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Speeds & Capacities Necessity of Boats for Improve the Competitiveness of the Short-Sea-Shipping in West Europe Respecting the Marine Environment

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ABSTRACT

This paper aims to contribute to highlight the main factors which determine the commercial success of Short-Sea-Shipping lines. As a part of complex topic of modal competition, we will focus on the ship's performances. The finality is to define the capacities and the speeds needed by ships for compete effectively with the services "all-by-road" of freight transport in West Europe. In fact, the flexibility is the main competitive advantage of road transport over the other modes as maritime, fluvial or railways, and the travel time is the second one. With exception of some cases which have ports as origin and destination, the transport "Door-to-Door" needs the participation of road transport ineluctably. So, the modal competition between the Short-Sea-Shipping and the road transport is in fact a problem of their complementarily. The really important matter is how to maximize the Short-Sea-Shipping' component into the travels which combine the maritime and the road transports. The main impediments for the SSS's component maximisation are the travel time of the boats and the ports passage time.

In continuity of our precedent researches, we use the results showing the more competitive SSS's lines (Martell Flores, 2007). On this base, we proposed the links between ports and the best operation way for each one, in "classical lines" of collecting & distribution or as "shuttle lines". All lines initially proposed are competitive with road transport under the costs criterion, but not always, even rarely, under the travel time criterion. We take the travel time by road as reference to define the travel time that the ships need to reach in order to be competitive. So, this analysis includes the cost & the travel time as criteria of comparison. We analyzed a network of the main 112 cities in West Europe, including 57 ports, which constitute our O-D matrix. For this analyse we use the DETCCM algorithm, it identified the differences between travel times of transports in "all-by-road" and in combined "maritime / road" for each possible link of the O-D matrix. The results show us a selected number of SSS's lines which are competitive in the current conditions of travel time. They show us the average speeds' necessaries to reach the competitive travel times for the rest of the lines. Finally, we made a performances' review of the more currents ships in order to propose the more adapted kind of ship to the SSS proposed lines. The results underline the necessity to make new naval engineering developments oriented to design a specific Short-Sea-Shipping' boat in the close future.

1. The factors of commercial success of the short-sea-shipping transport services

The particular characteristics of the different transport modes offer to shippers more or less advantages in function of the infrastructures capacities, vehicle's performances and the operating systems of each mode. The client point of view about the efficiency of a transport mode plays the most important roll in the modal choice. We have resumed the principal factors of the shippers' preferences as follow.

1.1. The cost of transport

Traditionally, the cost of freight transport was the principal criterion for shippers to choice between modes of transport. The majority of transports modal choice models was been designed in attention at this unique factor of choice. Today, the travel cost continues to lead the choice between modes. But in many cases, especially for medium and high value freight, the indirect costs of transhipments and/or of longer travel times push the shippers to prefer the road's transports even if they are expensive in comparison with other modes. In fact, the costs of Short-Sea-Shipping are attractive, and if we consider only this criterion, there are many maritime links with a high economics' potential of development (Table 1). But the other factors as the flexibility, the safety & security of freight, and travel time are more advantageous for the road transport.

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1.2. The safety and security of freight

The freight safety is a choice criterion which gives a great advantage to road transport in comparison with other modes and even in the case of combined transport (multimodal). One of the principal problems of the combined transport is the transhipment's handling between different vehicles from truck to boat, from truck to rail or other combinations. Each transhipment handling implies a "risk of damage" to freight. So, many shippers prefer to contract the transport services "all-by-road" to limit the number of transhipments handling and the risk's of freight damage.

The freight security is a choice criterion highly important but not really a discrimination factor between modes. Today, localisation by satellite and the tele-detection systems make possible to track vehicles, and containerized goods in an efficiently way and in real time. Thus, security level between transport modes is equivalent and it does not represent a disadvantage to Short-Sea-Shipping into the modal competition. Nevertheless, the shippers are more comforted with the idea of a "unique responsibi lity along the travel".

1.3. The flexibility of transport and the care of freight handling

The flexibility of a transport mode means the capacity of mode to link one origin and one destination everywhere and of the most directly way. The transport's services "door-to door" by the same vehicle represent the maximal flexibility. This is only the case of road transport because the truck may to go to any place communicated by the road network. For the others modes (maritime, railway, fluvial and aerial), the flexibility is reduced and represent a handicap, it make them dependent of the road transport to complete the services "door-to-door". In the case of the Short-Sea-Shipping, it is evident the necessity to find best compromises between maritime transport and the road transport to improve the offer of Short-Sea-Shipping's services. It is necessary to do the transport on the same contract and to find agreements between the road transport's operators and the Short-Sea-Shipping's operators with the finality to engage a unique responsibility in the contracts with the shippers.

1.4. The travel time

The travel time of freight transport becomes a very important criterion in modal choice, sometimes even in regard of the cost. The recent dynamics of the commerce as well as of the industrial's production and distribution has need of travel time reductions. The logistics exigencies derived of concepts as "just-on-time" pushed to reduce the travel times more and more. The "short travel time" becomes a key factor to the development of the Short-Sea-Shipping. The main objective of this paper is to demonstrate the necessity to improve the Short-Sea-Shipping boat's speed. Currently, the travel time reductions may to be done by the optimizing of the composition, rotations and itineraries of the fleet in service. Nevertheless, in the close future it will be necessary to design, to construct and to put in operation the adapted boats to the new necessities of speed. As well as more adapted to improve the freight safety and the handling care in order to increase their intermodal compatibility.

