAVECCHIA	ITCVV	ITALY	OLBIA-CIVITAVECCHIA	7	5,5	1	24-9-2014
OLBIA	ITOLB	ITALY	GENOVA	ITGOA	ITALY	OLBIA-GENOVA	3	13	1	24-9-2014
OLBIA	ITOLB	ITALY	GENOVA	ITGOA	ITALY	OLBIA-GENOVA	14	11	1	24-9-2014
OLBIA	ITOLB	ITALY	LIVORNO	ITLIV	ITALY	OLBIA-LIVORNO	14	7	1	24-9-2014
OLBIA	ITOLB	ITALY	PIOMBINO	ITPIO	ITALY	OLBIA-PIOMBINO	21	6	1	24-9-2014
OOSTENDE	BEOST	BELGIUM				OOSTENDE-				
PALERMO	ITPMO	ITALY	TUNIS	TNTUN	TUNISIA	PALERMO-TUNIS	2	12	1	14-9-2014

PALERMO	ITPMO	ITALY	GENOVA	ITGOA	ITALY	PALERMO-GENOVA	4	34	1	14-9-2014
PALERMO	ITPMO	ITALY	LIVORNO	ITLIV	ITALY	PALERMO-LIVORNO	4	22	1	14-9-2014
PALERMO	ITPMO	ITALY	SALERNO	ITSAL	ITALY	PALERMO-SALERNO	2	10,5	1	14-9-2014
PALERMO	ITPMO	ITALY	CAGLIARI	ITCAG	ITALY	PALERMO-CAGLIARI	1	11,5	1	24-9-2014
PALERMO	ITPMO	ITALY	NAPOLI	ITNAP	ITALY	PALERMO-NAPOLI	7	11	1	24-9-2014
PALMA DE MALLORCA	ESPMI	SPAIN	BARCELONA	ESBCN	SPAIN	PALMA DE MALLORCA-BARCELONA	7	7,5	1	14-9-2014
PALMA DE MALLORCA	ESPMI	SPAIN	BARCELONA	ESBCN	SPAIN	PALMA DE MALLORCA-BARCELONA	6	6,5	1	24-9-2014
PALMA DE MALLORCA	ESPMI	SPAIN	VALENCIA	ESVLC	SPAIN	PALMA DE MALLORCA-VALENCIA	7	8	1	14-9-2014
PALMA DE MALLORCA	ESPMI	SPAIN	VALENCIA	ESVLC	SPAIN	PALMA DE MALLORCA-VALENCIA	6	8	1	24-9-2014
PATRAS	GRGPA	GREECE	BRINDISI	ITBDS	ITALY	PATRAS-BRINDISI	7	15,5	1	14-9-2014
PATRAS	GRGPA	GREECE	LIVORNO	ITLIV	ITALY	PATRAS-CATANIA-GENOVA-LIVORNO	1	83,5	3	14-9-2014
PATRAS	GRGPA	GREECE	RAVENNA	ITRAN	ITALY	PATRAS-RAVENNA	5	33	1	14-9-2014
PATRAS	GRGPA	GREECE	IGOUMENITSA	GRIGO	GREECE	PATRAS-IGOUMENITSA	6	6	1	14-9-2014
PATRAS	GRGPA	GREECE	ANCONA	ITAOI	ITALY	PATRAS-IGOUMENITSA-ANCONA	6	23	2	24-9-2014
PATRAS	GRGPA	GREECE	BARI	ITBRI	ITALY	PATRAS-IGOUMENITSA-BAR	7	6,5	2	24-9-2014
PIOMBINO	ITPIO	ITALY	OLBIA	ITOLB	ITALY	PIOMBINO-OLBIA	14	6	1	24-9-2014
PIRAEUS	GRPIR	GREECE	HERAKLION	GRHER	GREECE	PIRAEUS-HERAKLION	7	9	1	14-9-2014
PORTSMOUTH	GBPME	UK	LE HAVRE	FRLEH	FRANCE	PORTSMOUTH-LE HAVRE	7	9	1	11-9-2014
PORTSMOUTH	GBPME	UK	BILBAO	ESBIO	SPAIN	PORTSMOUTH-BILBAO	2	63	1	14-9-2014
PORTSMOUTH	GBPME	UK	ZEEBRUGGE	BEZEE	BELGIUM	PORTSMOUTH-ZEEBRUGGE	2	13	1	14-9-2014
PORTSMOUTH	GBPME	UK	LE HAVRE	FRLEH	FRANCE	PORTSMOUTH-LE HAVRE	3	6,5	1	24-9-2014
PORTSMOUTH	GBPME	UK	CAEN	FRCFR	FRANCE	PORTSMOUTH-CAEN	18	7	1	24-9-2014
PORTSMOUTH	GBPME	UK	ST MALO	FRSML	FRANCE	PORTSMOUTH-ST MALO	4	12	1	24-9-2014
PORTSMOUTH	GBPME	UK	BILBAO	ESBIO	SPAIN	PORTSMOUTH-BILBAO	1	24	1	24-9-2014
PORTSMOUTH	GBPME	UK	SANTANDER	ESSDR	SPAIN	PORTSMOUTH-SANTANDER	1	24	1	24-9-2014
RAVENNA	ITRAN	ITALY	PATRAS	GRGPA	GREECE	RAVENNA-PATRAS	5	41	1	14-9-2014
RAVENNA	ITRAN	ITALY	IGOUMENITSA	GRIGO	GREECE	RAVENNA-IGOUMENITSA	5	33	1	14-9-2014

