NEW FRONTIERS THROUGH SHORT SEA SHIPPING

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ABSTRACT

Short sea shipping is a policy choice of the European Union and affects all transport activities across Europe. Taking the European experience as an example and not as a pilot project, expansion of short sea shipping can be achieved everywhere on the globe. Although short sea shipping offers many advantages to policy makers such as improvement of the efficiency of intermodal transport, environmental friendliness and enhancement of competitiveness, it also reveals the inadequate infrastructure of ports and hinterland connections and the gap between the policy makers and market forces. The growing demand for transport services (both freight and passengers), fast and accurate services -Just In Time, the increasing imbalance between different modes and the investment in transport infrastructure are the main points of concern of all planners. The only way to achieve the shift of cargo from land to sea is through technology and regulatory arrangement.

Technical solutions are not worthy when they cannot be applied. The main obstacle in promoting intermodality is the cost, and also some barriers of the existing legal system. Every design can be feasible if it is also included in the existing regulatory and logistical system. The researcher / engineer today must find solutions which comply with all constraints of the rules; he also has to introduce new regulatory adjustments, not only, as earlier, in safety matters.

*Short sea shipping is a part of a transport chain, so most of its traffic potential is closely related to real-time information system and **EDI** technology. Through **EDI** the scheduling and linkage of different modes are possible. Also, advanced cargo handling technologies can improve the flexibility of port connections. Shipborne cargo handling facilities will bring economies of scale to small ports that would otherwise be deprived and excluded in the new transport chains. Therefore there is a need for new designs: ships that are arranged for specific connections with special cargo handling equipment and electronic devices to monitor the cargo. It is also possible to derive intermodalism from innovations such as automated mooring facilities or cargo handling. In addition, fast sea vehicles, which are almost always limited to short routes due to fuel expenses, can eliminate possible objections of **JIT** users.*

All of the above strongly suggest the need for feasibility studies not only of shipborne equipment but also of ports in order to preserve the maximum utilization of invested material. Scale problems and special "local" cases prohibit the development of a unique model solution. In conclusion, these problems - new ship designs, special cargo handling and electronic equipment, application of every possible information technology and regulatory or policy recommendations - are the problems of future shipborne transport and shall be solved upon the basis of naval architecture and marine engineering.

NOMENCLATURE

EDI	**E**lectronic **D**ata **I**nterchange
EU	**E**uropean **U**nion
JIT	**J**ust **I**n **T**ime
LTL	**L**ess than **T**ruck **L**oad
SSS	**S**hort **S**ea **S**hipping
VTMIS	**V**essel **T**raffic **M**anagement and **I**nformation **S**ystem

INTRODUCTION

The domain of the engineering profession originally meant improving the technical or industrial process. It has come these days to mean also reconstructing, downsizing and reengineering. As implied by the comprehensive term "reengineering", there is a negative connotation and businesses have adopted this term to describe a way to improve existing bottom lines. In its purest sense, the new term of reengineering is lived and breathed by those on the front line. Whether it is improving a performance or innovating, engineers become accustomed to thinking of re-engineering as a way not only of doing more things but also improving them. The profession of naval architecture and marine engineering has been traditionally focused on technical subjects concerning marine structures and almost exclusively ships. That is also the result of an existing need since shipbuilding, maintenance, overhauling and evaluation of ships demanded research to solve several problems. So despite the fact that naval architects and marine engineers possessed a strong theoretical background and were allowed to exercise more than one profession such as mechanical or electrical engineering, their interest and research activities were strongly focused only on sea vessels. The shipping industry, as a conservative one, demanded from the shipbuilding industry mainly conventional vessels, so new advanced technology could not easily be applied since none would fund such an investment, unless there was a special demand, because of a rule or operational problems. The problem was the existence of a gap between the shipper and the shipowner. The shipper is in a direct way the customer and buyer of the services provided by the shipowners and in an indirect way the customer of the shipbuilding industry. So the customer has to compromise its needs with the existing fleet, in order to satisfy transport needs. An excellent example of this fact is the Greek coastal passenger network, as described in many papers (Psaraftis et al. 1992, 1994).

For several reasons, beyond of the scope of this paper, the shipping and shipbuilding market could not offer new challenges to researchers and design engineers except energy saving systems and safety matters implemented in existing rules and regulations. The vicious circle became visible when, due to the lack of special market interest, new research activities could not be funded, and fewer naval engineers were occupied in advanced technology job placements and fewer students of engineering followed the curriculums provided by universities. Computers and computerized techniques expanded our knowledge but mainly provided and still provide solutions of classical problems, replacing tedious engineering calculations and performing the new calculations generated by solving "old" problems more accurately and faster; however, computers have not changed the point of view of the profession.

Naval architects and marine engineers can be the engineers not only of the technical and physical environment of the vessel but also of its social environment and of other related fields such as ports, terminals, manufacturing, personnel and organizational structures. That can be easily proven when facing the problem of transport chains globally; researchers and operators have to deal with intermodality from sea to shore and vice versa. This mode interaction in intermodal terminals is not efficient and remains one of the crucial factors in improving the efficiency of a transport chain. It is a demand to shape a trading fleet consisting of appropriately trained personnel, ergonomic design and organizational and technological innovations, in order to keep shippers interested in waterborne transportation. In Europe, great infrastructure problems and less developed transport chains proved that short sea shipping is a vital solution for minimizing costs and providing better service. Short sea shipping (**SSS**) is almost always a costly solution since it demands a tailor-made technical answer: ships designed for a specific line, special cargo, minimized but highly educated crews, unmanned and automatic facilities for mooring, tracing and cargo handling, etc. But **SSS** can be a feasible and viable solution if the problem is examined from many different points of view.

The intention of this paper is to prove that **SSS** can open new research fields by encouraging research in existing fields for (say) fast transportation vessels and in demanding innovation fields such as cargo handling, terminal facilities and planning, telematics and logistics. **SSS** may never serve the volume and value of cargoes served by deep-sea vessels, but it can improve transport chains, increasing the competitiveness of several economies, and shifting cargoes from land to sea and thereby reducing the total environmental burden.

SSS IN THE INTERMODAL TRANSPORT CHAIN

Improvement of production processes offers limited profit due to previous investments, and manufacturers are focusing on logistics to enhance their competitive stance. Contrary to the situation in the United States, where land-based logistics are well developed, in the **EU** the fragmented nature of the transport industry and the differing national regulations make the logistic systems more complicated and less applicable, emphasizing the need for a meaningful involvement of shipping. The real customer of all transport services demands reliability, frequency and speed. It is evident that in order to maintain or even increase the competitiveness of an economy as a whole, it is essential to improve the efficiency of the economy and transport networks, considering that a significant portion of the final price of many products is paid for transportation. The competitiveness of a transport system, including **SSS,** depends on the price and quality of the offered services. The main factors are the **JIT** services, transport time and door-to-door services. All these demand unitized cargo and containerization as the obvious way and trend. As containerization continues to gather momentum, the need to expand areas of transport beyond the immediate port areas becomes apparent, helping ease the chronic congestion problems that beset many ports. Intermodalism and transit services are intricately intertwined. Transit is fundamentally a set of services provided to targeted customer markets. The effectiveness of service provision is dependent on the skill in handling intermodal connections. Intermodalism began as result of a specific deregulation[1] in the early 80s; mainly, land modes were connected in the U.S. mainland, and evolved, diffused and succeeded in less than a decade. Deregulation means the removing of barriers.