Table 1: The means of "Costs & Speeds" for the trucks and boats operation in Europe

Modal Choice Variable	Diffrents values for the same variable in fonction of sources	Mean Value considerto analyse (DETCCM)
Costs	[€/km]	[€/km]
Road Transport [Truck]	1,05 (b)	1,05
Short-Sea-Shipping [cont. 40']	0,75 (b)	0,75
Speeds	[km/h] (c)	[km/h]
Road Transport [Truck]	85 (c); 75 (a)	90
Short-Sea-Shipping [boat] 3	4 (18 Knot)	37 (20 knot)

Sources: (a) O bservatori de costos del transportde mercaderias per carretera a Cataluya
(b) SCEREN, Les ports maritimes français dans les échanges mondiaux
(c) Enquête de transit, Ministère de l'Équipement des transports et du logement

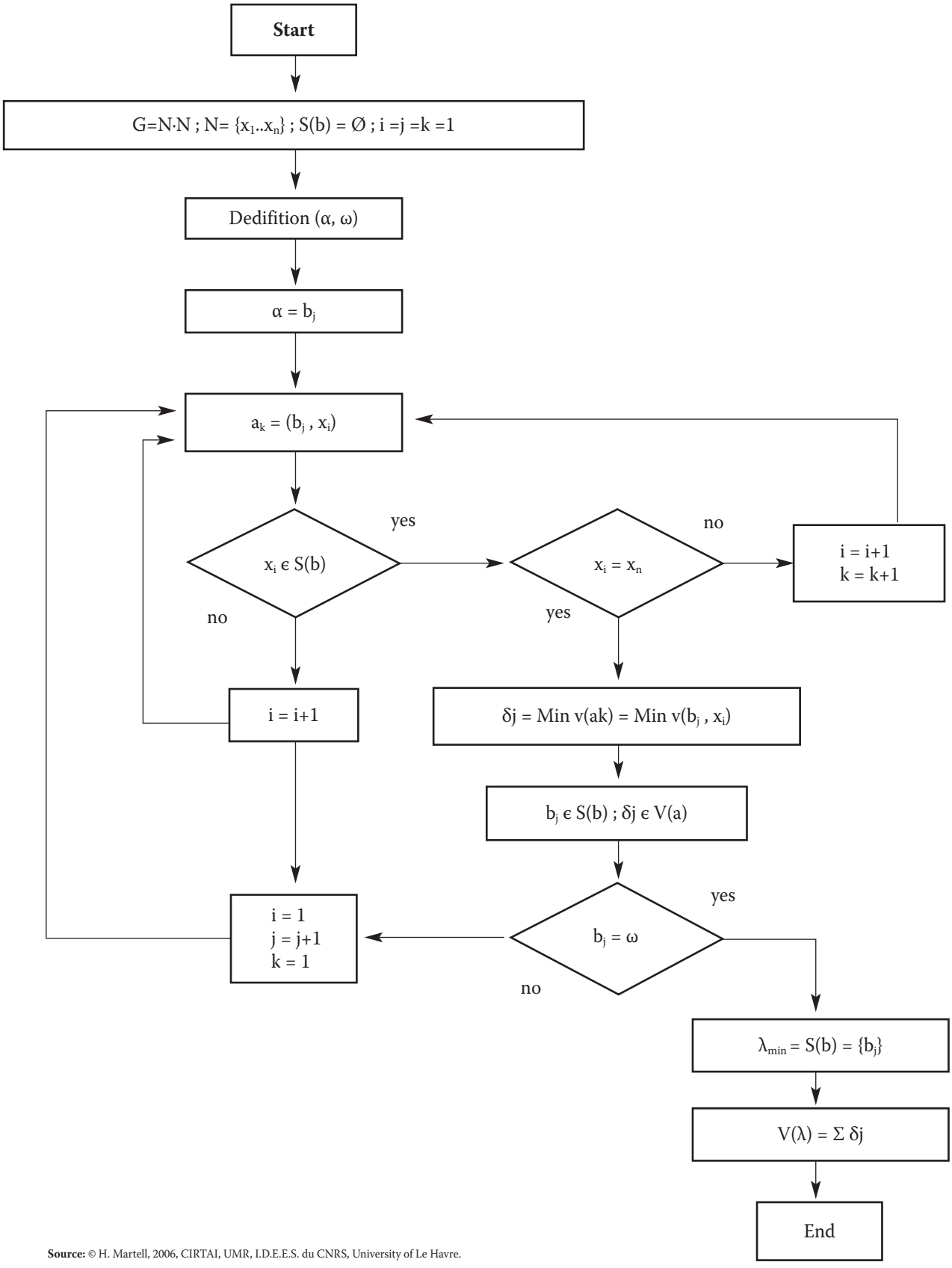
2. The more competitives links of the short-sea-shipping in Europe

To define the more competitive lines of Short-Sea-Shipping we can not forget the handicap caused by his lack of flexibility. So, we accepted his dependence of the road transport for complete the freight itineraries. Our analysis is based on the principle that Short-Sea-Shipping has to be considering not as an independent mode of transport in competition with the others modes, but as a part of a total transport chain. The real question is not how to do the maritime transport more competitive than road transport. But how to integrate the combined transport services "sea & road" to reach the performances of transports "all-road" with the largest component of Short-Sea-Shipping. Of course, a largest component of Short-Sea-Shipping means economies of costs, reduction of energy spent by cargo unit and reduction of pollution.

2.1. Evaluation of the Short-Sea-Shipping' competitiveness

As result of precedents works about competitive of short-sea-shipping to the transport of containerized general freight, we identified links between ports with high potential of development. This analyse was made on the base of a 112 European cities sample which 57 ports. We applied the algorithmic model DETCCM which is based on the Dijskstra's shortest way algorithm adapted to the case of combined transport services "Maritime & Road" (Martell Flores, 2007). This model finds and evaluates all possible combinations of transport "Maritime & Road" between the 112 cities. The principle of the algorithm is to superpose the maritime network onto the road network to analyse all possible combinations as only one network. Affecting the links of superposed networks by the different modal choice criteria we can evaluate the combined itineraries. The evaluation may to be done under different criteria of modal choice: the travel cost, the travel time, the energy spent or the travel pollution emission.

Figure 1: Flux diagram of DETCCM model "Optimized Detection of Combined Multimodal Chains".

