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CREATE3S: AN OUTLINE OF THE CONCEPT AND OVERVIEW OF POSSIBLE SOLUTION ROUTES FOR THE HULL FORM

M. Landamore[1*], O. Cabezas-Basurko[1], P. Wright[1], R. Birmingham[1], M. Reichel[2] and F. Kremer[3]

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Abstract

This paper reviews the work done at the early concept and preliminary design stages for an innovative new class of short sea vessel. This work is part of a new EU-funded project CREATE3S that will develop new ship design concepts aimed at improving the efficiency of short sea shipping. CREATE3S aims to develop a new generation of short sea vessels utilising advanced design and manufacturing techniques, enabling Europe to strengthen its shipping and shipbuilding competitiveness. With trade between European countries increasing rapidly year on year, great demands are being made on Europe's transport infrastructure. The only freight transport mode that has virtually unlimited potential for expansion, and which is considered environmentally friendly, is coastal shipping, hence the current EU focus on encouraging more cargo to move by water. However, the increasing volumes of cargo being shipped over relatively short distances require major rethinking on the part of shipping companies and ports. More or larger ships are required and for them to be efficient, faster cargo handling concepts are needed to ensure that port turnaround time does not exceed sailing time. The CREATE3S concept envisages a vessel consisting of two principal modules: a ship hull module and one or more large cargo modules. The CREATE3S concept is intended to be equally applicable to container, dry bulk and liquid cargoes. When the vessel arrives in port, it will be possible to quickly separate the cargo modules from the ship section, plac-

[1] Research Associate, Newcastle University, UK . [2] Ship Design and Research Centre CTO SA, Poland, [3]Marin, Netherlands. *Corresponding author: M. Landamore (m.j.landamore@ncl.ac.uk), +44 191 2228724, +44 191 2225491, MAST, Armstrong Building, Queen Victoria Rd, 00000 Newcastle upon Tyne, United Kingdom.

ing them on the quay. The ship module is then coupled with other cargo modules for the return voyage. The cargo units can then be unloaded and made ready for the next vessel call. This approach will combine the ability for a 'standard ship design' to be tuned to very different trades and commodities whilst using advanced construction techniques. The most revolutionary feature of the CREATE3S concept is the potential to transfer the complete cargo load in just one move. However, for certain vessel applications, it is possible that there may be more than one cargo module: more than one commodity may be moving on the same vessel or it may even be practical to mix bulk and container modules on the same sailing. The key feature remains that the individual cargo unit being discharged in one move will be far bigger than today where the maximum size unit is typically a 45ft container or 20ft ISO tank. Safety and sustainability are investigated and accommodated through a comprehensive risk assessment and integration of solutions that facilitate reduced energy consumption, emissions and waste. The new generation vessels will be assessed on their operational environmental and economic performance, in relation to total cost of ownership (including production, operation and end of life cost) utilising advanced design and simulation techniques.

Keywors: ship design, advanced construction techniques, simulation techniques

INTRODUCTION

Short Sea Shipping (SSS) has great strategic importance for the European maritime sector: it is a crucial home market for waterborne transportation, for the shipbuilding and ship repair industry, for the supply chain, ports, and for the research community. SSS is seen as key to increasing competitiveness and solving transport problems in an enlarging European Community. Market opportunities for modern SSS and the expected need for fleet replacement provide opportunities for EU shipbuilders and their supply chain; of the circa 180 cargo-carrying ships delivered by the Community of European Shipbuilders in the year 2004, more than 40% were short sea ships (CREATE3S, 2006). It is not certain however, that current transport and logistic systems can cope with the expected volume growth. Ships will have to compete with road transport on cost, reliability and flexibility without jeopardising safety or the environment. This requires, amongst many other factors, maximum fuel efficiency, low maintenance, support and operating costs achieved through the optimum use of technology and crew training. More and/or larger and faster ships will also have to be matched by improved ship-shore interfaces; shorter turn-around cycles in ports and improved cargo distribution to the hinterland. CREATE3S aims to develop a new modular ship concept consisting of two basic modules: a ship platform module; and interchangeable cargo-containing modules. For both modules a limited number of variants will be developed, corresponding with variations in trades and operational requirements. Several critical technologies arise from the required ship concept. Firstly, from a performance point of view, the ship design will have to take a broad operational spectrum into account. Traditionally, a ship would be designed for one (trial) speed and draft, here a wider range of parameters must be considered and optimised. This paper considers the organisational set-up of the project, the top level requirements on cargo transport, and the current concepts being regarded. It then briefly elaborates on the critical ship technologies, and finally considers the evaluation of environmental performance.