Multinational organizations dealing in energy will continue “perturbing” fuel prices with always increasing trends; therefore everyone along the transport chain has to minimize energy consumption by giving priority to energy-efficient transport means. Waterborne transportation has the inherent advantage of low energy consumption per ton-mile and, under an upper service speed limit, becomes a strong competitor to other transport modes. Trains have a distinct advantage over trucks due to their ability to use the entire range of primary energy sources - coal, oil, gas, hydraulic and nuclear power in the form of electrical power - because railways exploit special electric networks on a large scale economically. From this point of view, truck transport will always be required, due to the need for door-to-door services, short haulage and servicing non-interconnected depots. According to the above, the primary goals of a maritime contribution to optimizing transport resources are:

- increase of efficiency of the modes of a transport chain,
- reduction of costs of the different modes of the infrastructure,
- integration of the carriers, and
- consideration of ecological needs.

Towards this direction, it is observed that the number of post-Panamax vessels in service is increasing along with the number of hub ports, resulting also in an increase in feeder services, primarily because shipping lines are forming consortia and reducing the ports of call. If a port expects to be considered as a hub port, it will have to

[1] Staggers Rail Act and the Motor Carrier Act.

invest in equipment handling post-Panamax vessels and in other sophisticated equipment required to fulfill the liner and feeder requirements. The port also has to improve its logistical service packages, enabling the lines and the agents of optimal disposal of containers, reducing the overall cost, and promoting and improving intermodality.

Discussing the above success factors more thoroughly, one can set some criteria for customer satisfaction, broken down in more detail as far as they affect **SSS**:

1. Frequency and schedule flexibility along with reliability. These are the main requirements of any shipper. In order to achieved them one needs the 24 hr availability of truck and rail docking facilities on the terminal, advanced **EDI** systems, minimum engagement and dependency on personnel, and the avoidance of any complex technology. So **SSS** will satisfy a customer with a central booking and invoicing system, by being a neutral and available party to any interested shipper, by carrying a wide variety of cargo units and by being fully compatible with the customer's existing transport systems.

2. Time needed and costs. Minimization of total time is possible by faster ships available under all weather conditions, support by **VTMI S**ystems and advanced navigation systems, by use of standardized cargo units, advanced terminal interfaces between modes, 24 hr availability of docking facilities and by avoiding any traffic jams in any land network. The cost can be reduced by using proven and advanced technology, low fuel consumption, formulating cost saving agreements with port authorities and stevedoring companies for handling charges, and by promoting central booking, avoiding brokers and commissions.

3. Environmental impact and political acceptability. Ships are low-energy consumption modes and, by using purification technology of exhaust gases, are also by far the less-polluting means of transport. Additionally, they demand less infrastructure and have fewer accidents. This environmental friendliness of waterborne transport and lower capital demand for infrastructure are great advantages for a society to promote **SSS**. This increased safety and removal of cargo from roads contribute also to the relieving of land networks from heavy traffic and transport of many dangerous goods by trucks.

SSS is confronted with high break-even volumes of traffic, in much the same way as inland waterways and rail modes; consequently, operators will envisage investments in equipment and facilities only if demand for those services is relatively high. **SSS** therefore is interrelated to fast transport due to the environmental impact of road-bound transport, season related problems, and several other problems of land hauls, including the reluctance of societies to invest in land networks (Papanikolaou 1996). **SSS** vessels shall be competitive enough not only in terms of cost but also in terms of preset time limits. This does not necessarily mean that we need ships making speeds of more than (say) 30 knots or any other speed barrier, but ships with an operating speed fitted to the needs of the special route they serve. It may also mean a need for a ship to have two economic speeds, in order to serve the better seasonable payloads or to call on a different number of ports following an order of the land-based cargo monitoring system of the shipping company.

The aim of fast, reliable sea transportation, including the efficient cargo transfer from road / rail to ship with a minimum of interruption of cargo flow through the port, is the fast, accurate and reliable transport of such cargo volumes which could not economically be moved by other land modes. The vessel itself is considered to be a link in the waterborne transportation chain, thus this system is acknowledging the need for efficient interfaces between ship-port and port-land modes. In the foreseeable future there is no requirement for bulk cargoes to move fast by sea. This means that the problem is strongly focused on container and roll-on / roll-off (RO/RO) trades, including passengers with a possible extension to the reefer trade. Fast RO/RO services may introduce a workable alternative to road haulage. In almost all intermodal movements the first and last link of the transport chain requires a road movement. Although the trend is away from long distance door-to-door movement, this does not mean that importers and exporters are prepared to forego the convenience of trailers in exchange for containers or any other cargo unit. The proposed service seeks to retain the advantages to the customer of the use of trucks, as this intermodal way combines the advantages of road and sea transport. Also at this point is hidden a presumption made by many studies resulting in false images and trends, namely that the potential cargo suitable for sea-shipment is all cargo presently transported by road.

The concept of fast sea transport and rapid cargo transfer from road to rail and rail to ship is the minimization of the interruption of cargo flow to the extent possible (Papanikolaou 1995). One can minimize port time with:

i. Excellent maneuvering capability (twin-rudder, twin-propeller, etc. vessels).

ii. Docking at a customized docking facility fitting crosswise to the dimensions of the proposed ships. Assistance by an automatic shore / vessel-based mooring system.

iii. Terminal facility might be considered as an improved, intermodal container facility. The control of movement of cargo units is achieved through **EDI**.

So an **SSS** vessel shall fulfill the following requirements:

i. The vessel shall be suitable for **SSS** routes; therefore it will be of limited size and general dimensions and fast enough to be competitive with land modes,

ii. The design shall allow smart and quick cargo handling, suggesting and promoting the use of standardized cargo units such as EURO or ISO containers.

iii. The vessel shall be hosted by port terminals, designed for uninterrupted cargo flows safely and quickly.

iv. The vessel may even have the ability to work economically when it collects many lots of cargo from several ports, somewhat like a truck working under **LTL** conditions.

Realizing that manning costs are frequently a major percentage of ship operating costs, there was an effort to reduce crews through the design, development and operation of highly automated and sophisticated ships. That was also a trend originating from the need for competitive fleets in Europe, Japan and the U.S., where manning was expensive and, due to national crewing regulations, resulting in flagging out to make each ship more competitive than the equivalent conventional ship manned by low-salaried, inexperienced crews. Especially the European industry faced the challenge, proving itself to be technologically innovative and providing a base of expertise and the capacity to participate in the growth of **SSS** trades worldwide (Dibner 1992).