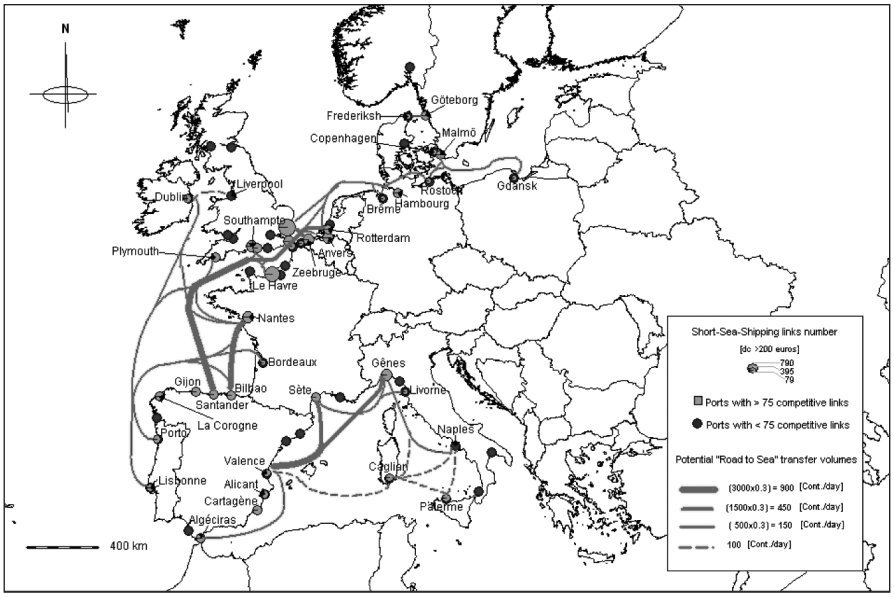


Source: © H. Martell, 2006, CIRTAI, UMR, I.D.E.E.S. du CNRS, University of Le Havre.

2.2. DETCCM's analysis results in the case of combined travels "road & sea"

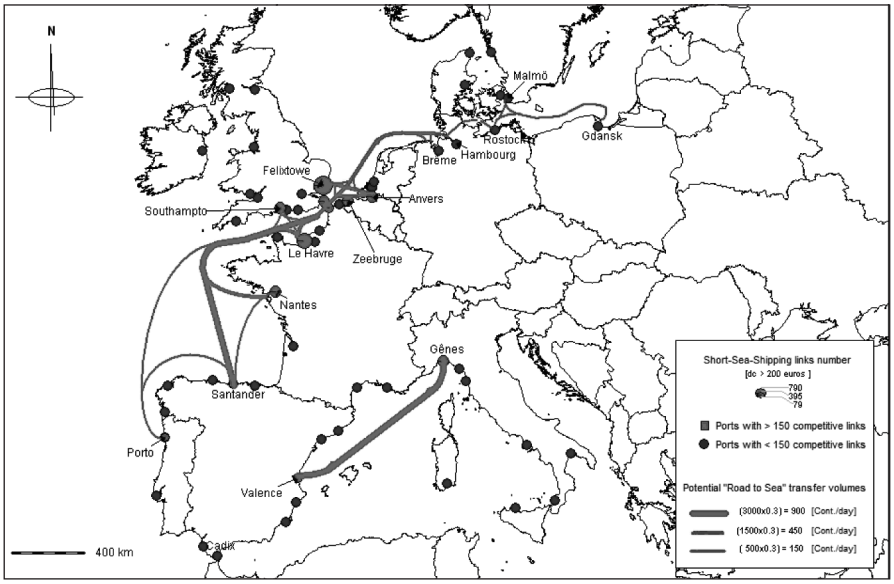
The model was applied to detect the combined transport optimal chains including the road transport and the Short-Sea-Shipping under costs criterion. To define the lines with high commercial potential we compared the "Road & Short-Sea-Shipping" combined chains between an origin city and a destination city, with the option of transport "All-by-Road" to the same couple of cities. The parameter of cost established for qualified links as "high competitive" is 200€. The freight's road to sea transfer was considered as the 30% of current road traffic. A systematically analysis was done for all the cities in our sample. The results show, in a first time, the ports' potential to absorb the freight flux currently transported by road. The ports with less than 75 potential links were considered as "not interesting", to develop the Short-Sea-Shipping lines. The ports with more than 75 links to develop the Short-Sea-Shipping appear in green colour. In a second time, we identified the more recurrent destinations from each "Highly potential port", in this way, we could defined the more interesting itineraries or "the lines of high development potential". The supposed transfer of 30%, give us a clearly idea of freight volumes to be absorb by the Short-Sea-Shipping lines proposed. In the next figure we can appreciate the global results of the analysis which demonstrate the viability of the lines in terms of costs.

Figure 2: The potential freight transfer from the road to the Short-Sea-Shipping in West Europe "Shuttle Lines of highly potential under the costs criterion".



Source: © H.Martell, CIRTAI, UMR 6063, CNRS, University of Le Havre, 2006.

Figure 3: The potential freight transfer from the road to the Short-Sea-Shipping in West Europe "Classical Short Lines with highly potential under the costs criterion".



Source: © H.Martell, CIRTAI, UMR 6063, CNRS, University of Le Havre, 2006.

The analysis of optimal transports chains or combined itineraries shows different results in function of the evaluation criterion. In the case of travel time criterion, we observed a several reduction of optimal itineraries in comparison with the cost criterion. As we said in 1.4, the travel time becomes a key factor to the development of the Short-Sea-Shipping. So, make improvements to diminish the maritime travel times are the priority for develop the Short-Sea-Shipping in a effectively way and to acheive the objectives of modal transfer of freight from the road to the sea. The precedent results were obtained considering the "ports passage". For that, we add twice the mean of 8h per port passage, and in the case of costs, the mean of 100€ /container 40' per passage. It is necessary to distinguish two kinds of Short-Sea-Shipping lines, the Roll-on/Roll-off for which the "truck" is the transport unit and the Lift-on/Lift-off for which the "container" is the transport unit. The Short-Sea-Shipping lines proposed in Fig.2 can to be developed in both modalities Roll-on/Roll-off or Lift-on/Lift-off, but it is recommended to use Roll-on/Roll-off in order to diminish the port's passage times, specially in the case of new lines.

3. The priority improvements for the short sea shipping

The Short-Sea-Shipping's activities need improvements in different aspects of the services. We consider that the main 4 improvements and their priority are: a) diminish the port pas-

sage costs and times; b) modernize the fleet; c) propose new services and differentiate them in function of shippers' need, and d) reduce the administration and the customs formalities. Each improvement needs special and more deep research works, in this paper we analysed the importance of the reduction the travel time as "the priority" to improve the competitiveness of the Short-Sea-Shipping services.

3.1. The currently status and the priority improvements

In the current conditions, the Short-Sea-Shipping transports of general freight have several unexploited potentials. In general, for the medium value cargo and the high value cargo, the Short-Sea-Shipping services are in fact condemned to stagnation in the modal split. As we saw the main solution to attract this kind of traffics is to diminish the travel times. What to do to diminish the travel times? What elements composed the travel? How to reduce the delays of these elements?