RAVENNA	ITRAN	ITALY	BRINDISI	ITBDS	ITALY	RAVENNA-BRINDISI	3	20,5	1	14-9-2014
RAVENNA	ITRAN	ITALY	CATANIA	ITCTA	ITALY	RAVENNA-CATANIA	3	38	1	14-9-2014
RIGA	LVRIX	LATVIA	STOCKHOLM	SESTO	SWEDEN	RIGA-STOCKHOLM	3	18	1	14-9-2014
RIJEKA	HRRJK	CROATIA				RIJEKA-				
RIO	GRRIO	GREECE				RIO-				
ROSSLARE HARBOUR	IEROS	IRELAND	FISHGUARD	GBFIS	UNITED KINGDOM	ROSSLARE HARBOUR-FISHGUARD	14	3,5	1	14-9-2014
ROSSLARE HARBOUR	IEROS	IRELAND	CHERBOURG	FRCER	FRANCE	ROSSLARE HARBOUR-CHERBOURG	3	18	1	14-9-2014
ROSSLARE HARBOUR	IEROS	IRELAND	CHERBOURG	FRCER	FRANCE	ROSSLARE HARBOUR-CHERBOURG	2	18	1	24-9-2014
ROSTOCK	DERSK	GERMANY	AARHUS	DKAAR	DENMARK	ROSTOCK-AARHUS	2	11	1	11-9-2014
ROSTOCK	DERSK	GERMANY	HELSINKI	FIHEL	FINLAND	ROSTOCK-HELSINKI	3	37	1	11-9-2014
ROSTOCK	DERSK	GERMANY	TRELLEBORG	SETRG	SWEDEN	ROSTOCK-TRELLEBORG	20	6	1	14-9-2014
ROSTOCK	DERSK	GERMANY	TRELLEBORG	SETRG	SWEDEN	ROSTOCK-TRELLEBORG	20	6,5	1	14-9-2014
ROSYTH	GBROY	UK	ZEEBRUGGE	BEZEE	BELGIUM	ROSYTH-ZEEBRUGGE	3	24	1	11-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	IMMINGHAM	GBGSY	UNITED KINGDOM	ROTTERDAM-IMMINGHAM	8	10	1	11-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	FELIXTOWE	GBFXT	UNITED KINGDOM	ROTTERDAM-FELIXTOWE	15	9	1	11-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	HULL	GBHUL	UNITED KINGDOM	ROTTERDAM-HULL	7	10	1	14-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	TEESPORT	GBTEE	UNITED KINGDOM	ROTTERDAM-TEESPORT	3	17	1	14-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	HARWICH	GBHRW	UNITED KINGDOM	ROTTERDAM-HARWICH	10	10	1	14-9-2014
ROTTERDAM	NLRTM	NETHERLANDS	KILLINGHOLME	GBKGH	UNITED KINGDOM	ROTTERDAM-KILLINGHOLME	3	14	1	14-9-2014
ROUEN	FRURO	FRANCE				ROUEN-				
SALERNO	ITSAL	ITALY	VALENCIA	ESVLC	SPAIN	SALERNO-VALENCIA	3	47	1	14-9-2014
SALERNO	ITSAL	ITALY	TUNIS	TNTUN	TUNISIA	SALERNO-TUNIS	1	25	1	14-9-2014
SALERNO	ITSAL	ITALY	MALTA	MTMLA	MALTA	SALERNO-MALTA	1	32,5	1	14-9-2014
SALERNO	ITSAL	ITALY	TRIPOLI	LYTIP	LIBYA	SALERNO-TRIPOLI	1	68	1	14-9-2014
SALERNO	ITSAL	ITALY	CATANIA	ITCTA	ITALY	SALERNO-CATANIA	6	13	1	14-9-2014
SALERNO	ITSAL	ITALY	CAGLIARI	ITCAG	ITALY	SALERNO-CAGLIARI	3	17	1	14-9-2014
SALERNO	ITSAL	ITALY	PALERMO	ITPMO	ITALY	SALERNO-PALERMO	2	9,5	1	14-9-2014