In view of the regularities of system optimization, decisive improvements can be anticipated from the integration of carriers. In this connection, it is essential that the subsystems be adopted to one another, that their strong points be utilized, that the problems which arise when using various means of transport be minimized and that the service user be made clearly aware of all opportunities. Integration of carriers is possible only when cargo can be shifted easily and feasibly from one mode to another, maximizing the productivity of the modes, the nodes and the labor force. The increasing cost of labor was the main reason for the introduction of container transport in developed countries and is also the reason why containerization is not applied everywhere. The need to increase labor productivity called for capital-intensive transport systems in which quantitative labor inputs were minimized; these changes brought a change in capital/cost substitution and an increase also in efficiency by speeding up the handling operations in ports. The intermodal trade technology can be employed at its best if the containers remain unbroken for as long as possible and are carried under multimodal transport arrangements. These two conditions have far-reaching implications for the physical and technical infrastructure needed, as well as for the administrative and political framework within which operators and shippers act.

The significance of an **SSS** cargo carrying fleet as a portion of the total world fleet can in no way be neglected. According to statistics (Crilley 1992), 33% of the total number of all vessels worldwide are cargo carrying vessels of less than 5000 GT (**SSS** vessels), where 20% of the total are of a GT over 5000 GT (deep-sea vessels). As expected, the portion of aggregate GT belonging to **SSS** vessels is significantly smaller, about 8%, where 87% belongs to deep-sea vessels. Neglecting vessels of less than 100 GT, which were also excluded from the above percentages, one can shape the idea that almost 63% of the total world fleet can contribute to **SSS** routes and, looking deeper into the age structure as reported in 1992, 55% of them are reported having an age of 5 years and above and 46% an age of 10 and above. In contrast, the deep-sea fleet reported as having an age of 5 and above is only 32% and an age of 10 and above is 24%. This highlights the lack of interest of investors till now in such ships and that in the future the world fleet will have to replace many of them with newbuildings, so **SSS** vessels acquire a special interest for the shipbuilding community and market. Adding to the above information some details about completions, scrapings and losses of both world fleets, in 1991, 549 **SSS** vessels were completed, where 320 were scrapped at the age of 24, and 424 deep-sea vessels were completed and 175 scrapped at the age of 25. The completion rate is about twice that of scrapping / loss rate; hence for both fleets the average age is increasing (albeit slowly) and has done so for the past decade.

Opportunities for **SSS** as a modality in the whole transport infrastructure can be created by strategic alliances between **SSS** organizations, terminals and other haulers' associations. The present moment offers a perfect timing, because the market is moving toward a new equilibrium. Due to world political changes there is a replacement of national by international enterprises, following the universal commitment to free markets, resulting in growth-oriented economic development. Economic development implies also increase of transport flows resulting from the peaceful dismantling of totalitarianism in Eastern Europe, the abandonment of totalitarian control in countries of Latin America, and the expansion of the former Soviet Union into a number of nations and states seeking for integration in larger regional markets and also redirecting previously centrally operated, low-cost **SSS** capacity to operate in European routes. The trend of regional economic integration is not only a European choice and practice, but is also followed by countries of the Far East, well-industrialized countries developing into a large **SSS** market. **SSS** is facing several challenges in several forms due to regionalized enterprises. The main challenge is consumer trade growth, and despite the good prospects from the demand side, **SSS** as supply must satisfy customer needs in freight and passenger movements. Another major challenge prerequisite for the cover of the demand is a world class distribution of standards and cost structures. Transport must be viewed as a part of the holistic approach of the production process: from the buying of raw materials to the delivery of completed products to the receiver, production, transport, storage, distribution and information are all integrated into one network. Free trade attracts improved flows and distributes them to more affluent and orderly regions, challenging **SSS** to become more innovative and competitive. To summarize, a less restricted **SSS** aided by the explosion of information technology can expand business and service worldwide, increasing also the modal competition in regions and simultaneously reducing the total cost.

If **SSS** has to become competitive in comparison to every other mode-fundamental innovation in ship design, construction, ship-terminal system and unit load technology has to take place. Trying to define the term "innovation" it was hard to avoid confusion, so an innovation was said to occur and dominate when the following three stages of the process were fulfilled:

Stage 1. A prospective idea implementing science, technology, economy and ecology-extending abilities (stage of invention).

Stage 2. The above idea is used successfully and economically (stage of trials).

Stage 3. The innovation is spread and used widely (stage of market acceptance).

It shall be noted that there cannot be any innovation without those three stages. In any other case it would be an idea, maybe genius but not feasible. In **SSS** either basic or improvement innovation can be applied; a basic innovation can be characterized as a new mooring system or self-loading unloading system, and an improvement as all existing facilities and devices which need improvement in order to be applied in **SSS** vessels economically, such us new propellers, new cranes etc.(Wijnolst 1993). Generally there are some triggers such as geographical conditions, economic parameters, regulations, both national and international, and technology (always in correlation with economic aspects).

Recently shipping experienced a trigger for innovation after the *Exxon Valdez* accident. New rules and regulations, such as OPA 1990, obligated the shipping industry to conform within a very short period. This is not something new since actually international rules appeared after the disaster of *Titanic*. Rules and regulations can be a trigger but also a burden, and it is outside the scope of this paper to exercise any criticism of existing or proposed rules, but the designer / engineer must comply with every single rule. Rules and regulations affect **SSS** in an indirect way, since there are no special rules for **SSS** vessels, except some minor differences, but the rules are stricter than the existing ones for land modes. So in land modes the designer / engineer can act more freely without strong boundary limits. The major problem is not a technical one but a market one. The existence of cabotage, labor and manning regulations affect **SSS** negatively. In this category of triggers, all environmental legislation or directives applied to sea vessels must also be included. Nevertheless, the shipping community is characterized by conservatism in regard to adopting innovations, due mainly to the safety aspect, which constitutes the main reason for caution.

As stated in previously, the investor is the shipowner, and the most powerful trigger for innovation in shipping is the drive of shipowners to develop new or special vessels with maximized earning capabilities. This maximization can be higher speed, greater capacity, special facilities for (say) passengers, or even minimization of several costs such as crewing, port fees and fuel. Focusing on **SSS,** the economic triggers can be analyzed as follows:

1. Maximization of revenues. A flexible design such a multipurpose ship can serve many ports and cargoes, minimizing the ballast voyage.

2. Economy of scale. The larger the ship, the lower the investment per ton; lower running and voyage costs are also needed.

3. Cost reduction, with special analysis in:

    - Capital investment. This can be achieved through economy of scale and through construction and production standardization.

    - Running costs. The major running cost is the crew and the "cost" of the flag. Both are regulatory problems although ship manning is based upon technical criteria, like the brake horsepower of the main engine or the GT. Automation technology may offer some new ideas and change existing concepts.

    - Voyage cost. This cost is broken down into bunker and port costs. Bunker costs depend on the vessel (geometry, speed, etc.) and on the type and price of the fuel. As long as the fuel prices are increasing, engineers will always try to find the most economic combination of hull and machinery.

    - Port cost. The **SSS** vessels call more frequently than any other cargo vessel in several ports, so the total cost of port calling is relatively high and should be reduced.

    - Cargo handling. Along with port costs, stevedoring and cargo handling are major costs as the sea-leg is usually of limited length. In order to reduce cargo handling costs, there has to be an increase of labor productivity (say) by using unit load cargoes and by outfitting the ship with cargo handling equipment, like the cement carriers. These will allow ships to call at the port anytime without the penalty of extra labor costs.