We consider that the Short-Sea-Shipping travel time is composed by the "Navigation time" and the "Port's passage time". So the reduction of travel times implies the reduction of both elements. We will focus on the navigation times and boats performances. The subject of "port's passage times" is another great problem for which the solution implies many factors as: labour laws in different countries, different labour costs between them, and the differences of cargo handling performances between ports in Europe. All mentioned aspects have to being the subject of future specific researches. We will continue with the definition of boat's performances necessities for emulate the road transport's performances about "travel times".

3. 2. The Short-Sea-Shipping' different services and the different needs of boats

The results of the highly potential lines were obtained in considering two kinds of services. The classical Short-Sea-Shipping service with rotations between many ports, and the shuttle services between two ports. In each case, the boat's needs are different. The classical service of Short-Sea-Shipping, needs ships with cargo's capacities of 500 -1000 TEU in order to transport and exchange the containers between all the ports of the rotation. The boats need to have an important stock capacity because more cargo capacity means more autonomy to serve a most important number of ports as well as the possibility of charging more goods in each rotation. But, more cargo capacity means less navigation speed and the more important travel times. About the boarding system, we find principally the boats Lift-on Lift-off (Lo-Lo) and rarely the boats Roll-on Roll-off (Ro-Ro) or with combined boarding systems.

In the case of shuttle modality the logic of operation is not the same. The principal interest is to serve the transport's demand between two ports in maintaining the frequency of the rotations in the shortness time. In the case of demand increase we can to affect another boat to the same line to double the capacity that we offer. In this case the cargo capacities may to be less important; the principal factor is ensuring a good the level of the service. It is the case of the ferries boats. Another case of the Short-sea-Shipping is the "dedicated services" as the case of "Airbus Maritime Logistics" between the different plane's factories along Europe. For this modality of shuttle, the fleet is principally composed of boats Ro-Ro and rarely of the ships with boarding' combined systems or of the ships Lo-Lo.

3.3. The necessity of "Fast-ships" to improve the competitiveness of Short-Sea-Shipping

The analyse results the transport chains "Road & Sea" in considering the travel time as comparison criterion, shows that the ports passage have an important impact in the total travel time. We consider the Short-Sea-Shipping total's travel time (SSS t) adding the navigation time between ports plus the ports passage's time.

$$SSS\ t = N\ t + 2\ PP\ t \quad [h]$$

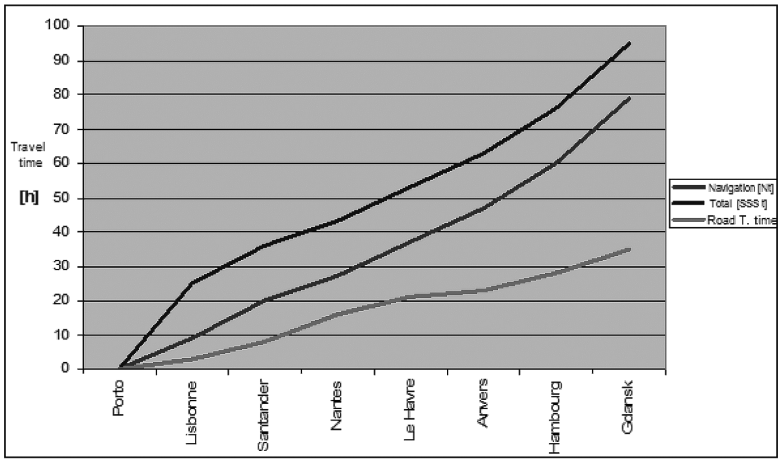
SSS t = Total travel time
Nt = Navigation's time
PPt = Port passage's time

For the navigation distances until 300 nm we have a mean navigation's time of 15h. The port passage in the case of containers on boats LO-LO has a mean time of 2x8=16h. In this condition the port passage represent 50% of total Short-Sea-Shipping travel time. As a first conclusion we can say that: "The Short-Sea- Shipping in the Lo-Lo modality is not really competitive for distances < 300 nm and only the Ro-Ro services will to be consider to develop lines to this very short distances. For the more important distances > 300 nm it become more competitive in function of the augmentation of distance. Nevertheless, even for the important navigation distances, the time of port passages represent a handicap to the Short-Sea-Shipping.

We can see on Figure 4 a comparative curve taking some representative ports in function of their distances to a hypothetical origin, we have chose "Porto" for appreciate the effect on the axis west-to-east. The two superior curves represented the time of navigation "Nt" and the port's passages "2xPPt". We can observe that with a speed of 20 knots, the competitivity of Short-Sea-Shipping decrease in proportional way of the distance increase. Otherwise, the increase of navigation distance reduces the negative effect of ports passage times into the total time of the travel "SSSt", but it rest no competitive.

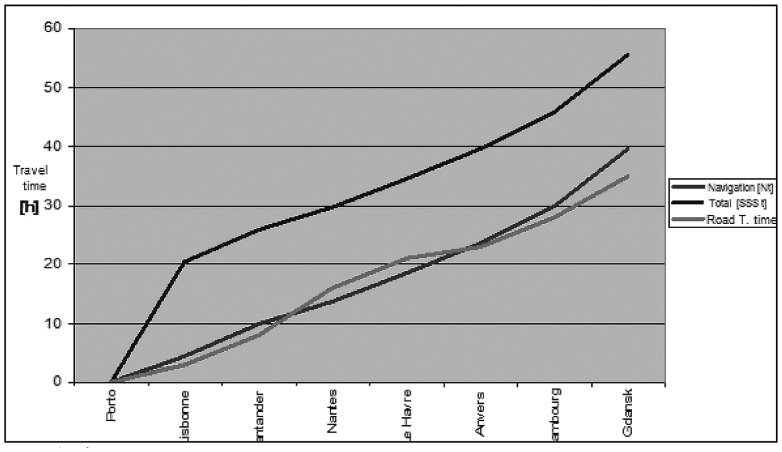
The Figure 5 show a curve which compares the Short-Sea-Shipping total travel time (SSSt), the navigation time (Nt) and the truck travel time (Rt). We can see the important delay of port passage in the Lo-Lo case. In the case of boats Ro-Ro the port's passage is reduced, we take a mean of 30min per passage. We can see that if the Short-Sea-Shipping' boats achieves the 40 knots as mean speed, the navigation times became almost similar than the truck travel times. In this condition, the Short-Sea-Shipping efficiency in terms of travel time is equivalent to the efficiency of road transport.