LOGISTICS REQUIREMENTS

CREATE3S work programme follows an end-user driven, problem solving approach. The project's starting point is the "cargo movement" along the entire logistic chain; so the cargo transport has been defined as the highest system level, at which top level requirements are set. The second system level defines the harbour cargo handling infrastructure system and the ship itself. Finally the third system level deals with the components, which build up the ship and harbour system. Therefore the requirements from the top level system flow down to the lower system levels; each level additionally takes into account its own requirements set by varying constraints (e.g. safety). Initially the logistic concept is determined in line with the logistic operator's requirements; in the same way, required capabilities on cargo carrying at sea and cargo handling in port will be the starting point for the development of the new ship concepts. The logistic operator will identify and quantify the economic/operational and technical parameters. This approach will ensure that the resulting ship concepts are economically efficient and attractive "transport vehicles'. Regarding the transport patterns for the European Short Sea fleet, the possibilities to develop an Intermodal solution based on the cargo envelope solution of Create3S must reduce turnaround time and be competitive regarding lead time (reduced or unchanged). Any solution that cannot cope with this requirement will be unacceptable. Thus, if cargo handling (terminal) operations linked directly and indirectly to the envelope are not adequately efficient, the total cost of the provided service will most likely remain unchanged. Hence, both terminal and vessel operations must be accounted for in order to obtain the optimal solution. The entire logistics chain must be considered when answering the overall question and analysing SSS operations in a consistent manner. In a *door-to-door* scenario, the total cost of transport and logistics consists of:

— Pre carriage cost from factory to port
— Terminal Handling cost
— Sea Transport costs
— Terminal Handling costs
— Hinterland distribution and port costs

Sea transport costs are closely related to the amount of cargo transported. Terminal handling costs are also affected, to a lesser degree, by the total volume to be processed. *Port-to-port* cost elements related to waterborne transport can be summarised as follows:

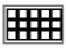
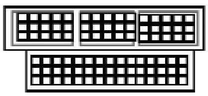
— **Capital cost**: determined by the delivery/purchase price of a vessel plus interest
— **Operating cost**: determined by crew wages, consumables and social benefits, maintenance and repair, insurance, administration
— **Voyage cost**: related to a specific voyage and include bunker, port cost, commissions, and other ancillary disbursements such as canal and seaway charges.

So a key success factor will be the ability to develop concepts which will contribute to both lead time and cost reductions on a door to door basis. Significant reductions of 20-25 % will secure the realisation of the concepts, but even with less significant savings of 10-15 % it might be possible to realise a concept. Apart from cost and lead time also other requirements are important in order to have an improved cargo transport. These are addressed in the following.

Availability of a transport mode means ensuring that transport is available when needed. While a truck may be called upon at short notice, for SSS, availability of sea transport means high frequency of operations. Further, availability may also means availability for all the cargo that is being transported by road, i.e. volume capacity of vessels and cargo type capability. To enhance availability in SSS, focus is seen on smaller vessels enabling a higher voyage frequency and therefore also higher flexibility. For SSS to be competitive against road only solutions, frequency is a critical parameter. More smaller ships with more regular departures will provide a more optimal solution than less frequent departures of larger vessels. This increase in flexibility and availability will result in reduced cargo transport lead time. The services provided must also be reliable, achieving an equivalent, if not better, level of reliability when compared with road only solutions. Cargo must be delivered according to schedule (on-time and right place), and without any damage. For the logistics chain, this implies: reliable sailing, despite weather, traffic, time slots, equipment failure, etc.; and reliable cargo handling, despite time slots, equipment failure, etc. An additional criterion for choosing a transport mode is the avoidance of physical damage. Cargo must be protected while transported as well as handled. Example of measures that can improve cargo safety (but add to the cost of transport) are conscientious scanning and inspections, ensuring cargo integrity, securing cargo environment, securing cargo tracking, and updating cargo and trade documentation and data. In the case of container freight, the risk of cargo loss or damage is reduced when using multimodal solution, because cargo is not handled when transferred from one mode of transport to another (e.g. from road trailer to vessel). This implies that improvement efforts must target the packing and unpacking of the "cargo envelope" to be transported. Therefore attention must be directed not only toward the safety of the vessels, but also to the loading/unloading of the cargo envelope. Cargo safety can also be security against damage to cargo from the transport itself that it is more protected and are transported more 'gently' at sea. Finally, since the ships need to be able to enter most European harbours, length, breadth and draft restrictions exist.

SHIP TYPES

The aim of the Create3S project is to develop a new concept of short sea ship. The use of this new ship should reduce costs e.g. by reducing the time spent during loading and unloading, reducing fuel consumption during the trip. But a brand new idea is not necessary for this new ship, it could be a new solution of using existing vessel concept. The concept which will utilise the existing infrastructure will without any doubts be easier to introduce than concepts which requires significant investment in new terminal infrastructure. But if a new vessel concept gives significant cost reduction it will in most cases be able to pay the price for the required infrastructure. Definitions of a cargo unit, package and envelope were deemed necessary to prevent confusion over terminology, these were agreed as follows (Newcastle University, 2007):

	Cargo Unit: A fundamental unit of cargo, e.g. ISO/ non-ISO/ cube max/ reefer container, tank container etc., or a new 'cargo unit' to meet the needs of how a new cargo might be unitised.
	Cargo Package: A number of cargo units handled together to facilitate loading and unloading. Minimum size is a single 'cargo unit' and the maximum size is a 'cargo envelope'. Maximum package size (number of cargo units) is set by cargo handling and logistic constraints
	Cargo envelope: A number of 'cargo packages' onboard the ship in a particular loaded condition or the nominal total capacity of the vessel assuming a specified weight per 'cargo unit' or 'cargo package'.