Vessels combining characteristics of other ship types are not unknown; on the contrary they have been a common practice for many years. Oil-Bulk-Ore (OBO) carriers are the most common case. In the same way ships of a considerably smaller size could promote **SSS** by transporting containers, oil or bulk cargoes, or containers and RO/RO loads. Concerning the economic outcome of these designs, it can be said that although they were products of innovative thinking, they were not adopted by the market, and the turnout was indifferent. But other designs are more promising and innovative: fast ferries for passenger movement and fast carriers for freight concentrate the interest of designers and operators. The high-speed craft shipbuilding industry has grown substantially over the past 25 years, approximately doubling in size every five-year period. It is characteristic that till 1990 most of the designs were almost entirely passenger-carrying craft and in the last five years most of the newbuildings had also a car-carrying capacity. It is evident that where the profit margin is large enough, as in the case of coastal passenger transportation, investors promote innovations. The fleets of hydrofoils in the Mediterranean and the application of hovercrafts on the Channel are proving their popularity and profitability. Generally most of the fast ferries have a relatively small payload capacity, so the required freight rate (RFR) is high and only passengers have such a high value of time and can be accommodated in the space provided. Lately, many cargo-carrying fast designs have appeared and aim to cover a middle market between airfreight and conventional seafreight movements. This transport product is quite different from a conventional container service, and cannot be involved in a box rate competition if the required frequency factors are met. At the same time, its value of time is not as high as that of airfreight. The rate of growth caught the interest of designers and shipbuilders worldwide and, in combination with the indispensable innovative technology associated with the design, manufacturing and the production of these vessels, has also provide a catalyst for change in the traditional way of thinking of naval engineers. Looking at the growth (Fig. 1), one can understand how radical can be the application of new technologies in only a five-year period.

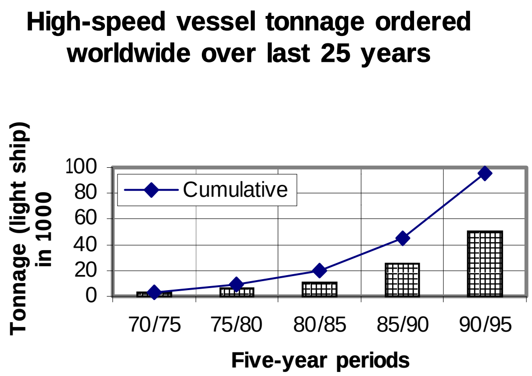

Figure 1. *(Phillips 1996)*

As noted earlier, **SSS** and fast sea transport are interrelated and the future of **SSS** is bound in a way to the economic speed of the vessels. This certain class of vessels has experienced an unprecedented period of development and order activity. Statistics published as a supplement in September 1995 are shown in Table I and give the number of high-speed craft by type, average year of building and totals of GT and passengers as of August 22, 1994, is:

Table 1

Type	Number	Average year	GT	Passengers
C	461	88	140,294	117,728
F	411	76	56,197	51,233
H	52	77	3,593	6,310
M	157	86	34,629	33,010
S	83	85	6,374	14,274
W	5	93	567	1,478

In Table 1, **C** stands for Catamaran, **F** for Hydrofoil, **H** for Hovercraft, **M** for Monohull, **S** for SES and **W** for SWATH. Visualizing the table with some graphs, one can extract very interesting results from this source alone.

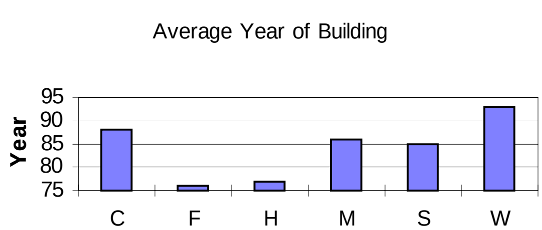

Figure 2. *(CRUISE & FERRY INFO 1995)*

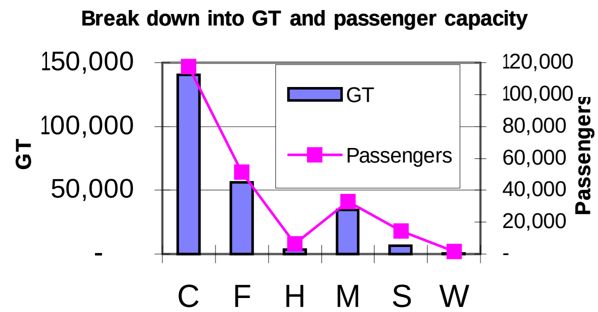

Figure 3, *(CRUISE & FERRY INFO 1995)*

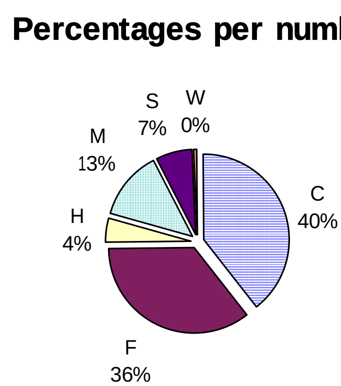

Figure 4, *(CRUISE & FERRY INFO 1995)*

From Table 1 it follows that the trend is the building of small waterplane area, twin hull (SWATH) vessels, and that catamarans dominate the market as it concerns the total GT and number of passengers. On the other hand, SWATHs represent almost nothing of the whole, and catamarans along with hydrofoils carve the greatest niche. This is expected because catamarans and hydrofoils were developed years ago and have served since the early 70s in many passenger lines. Cumulative experience and market acceptance are both a burden and a trigger for their expansion in new markets. Table 2 shows other statistics, published in April 1996, which are more updated and which do not alter the image.

Table 2

Type	Number		Growth	%Total Fleet	
	1990	1995	%	1990	1995
Catamaran	312	500	60.3	34.5	41.5
Hovercraft	45	52	15.6	5.0	4.3
Hydrofoil	368	408	10.9	40.7	33.8
Monohull	118	165	39.8	13.1	13.7
SES	61	81	32.8	6.7	6.7
Total	904	1206	33.4		

Table 2 reveals the real growth in recent years, where fast passenger transport has been in focus and where most technological advances applied to newbuildings. So comparing the two tables we see that hovercrafts are at a "stagnation point", along with hydrofoils, drawing the conclusion that these two types do not interest investors any more. This can also be explained by lack of substantial technological improvement. Catamarans are increasing, and in only five years have almost doubled their number, because of investor interest in fast passenger movement, mainly in SE Asia. To conclude, it is notable that catamarans are the only type of vessel, with increased share when all other types share almost the same as five years ago, and only hydrofoils are "leaving" the market. Anyway, fast ferries are continually increasing their number and their significance in the total world fleet.