Figure 4. Comparative curve of travel times from Porto to some Ports in Europe in relation with navigation distances. With classical ships [mean speed = 20 knots]



Source: Authors.

Figure 5. Comparative curve of travel times from Porto to some ports in Europe in relation with the navigation distances. With high speed ships [mean speed = 40 knots]



Source: Authors.

If the Short-Sea-Shipping transport achieves the same levels of service, especially of the "travel time" than the road transport, the freight modal transfer from the road to the sea will have really chances to be done. In the opposite case, if the Short-Sea-Shipping boats continue to offer the current mean travel speed (20 knots) and the" total travel times" like at present, the freight modal transfer from the road to the sea is not really possible by lack of performance. We do not say that increase the travel speed of the boats is the magic solution to succeed the modal transfer because there are many factors involved, but we affirm that is a condition "without which the transfer is simply not possible".

The speed boat's improvements might to equalize the competition conditions between road and sea. The potential effects might to be highly positives on the development of Short-sea-Shipping in Europe. In regard of the shipper's interests, the Short-Sea-Shipping services will be absolutely competitive with "all-road" transport. In other words, it will be cheaper, with same travel times, trustable and regular. Of course, it will rest dependent of the port's passages, but boarding/disembark systems might to contribute to diminish this dependency of human and social factors.

In the next section we analyse the characteristics of the boats employed by the Short-Sea-Shipping services. This section shows the differences between boats' available and currently used in Europe. We will discuss about their capacities and the relation between the mean speeds, the load pay, the boat hull design and the energy consumption.

4. The boat capacities & the needs of speed

The majority of Short-Sea-Shipping boats operating in Europe are ferries aged of 10 - 20 years in the case of Ro-Ro services. In the case of Lo-Lo services the fleet is principally composed by port containers Panamax boats aged of 30 years or more. These Panamax boats are the recycled boats from the regular intercontinental lines. Today is necessary to ask us about the necessity of a new generation of boats specifically designed to the Short-Sea-Shipping. We go to begin by describe the characteristics of current fleet.

4.1. The boats characteristics of current Short-Sea-Shipping fleet in Europe

The ferry and "Roll On /Roll Off" services have an important role on the passenger and on a small amount of freight transport, such as the carriage of trailers, trucks and vehicles. The boats "Roll On /Roll Off" have the advantage of the fast loading /unloading and simple stowing and lashing. The only inconvenient is their need for more specific ship designs and the adapted port facilities. To this kind of boats, the ports need ramps to load the trucks or trains.

The general cargo boats with "Lift-on Lift-off" systems might to be classified in function of the kind of cargo, for example: palletized cargo, forest products, cars, bulks, liquid bulks or containers. These goods can be moved by units but the port' terminals need special docks and tools to handle them, warehouses, tractors, forklifts and trailers. In the case of containerized cargo, the port system should be capable to handle different units such as: containers ISO/UECI, cassettes, storage boxes (dedicated ports) and Roll trailers. A big inconvenient is the fact that with the exception to the first case, the named units are stored in the port because they cannot circulate outside it. Additionally, the terminal needs devices to board the goods from those units to a container or trailer and vice versa, e.g. cranes, straddle carriers, forklifts are some of these devices.

Table 2: The specialized boats adapted to the cargo.

Type of user	Ship Type
Containers	Cellular or multipurpose ship
Pallets	Conventional twin deck or multipurpose ship
Cargo on trailer	Ro/Ro or multipurpose ship
Big pieces	Heavy lift or multipurpose ship
Lighters	LASH ships
General cargo	Conventional twin deck or multipurpose ship
Perishable goods	Reefer ship

Source: "El transporte marítimo". R. Romero. Ed. Logisbook. 2002.

The Short-Sea-Ships are usually quite smaller than deep sea ones from aprox. 400 to 6,000 DWT. This is because the demand is weaker usually in short routes and the high number of short journeys requires smaller ships in order to reduce the port calls' time. There are several classifications regarding SSS ships reducing them to three main categories as: single-deck bulk carriers, container – feeder vessels and ferries. Further Marlow et al. (1997) proposed that specific size ships are the ones involved in the coastwise transport system, and even considering that things could change in the following years, they could be split in the following categories:

— Tankers and bulk carriers up to 13,000 GT and /or 20,000 GT
— General cargo or break bulk carriers up to 10,000 GT and / or 10,000 DWT
— Combined passenger / cargo ships and Ro/Ro between 1,000 GT and / or 500 DWT and 30,000 GT and /or 15,000 DWT.

4.1.2. Technical characteristics of the conventional ships Lo/Lo

This kind of ships can be used in SSS but also in pure feeder traffics. Their main characteristics from a global point of view are the small size, cellular holds, no derricks (gearless, but there are also geared units). The geared units use to have 2 turning derricks that could be an obstacle for the port operations and make the ship more expensive to build.

During the year 2000, there were 1050 Lo/Lo units within the feeder range (100 – 1050 TEU's) in the world.

The common speeds range from an average of 18 knots and exceeding the 20 knots with no operational or building costs, increase. A typical modern ship of these characteristics can be defined as follows:

— Capacity of around 500 TEU's.
— Hatch coverless and geared.
— 137 x 19,5 x 5 meters.
— 6,200 metric tonnes deadweight.
— Speed: 15 knots.
— 2 x 4,700 kW transmitted by 2 azipods.
— Consumption of 1.6 Tm per hour at 90% MCR.
— Building cost with derricks of around 25 M€.

Technical characteristics of the conventional ships Ro/Ro

The Ro/Ro or cargo ferries are units typically used for coastwise and island traffics, together with the SSS. The cargo handling in this type of ships is quicker than in Lo/Lo ships and thus cheaper. They require no derricks but only a ramp to easy the operative. These ships have shoal drafts in order to have no obstacles to sail through the channels. However, their capacity can be as far as half than other Lo/Lo ships of the same size, because cargo goes on wheels, losing space under and above those units. Additionally, some space is lost in the holds because their internal structures are thicker: frames, beams and webframes. Also, they need spaces to locate the internal ramps, lifters and accesses including the space between trailers. All these details make the Ro/Ro ships, a more expensive ship, as far as doubling the building costs per TEU unit of the Lo/Lo traditional ships. The short distance operation benefits Ro/Ro ships by lower port costs, compensating the higher constructive costs.