SCZECIN, SWINOUJSCIE	PLSWI	POLAND	TRELLEBORG	SETRG	SWEDEN	SCZECIN, SWINOUJSCIE-TRELLEBORG	10	7	1	14-9-2014
SCZECIN, SWINOUJSCIE	PLSWI	POLAND	YSTAD	SEYST	SWEDEN	SCZECIN, SWINOUJSCIE-YSTAD	13	8	1	25-9-2014
SCZECIN, SWINOUJSCIE	PLSWI	POLAND	TRELLEBORG	SETRG	SWEDEN	SCZECIN, SWINOUJSCIE-TRELLEBORG	19	8	1	24-9-2014
SCZECIN, SWINOUJSCIE	PLSWI	POLAND	YSTAD	SEYST	SWEDEN	SCZECIN, SWINOUJSCIE-YSTAD	28	9,5	1	24-9-2014
SEVILLA	ESSVQ	SPAIN				SEVILLA-				
SOUTHAMPTON	GBSOU	UK				SOUTHAMPTON-				
STOCKHOLM	SESTO	SWEDEN	HELSINKI	FIHEL	FINLAND	STOCKHOLM-MARIEHAMN-HELSINKI	4	12	2	14-9-2014
STOCKHOLM	SESTO	SWEDEN	HELSINKI	FIHEL	FINLAND	STOCKHOLM-MARIEHAMN-HELSINKI	7	12	2	14-9-2014
STOCKHOLM	SESTO	SWEDEN	TURKU	FITKU	FINLAND	STOCKHOLM-ALAND-TURKU	8	10	2	14-9-2014
STOCKHOLM	SESTO	SWEDEN	TURKU	FITKU	FINLAND	STOCKHOLM-TURKU	6	10	1	14-9-2014
STOCKHOLM	SESTO	SWEDEN	RIGA	LVRIX	LATVIA	STOCKHOLM-RIGA	3	17	1	14-9-2014
STOCKHOLM	SESTO	SWEDEN	TALLINN	EETLL	ESTONIA	STOCKHOLM-MARIEHAMN-TALLINN	3	17	2	14-9-2014
STOCKHOLM	SESTO	SWEDEN	TURKU	FITKU	FINLAND	STOCKHOLM-LANGNAS-MARIEHAMN-TURKU	14	10,5	3	14-9-2014
STOCKHOLM	SESTO	SWEDEN	MARIEHAMN	FIMHQ	FINLAND	STOCKHOLM-MARIEHAMN	7	11	1	14-9-2014
STRANRAER	GBSTR	UK				STRANRAER-				
TALLINN	EETLL	ESTONIA	HELSINKI	FIHEL	FINLAND	TALLINN-HELSINKI	20	2	1	14-9-2014
TALLINN	EETLL	ESTONIA	STOCKHOLM	SESTO	FINLAND	TALLINN-MARIEHAMN-STOCKHOLM	3	16	2	14-9-2014
TALLINN	EETLL	ESTONIA	HELSINKI	FIHEL	FINLAND	TALLINN-HELSINKI	28	2,5	1	14-9-2014
TALLINN	EETLL	ESTONIA	HELSINKI	FIHEL	FINLAND	TALLINN-HELSINKI	14	2,5	1	14-9-2014
TARRAGONA	ESTAR	SPAIN				TARRAGONA-				
TEESPORT/HARTLEPOOL	GBTEE	UK	ROTTERDAM	NLRTM	NETHERLANDS	TEESPORT/HARTLEPOOL-ROTTERDAM	3	18	1	14-9-2014
TEESPORT/HARTLEPOOL	GBTEE	UK	ZEEBRUGGE	BEZEE	BELGIUM	TEESPORT/HARTLEPOOL-ZEEBRUGGE	3	17,5	1	14-9-2014
TENERIFE	ESSCT	SPAIN	LAS PALMAS	ESLPA	SPAIN	TENERIFE-LAS PALMAS	21			24-9-2014
TERNEUZEN	NLTNZ	NETHERLANDS				TERNEUZEN-				
THESSALONIKI	GRSKG	GREECE				THESSALONIKI-				