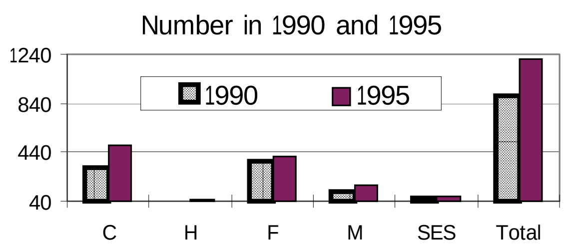

Figure 5, *(SHIPPING WORLD & SHIPBUILDER 1996)*

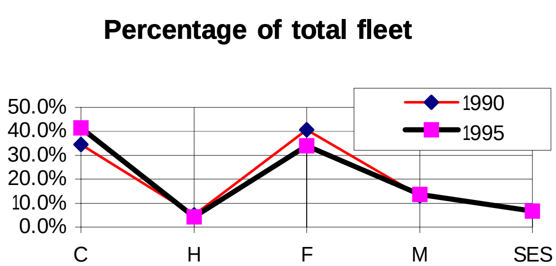

Figure 6. *(SHIPPING WORLD & SHIPBUILDER 1996)*

As far as it concerns passenger vessels, the major factors affecting public perception are safety and speed. The public and investors are now looking in a different way at the fast craft, and that because small craft have both exposed and allayed fears by their behavior in disasters or minor incidents, such as the of the *Saint Malo* catamaran accident off Jersey Island in the English Channel. Inherent vessel stability and the ease of evacuation were the main factors that prevented disaster, and that large-scale "experiment" convinced researchers and the market of the special advantages of these designs.

At this point it would be very useful to mention that companies got the message that it is not enough to route a fast vessel in a promising line. Successful enterprises in Northern Europe[2] are based upon accurate and fast round trips (service speed of 45 knots) and quick loading and unloading of the vessel (120 cars evacuating or entering a single-level car deck in 15 minutes). The operation of the vessel proved to be extremely efficient. Heavy vehicles, trucks, buses, campers and 600 passengers are catered for by two new so-called *combi*-ferries, with service speed of 18 knots, operated by the same company. A major investment has been made in port; the two terminals are leased to the company, so the ships do not have to follow the rules set by other local conflicting interests. In docking, mechanical aids are used in lieu of ropes; at the correct position there are two towers, one at the bow and the other at the side, hydraulically operated and locking the vessel firmly into position. The pricing policy is combining the four vessels (the two fast ferries and the two combi-ferries), differing only ≈12.8% when the passenger prefers fast transportation. In another interesting region, Australia, researchers concur that the management systems of such vessels will have to move closer to the air freight industry than to conventional liner shipping practices. Passenger and freight volumes especially will be smaller, the number of customers is likely to be fewer and many of these could be on long term contract, while there is a need for tight control over cargo deliveries to and from the terminals. Because make or break for every fast operation is the Required Freight Rate and other trades depending on suitable cargoes might be attracted, potential shippers and investors are beginning to investigate the scale of opportunities for the near future. Concerning the above special needs for success, operators and designers are also proposing dual-purpose vessels. Such a vessel can undergo seasonal changes[3]; in the car / passenger mode can carry 800 passengers and up to 230 cars and in the freight mode 26 trailers of 12.5m length or 23 of 15.5 m length. Due to sophisticated coupling of main engines and machinery the vessel can serve at two speeds: 40 knots for passengers and 23.5 knots for trucks. Such designs can help solve the

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[2] *Mols-Linien* (Denmark) operates two innovative fast catamarans between Ebeltoft in Jylland and Sjaellands Odde in Sjaeland.

[3] Knut E. Hansen's proposal was published in *Ship&Boat International*, issue 96/9, page 33, November 1996.

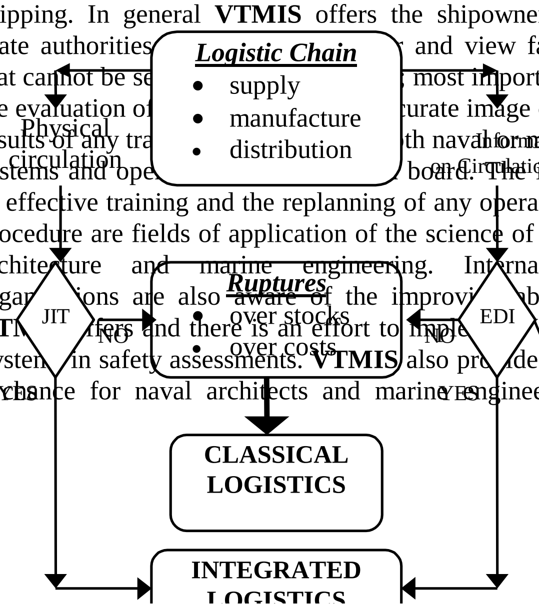
problem of seasonal service, allowing operators a year-round exploitation of the vessel.

Another interesting innovative technological field is the Vessel Management & Information System. **SSS** demands **VTMIS** because of the fact that most of the routes pass near or through harbors, cities, and other sensitive areas. So for safety's sake measures must be taken for the avoidance of any kind of accident. This aspect is very important for **SSS** since it is new in the market and has to attract shippers by providing reliable timetables and safety; this can be achieved only by correctly managing ship traffic. The proper monitoring of the traffic is also a tool for supervision of the compliance, conformity and application of all international rules of shipping. In general **VTMIS** offers the shipowner and State authorities [illegible] and view factors that cannot be se[illegible] most important is the evaluation of [illegible]curate image of the results of any tra[illegible]th naval or marine systems and ope[illegible] board. The issues of effective training and the replanning of any operational procedure are fields of application of the science of naval architecture and marine engineering. International organ[illegible]ions are also aware of the improvi[illegible]bilities **VT**[illegible]ffers and there is an effort to imple[illegible] VTMI System[illegible] in safety assessments. **VTMIS** also pro[illegible]ides also a chance for naval architects and marine engineers to design vessels or systems that will minimize or even eliminate hazards, besides offering effective monitoring from head offices and support from the authorities in case of an accident. Consequently, **VTMIS** provides statistical monitoring, data or information feedback for new research.

So far, economy of scale has succeeded in reducing operating costs and in providing more predictable transport times, but shippers demand better service at lower cost. The need to control the complexity of ports and terminals as hub centers, increasing labor costs and the availability of technology have persuaded some operators to introduce automation. The majority of shippers and port terminals face storage problems. Only some companies offering **JIT** services can claim that they do not face such problems. The storage procedure is confronted with two separate challenges. The first is the proper scheduling of orders and the other is the effective occupation of the "expensive" areas. These problems are not yet solved and demand solutions, and that is of great interest in **SSS** because storage fees affect total costs and because an automated procedure may allow self-loading or unloading from the vessel assisted by a proper **EDI** system.

EDI is a real-time technology tool tied to advanced logistics. In the logistic chains there are three key elements - supply, manufacture and distribution - developed in parallel with information flow, and three basic elements - strategy, technology and information. Examining briefly the implementation of **EDI** in **JIT** services, it is meaningful to underline that **JIT** systems and **EDI** can exist separately but, as time goes by, they are both necessary in integrated logistics. **EDI** is the condition of proper information circulation and **JIT** of physical circulation (movement). **EDI** can play a role in the success of a **JIT** system and also can become a vital factor bridging supply and demand. The following scheme (Fig. 7) can help in understanding the differences among classical and integrated logistics (Pesquera 1992)

Fig. 7



The first step towards automation was automatic information processing (tracking and tracing) and the next step was the automated handling process itself. But cost-effective automation of cargo today is still confined to administration and planning. A flexible terminal for every industrialized procedure is flexible only when it operates manually. However, in view of the technological developments and the wage costs it is tempting to investigate the conversion of existing terminals to automated physical handling. Human resources will remain a key element in an automated container terminal, especially from a performance point of view. Teamwork and team self-control are becoming increasingly important; therefore any introduction of automation should include the development of labor organizations and the involvement of employees. In general a terminal is as productive as its dockers and an automated system is ideally suited to repetitive actions, assuming a steady cargo flow. Therefore it is not possible under present circumstances to convert manual work to unmanned procedures. Regarding safety, automation is only feasible in a grass-roots developed facility and any partial automation invariably fails when the subject of the safety of lashers and ship personnel is raised. Finally, no two terminals are alike so only tailor-made solutions can be applied when automation of stacking is considered (d'Hondt, 1996).