Figure 6: The Mono hull, Lo-Lo ship at Nantes.

Source: Gilbert Cailler.

Figure 7: Mono hull, Ro-Ro ship at Dunkirk.

Source: Acomimage.

The nowadays configuration of these ships, is based on a cargo space, distributed in 2 or 3 decks; to accept the trailers and rolling material. Their cargo capacity is measured in lineal meters to calculate the number of trailers to be carried (among 13, 14.5 or 16 meters long each). It is desirable that the cargo garage be squared with parallel rows to park the vehicles. They are equipped with ramps astern and sometimes ahead. The biggest ships have side ramps or even in the quarter, which allows them to be operated in the so called Mediterranean disposition. The port operation is carried out through tractors that can handle easily the rolling cargoes like trailers or roll trailers.

Figure 8: Mono hull, combined Ro-Ro/Lo-Lo ship at Le Havre.

Source: Agencies.

An example of modern Ro/Ro ship can be seen in the STENA RUNNER:

— 184 x 28 x 6,6 meters (only loading in the hold).
— Capacity of 370 TEU's or 2,700 lineal meters (185 trailers x 15 m.).
— Up to 1,000 TEU's on deck.
— Speed of 22 knots.
— 4 x 5.760 kW (23.000 kW) engines output connected to 2 shafts with variable pitch propellers.
— Flap rudders.
— 2 x bow thrusters of 1,000 kW each.
Hourly consumption of 4.6 tm at 90 % MCR.
— Cabins for up to 12 drivers.
— Building cost in 1998 of around 35 M€ (100,000 € / TEU).

The Ro/Ro–Ro/Pax series STENA TRANSFER (1977-1981):

— Length 151.9 / 184.6 meters.
— Beam 23.58 / 25.28 meters.
— Draft 6.37 meters.
— GRT between 16,776 to 21.162 LT
— Passenger capacity between 12 to 166 .
— Capacity of 2,500 lineal meters.
— Speed of 17 knots.

The Ro/Ro series MERCHANT (2002-2007):

— Length 180 meters.
— Beam 24.3 meters.
— Draft 6.5 meters.

— GRT 25,028 GT
— Capacity of 2,196 lineal meters.
— Passenger capacity 210 up to 550.
— Speed of 22.8 knots.

We are going to specify up to 5 different types of ships, susceptible to be used in SSS:

1) Barges of around 500 TEU's, sailing at 8-10 knots.
2) Conventional Lo/Lo of around 500 TEU's of capacity and 15-20 knots.
3) Ro/Ro (Ro/Lo or Ro/Pax) of around 250 TEU's and 18-24 knots.
4) Fast monohull Ro/Ro (Ro/Pax) of around 200 TEU's and ≥ 28 knots.
5) High speed catamaran Ro/Pax of around 100 TEU's and ≥ 28 knots.

4.2. The constraints of the relation between and payload capacities & speeds

A transport operator has the option of choosing between different types of ships to operate a Short-Sea-Shipping service, each of which has specific transport characteristics. The operator's choice is based on the type of cargo to be transported and on market demand. The maximum average speed of the ships that work on SSS services is 20 knots for conventional container ships and 23 knots for conventional Ro-Ro ships.

Table 3: The speeds according to the type of ship and the line.

Type of transport	Type of network	Type of ship	Speed
Interior maritime transport	Intra-European Net	Sea/river ships	10-12 knots
Conventional	Intra-European Net	Conventional (multipurpose, small oil tankers among others)	12-15 knots
Container	Fedder Net Intra-European Net	Conventional container	12-20 knots
Ro-Ro	Intra-European Net	Conventional ro-ro Fast ship (ro-pax) High-speed vessel (ro-pax)	15-23 knots 23-30 knots 30-40 knots

Source: Becker et al., 2004.

High-speed vessels are mainly used for passenger transport. Around 92% of the 1,600 high-speed European vessels only transport passengers. The remaining 8% are used to transport goods (in closed waters). The ships that combine passengers and vehicles include a space for cars and trucks which can also be used for the transport of goods (called Ro-Pax). To absorb an increase of goods in maritime transport, big ships could increase their cargo capacity even if this implies more time at port. The frequency of the service could be increased through new propulsion systems, new ship designs or more effective cargo handling. The main ships used in Short-Sea-Shipping are Ro/Ro, and have either passengers and cargo or only cargo. On short-distance routes, cargo and passengers are usually combined on ships, including transport vehicles with frozen cargo for which speed is the most important factor. For this reason, in recent years various HSC modes have been developed, above the cost criteria, which reduce the length of the trip by up to a quarter. The Ro-Ro ships have been characterized as having speeds greater than other types of ships. They usually cover relatively short distances on trips that take less than 24-30 hours. Most HSC have a tonnage up to 500 GT, some have over 2000 GT. This shows that HSC are not designed to transport heavy cargo loads. They are more appropriate for the transport of passengers and cars, due to their reduced cargo capacity. However, the most valid option for specific routes is that of combining passengers and cargo.

4.3. The high performances and more adapted boats

In this section we described some boats with the more adapted characteristics to put in operation on the Short-Sea-Shipping services.

4.3.1. The Fast Mono-hull Ro/Ro

The fast Ro/Ro ships, are generally ships developing speeds in above 28 knots and are becoming popular to be considered in coastwise and trans oceanic passages. Some of the main operational aspects are the increase in the hydrodynamic resistance and the generated height wave, as the ship's speed increases. The resistance depends on the wet surface size and shape. In order to reduce the resistance, the solution is to reduce the wet surface in the early stages of the ship's design, by means of different techniques. The displacement might be improved in modifying the hull shape like in the multi hull ships and using lighter materials and engines. The hydrodynamic elevation is another characteristic which is capable to improve the speed, the hull elevates slightly on the sea surface thanks to the air pressure or hydrodynamic forces. Within this category we can find the hydrofoils, hovercrafts or SES and WIG designs. These ships may reach the 50 knots even more in the hovercrafts case. However, these types of ships are limited by its operational cost to low deadweight, passengers and short distances. From the freight point of view, we only consider the displacement ships. As example we have:

The Blohm & Voss FM 147 Trailer Ferry (EMMA):

— Hull design in deep V, combining stability at high speeds and more width and space on the higher decks.
— 162 x 26 x 7 meters.
— GRT 17,300 LT.
— Deadweight 4,000 Tm.
— 2 engines x 16,800 kW in a single shaft.
— Maximum speed of 28 knots, but 25 knots at 90% MCR.
— 1,460 lineal meters or 100 trailers of 15 meters in 2 different beam decks. Single ramp astern.