TILBURY	GBTIL	UK	ANTWERPEN	BEANR	BELGIUM	TILBURY-AMSTERDAM-ANTWERPEN	1	53	2	11-9-2014
TILBURY	GBTIL	UK	GOTHENBURG	SEGOT	SWEDEN	TILBURY-GOTHENBURG	2	35	1	11-9-2014
TILBURY	GBTIL	UK	PALDISKI	EEPLA	ESTONIA	TILBURY-PALDISKI	1	93	1	14-9-2014
TILBURY	GBTIL	UK	KOTKA	FIKTK	FINLAND	TILBURY-KOTKA	2	114,5	1	14-9-2014
TILBURY	GBTIL	UK	HANKO	FIHKO	FINLAND	TILBURY-HANKO	1	62	1	14-9-2014
TILBURY	GBTIL	UK	RAUMA	FIRAU	FINLAND	TILBURY-RAUMA	1	86	1	14-9-2014
TILBURY	GBTIL	UK	ST PETERSBURG	RULED	RUSSIAN FEDERATION	TILBURY-ST PETERSBURG	2	115	1	14-9-2014
TILBURY	GBTIL	UK	ANTWERPEN	BEANR	BELGIUM	TILBURY-ANTWERPEN	1	18	1	14-9-2014
TILBURY	GBTIL	UK	ZEEBRUGGE	BEZEE	BELGIUM	TILBURY-ZEEBRUGGE	11	7	1	14-9-2014
TRELLEBORG	SETRG	SWEDEN	SASSNITZ	DESAS	GERMANY	TRELLEBORG-SASSNITZ	14	4,5	1	14-9-2014
TRELLEBORG	SETRG	SWEDEN	TRAVEMÜNDE	DETRV	GERMANY	TRELLEBORG-TRAVEMÜNDE	23	8	1	14-9-2014
TRELLEBORG	SETRG	SWEDEN	ROSTOCK	DERSK	GERMANY	TRELLEBORG-ROSTOCK	20	6,5	1	14-9-2014
TRELLEBORG	SETRG	SWEDEN	SWINOUJSCIE	PLSWI	POLAND	TRELLEBORG-SWINOUJSCIE	6	10	1	14-9-2014
TRELLEBORG	SETRG	SWEDEN	SWINOUJSCIE	PLSWI	POLAND	TRELLEBORG-SWINOUJSCIE	20	7	1	24-9-2014
TRIESTE	ITTRS	ITALY	DURRES	ALDRZ	ALBANIA	TRIESTE-DURRES	2	36	1	14-9-2014
TURKU	FITKU	FINLAND	LUBECK (TRAVEMÜNDE)	DELBC	GERMANY	TURKU-RAUMA-LUBECK (TRAVEMÜNDE)	1	47	2	11-9-2014
TURKU	FITKU	FINLAND	LUBECK (TRAVEMÜNDE)	DELBC	GERMANY	TURKU-LUBECK (TRAVEMÜNDE)	1	40	1	11-9-2014
TURKU	FITKU	FINLAND	PALDISKI	EEPLA	ESTONIA	TURKU-BREMERHAVEN-HARWICH-CUXHAVEN-PALDISKI-	1	144	4	14-9-2014
TURKU	FITKU	FINLAND	STOCKHOLM	SESTO	SWEDEN	TURKU-ALAND-STOCKHOLM	8	10	2	14-9-2014
TURKU	FITKU	FINLAND	MARIEHAMN	FIMHQ	FINLAND	TURKU-MARIEHAMN-LANGNAS-STOCKHOLM	14	10,5	3	14-9-2014
TURKU	FITKU	FINLAND	STOCKHOLM	SESTO	SWEDEN	TURKU-STOCKHOLM	6	10	1	14-9-2014
VALENCIA	ESVLC	SPAIN	CAGLIARI	ITCAG	ITALY	VALENCIA-CAGLIARI	3	26	1	14-9-2014
VALENCIA	ESVLC	SPAIN	LIVORNO	ITLIV	ITALY	VALENCIA-LIVORNO	6	38	1	14-9-2014
VALENCIA	ESVLC	SPAIN	SALERNO	ITSAL	ITALY	VALENCIA-SALERNO	3	47	1	14-9-2014
VALENCIA	ESVLC	SPAIN	SAVONA	ITSVN	ITALY	VALENCIA-SAVONA	6	24	1	14-9-2014
VALENCIA	ESVLC	SPAIN	FORMENTERA	ESFNI	SPAIN	VALENCIA-FORMENTERA	4	6,5	1	14-9-2014