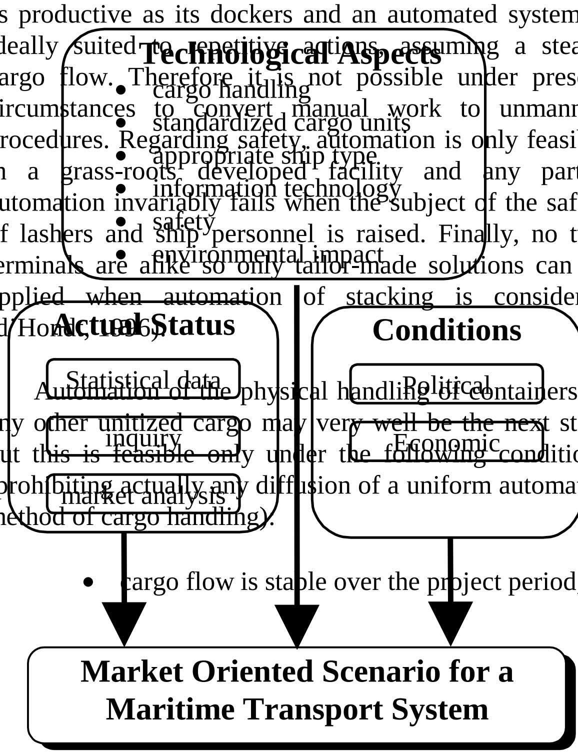
Automation of the physical handling of containers or any other unitized cargo may very well be the next step, but this is feasible only under the following conditions (prohibiting actually any diffusion of a uniform automated method of cargo handling):

- cargo flow is stable over the project period,
- present service levels are maintained and even enhanced, particularly in unpredictable peak conditions, and
- the cost efficiency of the automated terminal is increased.

The major objective of hub terminals is to simultaneously handle large container flows to and from many modes of transportation with guaranteed handling productivity. The design of such complex automation requires a parallel development of handling techniques and equipment, information and process control systems, and the organization of labor. All these components must be integrated within a system, and a comprehensive design should recognize some specific areas, such as: limitation of types (specific container types, say), reliability of components (reliable equipment and software), user involvement (user friendliness as a design objective), weatherproof equipment, environmental control, cargo positioning, and modular designs (Rijsenbrij 1996). To summarize, automation of the terminal is not the vital element for success in the present situation, but is a challenge for the management of all parties. Given good accessibility for vessels, the intermodal connections of a terminal are far more important.

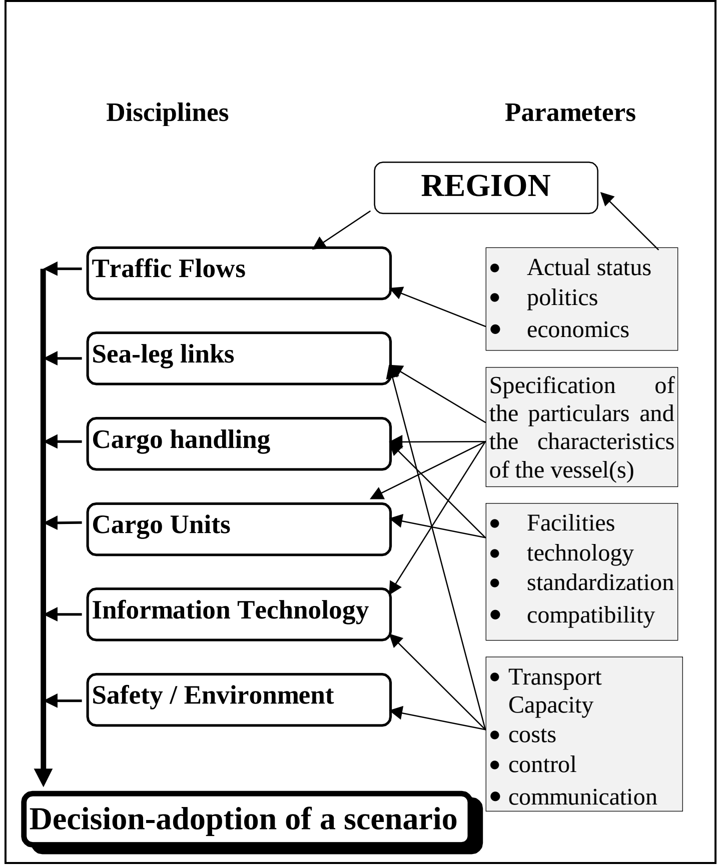
From all the above a useful conclusion can be drawn: the appropriate methodical approach is a mixture of political and economic conditions, technological aspects and actual status of the market. Every possible scenario should be approached as the following scheme (Fig 8) visualizes (Hoffman, 1994):

Fig. 8



This concept is based on the determination of the actual customer, i.e., freight and passenger flow, examines the current flows of the existing transport capacity, examines the general framework in force, and sets the technical requirements for the goal achievement. The whole procedure may be considered a trivial process, but is the only effective one when attention is paid to the prerequisites such as the interlinking of transport means, freight and passenger terminals, the appropriate and compatible information technology and the demand-oriented specification of the sea vessel. The above process is visualized in the next figure (Fig. 9):

Fig. 9



THE EUROPEAN EXPERIENCE

In Europe and specially in the **EU**, **SSS** is a policy choice. **SSS** is important for the European cohesion because it:

- promotes European trade competitiveness
- maintains vital transport links
- decreases unit cost of transport
- facilitates Eastern European integration
- relieves congestion from land based networks

In the new political environment, where borders are dismantled and Eastern Europe offers new markets of trading, **SSS** is gaining a prominent role. Cohesion should not be viewed in its social or economic meaning alone, but also as an efficient connection achieving mobility (Psaraftis 1995).

In Europe, road and rail networks are much denser as a reflection of the population distribution pattern. Flexibility and frequency of service receive more attention from shippers and consignees than do the economies of long-distance haul. In Europe the 20-ft container is the dominant one. Railroads must strive harder to gain a competitive advantage over trucks on the relatively short distances that characterize the average journey within the continent. Originally the majority of containers were transported by road and thus, because the initial arrangement was underlined by U.S. carriers, the principle was that every container should have a chassis. This led to investments only few could afford. This trend reversed completely and now almost 80% of containers that move over long distances travel by rail, although double-stack railcars are not currently in use in Europe because of the low bridges height. This can be explained by the railway system in general, its size and capacity, which solves the quantitative problems of container transport to and from the hinterland. As an example, the break-even point between rail and road haulage is about 170 to 250 km from the sea terminal (Schiffer 1996). This result also emphasizes the fact that a port inaccessible to a major railway axis or system is seriously handicapped in the competition of intermodal traffic. By optimizing container movements and increasing the use and the number of inland depots, trucking companies are tending to concentrate their activities on short-haul movements and door-to-door services. In accordance with the above, the strategic objective of **SSS** in Europe is the diversion of freight streams from across the mainland of Europe to around the continent, requiring an alliance between terminal corporations, **SSS**, and land mode organizations and shuttle companies.