— Cabins for 100 passengers.
— Consumption of 6.0 Tm / Hour.
— Building costs 49 M€ or 245,000 € / TEU (2.5 times the previous example).

4.3.2. High speed Catamaran Ro/Ro

The catamaran ships offer an ideal platform to build a Ro/Ro ship, because they are wide, relatively short and the deck is over the sea. The only major inconvenient is the fact that high speed is mainly efficient on passenger ships with a small capacity for freight. One of the most innovative design at their time were the STENA HSS 1500, based on the wave piercing designs during the nineties from INCAT builders, that in 1999 was selling the INCAT 96 (96 meters length) like the Millenium I and Alborán. As example we have:

The AUSTAL 112 TE freight – only hull catamaran:
— 112 x 25 x 3.6 meters.
— Deadweight 1,400 metric tonnes.
— GRT: 6,000 LT
— Capacity for up to 44 trailers or around 660 lineal meters.
— 2 x turbines developing 45,000 kW and water jets.
— Speed of up to 40 knots.
— Consumption of up to 9.9 Tm (hour).
— Accommodation for up to 48 passengers

Building cost of 45 M€ or about 500,000 € per TEU (ten more times than the Lo/Lo ship, 5 more times the fast Ro/Ro and double than mono hull).

The AUSTAL BENCHIJIGUA EXPRESS:
— 126.7 x 30.4 x 4 meters.
— Deadweight 1,000 metric tonnes.
— Capacity for up to 1,350 passengers and 727 lineal meters or 450 l.m. for trucks and 123 cars.
— 4 x 8,200 kW MTU 20V engines, totalling 32,800 kW.
— Speed of up to 40.4 knots with only 500 metric tonnes of freight.
— Propelled by three water jets and 2 bow azimuthally thrusters

4.3.3. The High Speed Craft as a best choice on the Short-Sea-Shipping

It could be considered that small ships operated at high speeds are less attractive than big ships that navigate at conventional speeds, due to the high cost of fuel and the construction costs. During the 20th century, the average speed of services has increased gradually. In fact, it has been shown that high-speed vessels can reduce loading costs. Speed minimises the storage time, which greatly decreases the total cost of the logistic chain, particularly for goods that must be delivered "just on time". In these cases, speed is an aspect of the quality of service. There are certain commodities and routes for which the higher cost of sea transport within an intermodal transport chain (due to legal systems, infrastructure differences or less developed transport vehicles) could be assumed by using more expensive transportation units such as high-speed vessels.

To define high-speed maritime transport we should consider all of the options for increasing the overall speed of transport. These options include higher speeds at sea, quicker operations and increased service frequency. In general, high-speed transport is basically undertaken with the high-speed craft (HSC) defined in the HSC Code. The introduction of high-speed ferries has created enormous market opportunities for vessel operators, designers and shipbuilders. An increasing number of ferry routes are served by high-speed craft, and new and larger HSC are expected to replace some of the existing conventional ferry capacity. Although these new routes can offer transportation benefits, they can also generate conflicts between the ferries and environmental and recreational interests. The advantages of the HSC are the increase in speed which reduces travel times, and the high frequency can minimise waiting times to users. The HSC may reach service speeds of 30 knots (56 km/h). The average speed of cargo trains into the European Union or long-distance road vehicles (considering the limits with respect to driving hours) is lower. The sea highway is free, while the road highways and the railroad need funding for construction and maintenance.

The disadvantages of the HSC are the delays at ports which are very frequent in many terminals, due to bad organisation and to the lack of appropriate equipment and installations. But this is an external problem depend of each port authorities. To develop successful high-speed maritime transport, appropriate port infrastructure is required to load and unload cargo rapidly. Other inconvenient is the cost of fuel used for this type of ships. In comparison with classical boats HSC are consume more energy and are responsible for highly pollutant gas emissions. They behave worse on the deep sea than conventional ships. High-speed ferries on many routes throughout the world have sparked numerous conflicts between ferry operators and environmental, coastal and maritime authorities. Conflicts have led authorities in many countries to require high-speed vessel operators to include in their operation permits an assessment of the effect of their navigation on the health of people and the safety of small vessels.

4.3.4. The More Recent High-Speed Ship Concepts

We will now describe the following concepts that have been designed for freight transport:
— PACSCAT
— Easyshift
— EHSVC
— FastShip

The PACSCAT design is a flat bottom (slender) catamaran that is suitable for high speeds and partly supported by an air cushion. It has a reduced draft, which supports a set of fans that enable it to approach the shore. The operational speeds are up to 40 Km/h (22 knots). This European project was initially developed by IMMA (UK). The hull is made of welded steel and connected to ducted propellers. No specific berth infrastructure is required. It is connected to ducted propellers. No specific berth infrastructure is required. It is sized of 135 x 22.8 meters. The dead weight is 2,200 metric tonnes and his loading system is combined Ro/Lo up to 160 TEU's

The EASYSHIFT® is an intermodal transport concept, using the existing port and river infrastructures. It have a Semi-submersible concept (sail on/sail off, so-so). This system avoids the shift from barges to ship, as it is a multipurpose ship that admits whatever type of cargo that would be contained on barges. The time of loading/discharge is relatively short (< 4 hours). The length needed is 15–18 meters. This catamaran design with 4.5 meters of draft and up to 6 big barges (2,000 to 2,400 TEU's) or 38,000 Tm of dead weight. The mean travel speed is around 20 knots.

The European High-Speed Cargo Vessel was developed by NAVANTIA (ex-IZAR) and Rolls Royce. The aim was to design a commercially viable ship for short distances. It is considered that HSC will gain market share due to the advantages in terms of costs, speed, service and reliability. The ship's operational cost on different routes with varying cargoes needs to be assessed in order to verify its commercial viability. However, the current cost of fuel has halted the project. It is considered that this vessel would be viable on routes between 300' and 800' with an 80% occupation rate and an average speed of 37 knots. The port operations could be undertaken on several decks at the same time. The ships shall have the following characteristics:

— High hydrodynamic and seaworthy performances.
— Garage: 1,700 lineal meters or 113 trailers of 15 meters.
— Dead weight: 3,000 metric tonnes.
— Service speed of up to 38 knots and 750' of range.
— Port operative time of only 3 hours.