VALENCIA	ESVLC	SPAIN	IBIZA	ESIBZ	SPAIN	VALENCIA-IBIZA	7	6,5	1	14-9-2014
VALENCIA	ESVLC	SPAIN	PALMA DE MALLORCA	ESPMI	SPAIN	VALENCIA-PALMA DE MALLORCA	6	8	1	14-9-2014
VALETTA	MTMLA	MALTA	CATANIA	ITCTA	ITALY	VALETTA-CATANIA	1	9	1	14-9-2014
VALETTA	MTMLA	MALTA	GENOVA	ITGOA	ITALY	VALETTA-GENOVA	1	39	1	14-9-2014
VALETTA	MTMLA	MALTA	LIVORNO	ITLIV	ITALY	VALETTA-LIVORNO	1	57,5	1	14-9-2014
VALETTA	MTMLA	MALTA	SALERNO	ITSAL	ITALY	VALETTA-SALERNO	1	26,5	1	14-9-2014
VALETTA	MTMLA	MALTA	TRIPOLI	LYTIP	LIBYA	VALETTA-TRIPOLI	1	27	1	14-9-2014
VENEZIA	ITVCE	ITALY	PULA	HRPUY	CROATIA	VENEZIA-PULA	5	3	1	14-9-2014
VENTSPILS	LVVNT	LATVIA	TRAVEMÜNDE	DETRV	GERMANY	VENTSPILS-TRAVEMÜNDE	2	25	1	14-9-2014
VLISSINGEN	NLVLI	NETHERLANDS				VLISSINGEN-				
WARRENPOINT	GNWPT	UK				WARRENPOINT-				
ZEEBRUGGE	BEZEE	BELGIUM	BILBAO	ESBIO	SPAIN	ZEEBRUGGE-EL FERROL -SANTANDER-BILBAO	1	78	3	11-9-2014
ZEEBRUGGE	BEZEE	BELGIUM	ROSYTH	GBROY	UNITED KINGDOM	ZEEBRUGGE-ROSYTH	3	24	1	11-9-2014
ZEEBRUGGE	BEZEE	BELGIUM	BILBAO	ESBIO	SPAIN	ZEEBRUGGE-BILBAO	2	40	1	14-9-2014
ZEEBRUGGE	BEZEE	BELGIUM	HULL	GBHUL	UNITED KINGDOM	ZEEBRUGGE-HULL	7	14	1	14-9-2014
ZEEBRUGGE	BEZEE	BELGIUM	TEESPORT	GBTEE	UNITED KINGDOM	ZEEBRUGGE-TEESPORT	3	16	1	14-9-2014
ZEEBRUGGE	BEZEE	BELGIUM	TILBURY	GBTIL	UNITED KINGDOM	ZEEBRUGGE-TILBURY	11	7	1	14-9-2014

9 APPENDIX 3: SAMPLE LETTER TO POTENTIAL DATA PROVIDERS

Similar letters were send to other potential data providers

Technische Universiteit Eindhoven University of Technology

Department of Industrial Engineering & Innovation Sciences

Prof. Dr. P.W. de Langen
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The Netherlands

To:
Journal of Commerce
Zach Gorman
Sales and Marketing Associate
Ph: 973.776.7820
E-mail: zgorman@joc.com

Subject
Contact

Date
7 October 2013

Contact
T +31 611768877
p.w.d.langen@tue.nl

Dear mr. Gorman,

Eindhoven University of Technology is working with 12 industry partners, including the European Sea Ports Organisation (ESPO) on a EU funded project, PORTOPIA, to develop a set of port performance indicators. The goal is to realize a permanent 'observatory' that is rooted in academic expertise, supported by the industry, and financially self-sustaining. Most indicators will be developed based on data provided by the ESPO members, the port authorities. In addition, we will also develop some indicators based on other data. A central one is a *maritime connectivity indicator*. This indicator expresses the quality of connections of EU ports with markets overseas. The indicator deals with containers only. We have developed a method to calculate a connectivity indicator based on the connectivity between 'port pairs' (e.g. Rotterdam Shanghai). Ideally the indicator should capture data on:

- Frequency of services
- Transit time of services
- Ship size of services
- The number of competing carriers that provide services

We strongly believe such an indicator is valuable for port authorities, shipping lines, shippers and policy makers.
A major challenge is the data collection. These data are available from the shipping lines, but collecting them is time consuming. Alternatively, we may be able to develop a partnership with JOC, where JOC provides the data (with clearly defined limits regarding the use of the data) and Eindhoven University of Technology (the lead partner for the development of this indicator) performs the calculations to develop the indicators. The project does not allow for purchasing the data, so we would have to discuss a potential win-win partnership on another basis. We see two potential benefits for JOC:

Where innovation starts