European ports are innovative and have broken from traditional jobs of just handling and storing cargo, and now offer service packages. The ports are entering into joint ventures with companies moving in special markets like fruit trade, offering intermodal links and the monitoring of cargoes for the shipper and for the forwarding agent in a compatible **EDI** way.

New types of ships are most unlikely to be needed in the European **SSS** routes, as far as the general principles and concepts are concepts, but important details of existing vessel types need more investigation and consideration. More likely, flexible load-on / load-off (LO/LO) dry cargo vessels and other small cargo vessels offering the ability to work under **LTL** conditions bypass the season-related obstacles. On the other hand, Europe needs more fast vessels. In Europe many fast ferries are constructed and operated by European-based companies. This focused interest originates from the ever-increasing value of time and the concentrated wealth needed for such investments. The European policy of Marine Corridors is offering a very strong initiative for investments, especially in wealthy countries, where time costs more and money is available for investment. It is not accidental that although **SSS** can and should flourish in the southern regions, and specially in the vital routes for the social cohesion of the

Mediterranean, the majority of **SSS** applications are in the Baltic Sea, the North Sea and the English Channel.

The European **SSS** industry possesses more strategic advantages than other regions because of favorable geography, networking limited land areas, and extensive coastlines and a traditional and successful operating culture among different nations (Europe comprising so many different nations in contrast to North America with only three). In Europe, market mechanisms are highly developed, there is an aftermarket for aging vessels, and the technology is impressive. **SSS** in Europe faces challenges but it has proven to be innovative and viable with vigorous competition in most of its sectors, so European **SSS** can provide a base of expertise and capacity for participation in new markets.

Europe did not follow the American model of national merchant marine development. The primary difference between the cabotage laws in Europe and those in the United States stems from the building provision. The direct restrictions originating from the Jones Act prohibit the viable entrance of small vessel in the coastal chains. U.S.-built vessels are relatively more expensive and the cost of the U.S. flag is burden. In an indirect way this Act promotes a sheltered market and cabotage conditions. This U.S. model proves also that separate national regulation is a major obstacle to competitiveness and that regulatory structures should support a concordance with world standards and trends. The unavoidable high costs of small vessels led also to the implementation of tug-barge systems in coastal trades. It should also be underlined that due to the Jones Act, U.S. economy missed the integration of ship ownership, ship operation, ship repair and marine technology development. The integration of these activities is a vital element of successful long-term market evolution. Europe's ability to be a source for its own short sea tonnage requirements is an important foundation, and exports of ships and domestic opportunities will continue to provide high paying employment. The U.S. experience has shown, that the loss of any element of this capability ultimately erodes the competitiveness of the entire marine-related industry.

To summarize about **SSS** in Europe, it is very interesting to outline the research trends concerning this special topic within the **EU**. In December 1992, the Commission issued a "White Paper" for the development and promotion of a Common Transport Policy (CTP), where three strong conclusions emerged:

i. the demand for both freight and passenger transport services is increasing,

ii. there is an imbalance between modes, which is annually increasing, and

iii. there is a worrying stagnation in transport infrastructure investments.

The quantitative approach in large scale indicates that more than 90% of EU's external trade and almost 35% of its internal trade is carried by ships, where at the same time ports served 12.5% more cargo load, and in the past decade seaborne world trade increased about 54%. The convergence of all these trends has resulted in congestion in land networks and dangerous environmental impacts: therefore CTP has adopted the promotion of **SSS** and the shifting of transport flows from land to sea in a non-mandatory and non-artificial way. The CTP aims also, in addition to all inherent advantages of **SSS** as transport practice, to achieve further growth and development of peripheral and isolated regions (achieving cohesion through **SSS**) and the indirectly contributing significantly to the development of European shipbuilding and supporting industries.

Exploring the feasibility of this policy, it became clear that several obstacles were hindering the whole effort. Due to improper infrastructure, including documentary and procedural requirements, and connecting links to the hinterland, a large number of ports fail to attract investors and shippers to use **SSS**. Almost all southern ports charge high fees, transit times tend to be longer, and finally there is insufficient integration with other modes, so the **JIT** requirements are not easily met. The market has an old-fashioned image of **SSS** services and it is not aware of **SSS** capabilities.

The Commission's decision to support **SSS** is expressed through funding effective R&D in new maritime transport technologies, aimed at enhancing the competitiveness of European shipping, the development of **SSS** in parallel with an increase of port efficiency and the improvements in reliability and safety. More important the CTP expects the shipping sector to adopt proper cargo units for optimal intermodal utilization, automated mooring and loading procedures to reduce turnaround time, and the design and construction of suitable sea vessels compatible with the information technology based logistic systems and port-terminals. CTP urges implementation of the following measures in the total design of transport chain:

- use of **VTMIS**,
- optimal use of human resources,

- reengineering in maritime transport, and

- promotion of inland waterway transport systems.

Taking into account all these factors and policy choices, the Commission-sponsored R&D in all maritime transport activities, and focusing on **SSS**, as a policy object, **SSS** has to play a major role in the future of European transport under the summary title-theme "Integration of Fast Waterborne Transport Systems in the Logistical Chain."

A special request for research on waterborne transport produced a noticeable collection of information from papers, research projects and programs, books, articles, etc. (Psaraftis 1996). The material is available on the Internet and is supported by a search engine, assisting the researcher to get the most out of the data[4]. The data from all sources[5] are gathered in a final matrix

Table 3

	Ships	Cargo	Ports	Networks	Telematics	Total
Eng.	**221**	**23**	**32**	**23**	**5**	**304**
E/L	**82**	**41**	**61**	**54**	**17**	**255**
B/M	**88**	**29**	**66**	**48**	**18**	**249**
R/P	**32**	**6**	**28**	**40**	**6**	**112**
E/S	**23**	**7**	**16**	**10**	**5**	**61**
Total	**446**	**106**	**203**	**175**	**51**	

After solicitation for input, computerized retrieval, and presentation to the sponsor and to the academic community in June 1996, this material is also presented here focused on the statistical results, which were never presented before. All inputs followed a special taxonomy broken down by discipline and subject. Analyzing the above information to two pie charts (Figures 7,8) we can understand where research is focused in Europe.