The "Fastship" was designed to linking North America and Europe. This port gate-to-port gate service will enable door-to-door delivery times that are comparable to standard air-freight at half the cost. FastShip's initial North Atlantic service will operate between Philadelphia and Cherbourg, France. A commercial service on the North Atlantic is expected to begin in 2011. The "Fastships" have a capacity of 10,000 tonnes each. The ship will be capable of carrying container loads across the North Atlantic at 38 knots. It ensures a high degree of service reliability (98% on-hour port arrival). It needs a specialised terminal operation. This is the place where ship operations and inland transportation come together to create unparalleled savings in both time and cost.

4.4. The new generation of Short-Sea-Shipping' boats

Regarding the boat for Short-Sea Shipping, new generations talking about we must have in mind Requirement tat the customer demand for speed & Their volume charges. In fact, as commented previously, two types of high-speed transport ships for maritime Have Been Analyser:

— Container ships
— Ro-Ro and Ro-Pax ships with speeds of over 25 knots.

For this selection, after comparing the different types of vessels that are currently used, and criteria required by customers, we believe that the best option is to high-speed vessels applied for this type of traffic. However, in choosing a ship really effective for short sea shipping, we must recognize that depends largely on the volume of traffic related. In an era of cost reduction, implemented in all sectors, the shipping is no exception; the fall in traffic has been experienced in the last three years, and leaves us in serious commitment to these new challenges. This, once the current economic plight, perhaps make us thoroughly rethink the way we do this business, both to design efficient business model in all areas, among them the ability to adapt ships existing, or perhaps the need for new designs that meet the requirements of the shipping market. But we know that speed is not the only factor to consider, having studied the advantages and disadvantages of this type of vessel, it is very important capacity you have, and all the time in operations, and the ability port to handle this type of traffic, the speed for uploads and downloads, and the updating and standardization in document processes that facilitate the operations at ports and allow, that the time has earned in navigation, not congestion closed see only bring increased supply chain costs.

Given all these considerations, we find that a model ship and the European High-Speed Cargo Vessel, is one of the most suitable for these routes, as it is specially designed to cover short distances carrying large volumes. It's a good bet not only for its port operations in time (only three hours) but by its design, which blends the concepts of high speed, high load capacity and easily give services, for example, you can perform operations in several decks at once. It should be borne in mind that It is Considered That Would Be this vessel on routes viable Between 300 'and 800' with an 80% occupancy rate and an average speed of 37 knots, so as mentioned above, it is necessary to study economic viability of this project.

The new generations of ships, should be as similar, at least for now, this model explained, as it helps us to take into account many factors that have been identified as obstacles or disadvantages in previous models of ships, or the recent experience of short sea shipping and that are obtained from future studies. Standing in a changing market, as in the maritime business, and the evolution of naval and nautical engineering, any new development must be adapted to the demands of modern times, the requirements of each route in order to meet the expectations customers and keep up the circumstances, respecting the factors of sustainability and environmental friendliness, which are essential for sustainable development and sustainable development of a system. Perhaps these new designs will light we now consider alternative bio-fuels, to achieve ultimate combat to the emissions' problem, major reason for this type of transport, achieving efficient development of a transportation system that allows the benefit of all stakeholders, including in the main: The environment & the respect to the planet.

5. Conclusions

The Short-Sea-Shipping is a competitive mode of transport and it can to take a more important place in the European modal split. It can to take an important part of fluxes currently transported by the road transport. But it is not really competitive anywhere. The highly potential links of Short-Sea-Shipping have to be more studied and to exploit in function of their

own particularities of potential demand. In fact, the real success of the Short-Sea-Shipping consists in taking more flux from the road transport. Principally of "more elaborated" and "high valued" goods' traffics, and not only the traffics of bulks. The Short-Sea-Shipping services for special industries and the Ro-Ro services, have a good progression, but if the Lo-Lo traffics are not developed, the modal transfer "from the road to the sea" at the European scale is simply not possible. The Ro-Ro modality has more success than Lo-Lo services because the travel speed is higher and the port passage is quickly. This conditions need to be equalized, or at least, their differences have to be diminished.

As a first conclusion about the kind of boats the best adapted for Short-Sea-Shipping services, we can say that for the distances of less than 300nm is not really useful to employ the Lo-Lo boats. In this case the configuration Ro-Ro is the more adapted. Of course, the utilisation of the Ro-Ro boats for distances > 300 n.m. is recommended too, but the operation costs are more important than the same services with Lo-Lo boats. About the operation of the service, the shuttle modality is recommended for increase the competitively of the services. For the nautical distances of more than 300nm the Lo-Lo boats are in general more appropriate. Nevertheless, the port's passage times may put the Lo-Lo services "out of competition" against the road transport; it is a problem to solve in local way. So the utilisation of Ro-Ro boats may to be better on some highly potential links with important distances between ports but with the disadvantage of diminish the load pay in comparison with the Lo-Lo boats. The highly potential shuttle links and the classical lines were defined in this work. The next step before the implantation of new lines or new services is to study the particular conditions of ports in each case.

The utilisation the most convenient of the Lo-Lo boats is on the classical lines modality of the Short-Sea-Shipping, touching several ports and covering great distances into a rotation. For this modality of services, the port passages diminish in highly important way the competitive of the boats in terms of the travel time (until 100% of navigation time for the 300nm distances). But a mean speed increase at 40 knots can relieve this external disadvantage of the Short-Sea-Shipping. Finally, if we accept the necessity of the travel time reduction and the increase of the boat's mean speeds, there are two ways to succeed the diminution of "travel time" and the competitiveness improvement. The first way is to affect the more adapted kind of boat to the specific link of Short-Sea-Shipping in function of their own potential demand, their distance between ports and their modality of operation (shuttle or classical line). The second way is to renew the fleet with boats specifically designed to the Short-Sea-Shipping. Why not to think to the design of the new generation of Short-Sea-Shipping's fast ships?

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