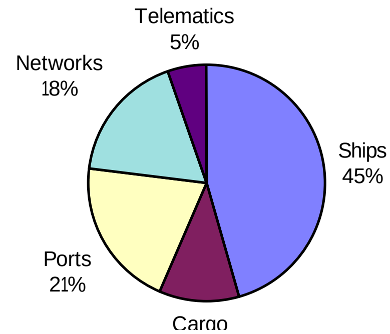


Fig. 10

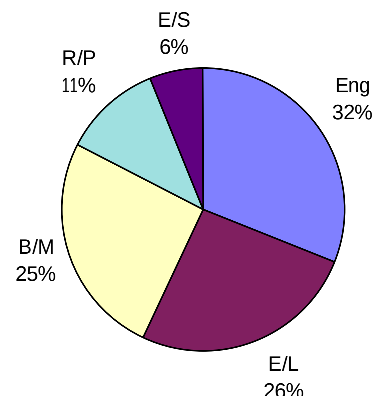


Fig. 11

In the graphics **Eng.** stands for engineering, **E/L** for economics / logistics, **B/M** for business / management, **R/P** for regulatory / policy and **E/S** for environmental / safety.

It is obvious that ships as a subject are the primary target of European research and they are examined intensively from the engineering, managerial and economics points of view. Although intermodality and **SSS** chains demand the efficient interface among modes - that port terminals be integral parts of the shipping system - researchers are primarily interested in ships and as far as ports are concerned, only in their managerial and logistic problems. Terminals hold pivotal positions, but do not attract the interest of researchers.

From Table 3, it is obvious that 72.4% of all engineering-related entries are of pure engineering interest. Consequently, 49.6% of all ship-related entries are products of engineering research, 38.1% of economic and managerial origin and only 12.3% of regulatory or policy matters, including safety and environmental issues. It is remarkable that most entries on these public decision issues such as policy, regulation and safety are conducted

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[4] The material and the search engine is available at *http://www.maritime.deslab.naval.ntua.gr/casss/search.htm*

[5] At this point it is useful to note that the source of the input data are the conferences **FAST** 91, 93 and 95; the European Roundtables 92, 94, 96; the participants in this project, **WEGEMT**, **ISL** and the **EU** itself.

in several countries and funded by national budgets. Another interesting result is that only 48 out of 441 entries are reported as telematics. A translation of this can be that there is not yet a real interest in such matters.

Observing the trends of data from the conferences as a mirror of the research and the interest of researchers, it should be noted that in the first conference on **SSS** papers of all kinds were presented. The strongest field of interest was policy and network regulatory matters. In the **ESSS**92 conference, 5 out of 6, including all FAST conferences, telematics-related paper appeared, where in no other conference one was presented. As expected also in the **ESSS**94 conference, regulatory and policy matters dominated, but this time the interest was broken into two: ships and networks shared almost the same percentage of 35%. This conference represents the 56.3% of environment and safety-related papers. At the **ESSS**96 conference the focus was on logistics and management. Also for the first time many papers on cargoes were presented.

RESULTS

The sea-leg is often the largest part in a logistical chain as far as the traveled distance is concerned, but not in the cost logistic. Trying to improve each part, the total performance is only marginally optimized. That is the reason for an holistic view of every transport chain.

Governments should not provide financial assistance or subsidies to shipowners or shipbuilders, in order to avoid causing irrational business developments. Public intervention distorts markets and proves itself dysfunctional on a long term basis. The American status quo and the different European one are the two messages received from these parallel experiences. If governments wish to promote **SSS** and waterborne transportation, it would be better to fund research and development programs and to minimize infrastructure obstacles. Initiation of port and terminal reconstruction investments towards more efficient services will also promote the employment of new fleets, letting the market decide the size, the type and the technology applied on the vessel. Removing regulatory barriers is the other main task of the public sector for promoting **SSS**. Multinational conformation to rules and assimilation of governing laws is the stronger initiation for investors.

There is a need to view the many different aspects of the term “integration”; such as integration in the transport chains, in market evolution, in regional markets, and in worldwide compatible cost and distribution systems. Transport integration implies that all modes share the common objective of optimum service in the holistic approach to the production process. Intermodality should be achieved in order to exploit better any single mode and to minimize cost and time wastage in terminal or cargo shifting nodes. Transport integration affects the market also by another more direct way. The alliances between organizations and companies shape joint lobbies that influence authorities to adopt rules and to invest in specific infrastructure. These alliances promote standardization and information management, creating also the appropriate wealth for investments in new technology. Integration in markets means that ship ownership, operation, building and repair shall be well founded in the market. From the same point of view port authorities, shippers and supporting industry shall also be well founded in the market. This integration provides high-paying employment and industrial development. Regional integration is synonymous with the term “statewide cooperation”. Today’s transports and especially **SSS** need high volumes in order to achieve acceptable break-even points, and usually the frequency and the volumes needed are offered by more than only one state. In addition to the dismantling of borders, regional integration leads to larger, more homogenous and integrated markets, improving commercial terms and allowing further evolution and market expansion. The expansion of a regional economy under free trade tends also to reduce the complexity of trade patterns, helping to proceed to the next step of a larger regional market and a worldwide integrated transport market. For the achievement of this goal, the existence of common ground in cost and time logistics and a compatible way of cargo shifting is vital. This will not only produce a base line for all transactions but will generate trades between regions that are isolated today due to different regulatory and logistic approaches.

Ports and terminals should change attitude - from a traditional passive role to that of an active concern for the total production chain. Ports and terminals should integrate successfully and accept cooperation with other transport nodes and companies involved in the chain.

In conclusion, **SSS** can provide new and wide traditional fields of research and occupation for naval engineers. Marine related engineers have always to consider that the product of their thinking involves three separate and interactive environments: First is the technical one consisting of the design, construction and interaction with classification societies and specialized international or national organizations. Second is the managerial environment, where shipowners, operators and supporting staff try to supply the vessel with money, documentation, people and cargo, and third is the operational environment, where people operate the vessel

- in other words, handle someone else's capital - the crew, pilots, shore staff, etc. So it is meaningless to focus all interest only on technical matters when so many other factors affect the proper operation. The application of new technology and the reduced number of crew demand more skilled and well trained personnel onboard and these serious problems deserve a scientific approach. Almost all these fields and problems are approached by many scientists, but the naval architect / marine engineer is the proper one to extract the best and final solution from all possible approaches and methodologies, because the naval engineer is the engineer of the marine environment and has a focused interest in promoting seaborne activities. Consequently, a very small list of possible activities and interests can be as follows:

- ⇒ New designs and improvement of existing ones.
- ⇒ Cargo handling equipment.
- ⇒ Cargo unitization.
- ⇒ **EDI** and information technology.
- ⇒ Energy saving and conservation systems.
- ⇒ Unmanned systems and unattended machinery.
- ⇒ Crew training and proper number and type of manning.
- ⇒ Planning and design of intermodal terminals.
- ⇒ Design of special automation.
- ⇒ Advanced transport logistics.
- ⇒ Regulatory proposals and market investigations.

This approach is common practice in the profession, though it can be stated that no engineer is only conforming his design according to (say) safety rules and regulations but also tries to find the most ergonomic and operationally viable solution for the specific vessel. The new aspect is to "view" not only the onboard systems but also market needs and their effect on the vessel and the vessel as part of a more generic transport flow chain. All **SSS** aspects, approaches and innovations can also be transferred, up to a point, to deep-sea vessels. Deep-sea vessels interact with **SSS** vessels mainly in hub ports and are also integrated in the total chain. Many advanced technological applications may also be applied to many deep-sea vessel types.

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