There are four types of ship which are the target of Create3S project:

— **Container ship:** Most relevant in SSS, it should be able to take a range of intermodal units such as standard ISO containers, 45 ft containers and swap bodies in the same envelope or package, increasing ability to sail with fully utilised capacity.

— **Dry bulk cargo ship:** Size of the ship is dependent on the operating distance and cargo volume available for transport; as well as port draft, fairway width, quay length and cargo handling facilities. Create3S is concerned with ships that can accommodate 2000-8000T dry bulk cargo, and meet vessel size restrictions of small Baltic/North Sea ports.

— **LPG/LNG ship:** Most demanding to outfit. LNG must be pressurized and transported at -163°C. Propane, butane, ethylene or propylene must be transported at -51°C. The target is to accommodate 1000m^3 to 3000m^3 LNG, on 100-2000 nm routes.

— **Petroleum products ship:** Typically 10-50+ compartments (product tanker - chemical tanker). Stainless steel chemical tank construction is standard. Recommendations for Create3S would be to develop concepts that can accommodate from 2000-8000T cargo.

It is not considered possible to develop one ship type which will economically operate with all cargo types. It is also not viable to develop one generic hull design for all types of ship, due to different outfitting necessities, cargo dimensions and volume/deadweight ratios.

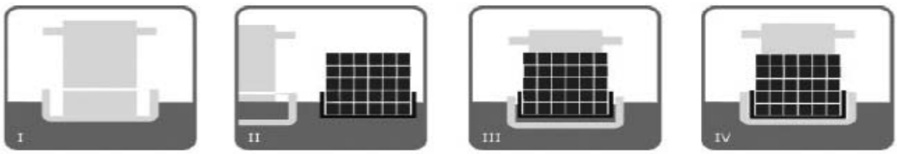
DIFFERENT SOLUTIONS FOR CARGO TRANSPORT

Transporting the cargo from ship to dock and vice versa can have a large impact on delivery time for short sea cargoes. The ideal solution would load and unload the cargo envelope in one move or as a few packages with a continuous transfer process. Create3S focuses on the best available solutions for every type of cargo considered in the project. Four existing solutions were presented for cargo handling (TU Delft, 2007a):

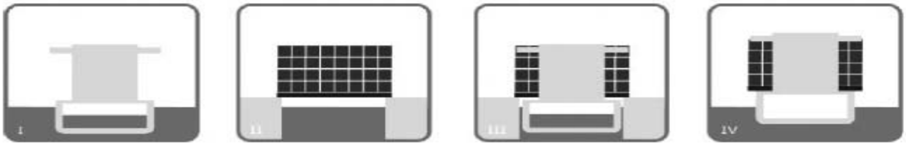
Lift on - Lift off [lo-lo]: This solution is designed for transport of containerized cargo. The crane can be either quay or ship mounted. This type of transport not allows to transfer the entire cargo in one move, but the continuous loading and unloading is possible.

Roll on - Roll off [ro-ro]: The solution used first of all in the ferry sector. The ramps can be mounted in the ship and on the quay. This type of transport is not efficient in terms of maximizing payload, but fast turnaround times can be achieved.

Float on - Float off [flo-flo]: This solution is appropriated to loading a buoyant cargo envelope. Special port infrastructure is not necessary. The ship fills its ballast tanks to adjust the draft, a buoyant envelope floats over the deck, where after the ballast tanks are emptied. This type of transport allows to transfer the entire cargo in one move.



Ballast on - Ballast off [bo-bo]: The ship's ballast tanks are used like in flo-flo, but the cargo envelope is non-buoyant. The entire cargo envelope can be transported in one move. The critical part of this solution is the maintenance of stability during the envelope transfer.



CARGO TRANSFER SYSTEM AND SHIP PLATFORM

The initial stages of the CREATE3S project have contributed 4 novel potential solutions to the issue of cargo transfer; these are being developed at the concept level to ensure that an informed decision can be made over which solution to take forward into the detailed stages of development. These can be categorised as:

1. Truck-Trailer: A sea-going push or pull barge concept. The ship consists of two parts, the 'engine' and the 'cargo', the latter defined as the envelope. The envelope is buoyant and could act as a floating warehouse; this can optimise terminal handling. Dividing the envelope into multiple packages is possible, but is not so relevant for the ship concepts. The envelope can be loaded independently of the engine, and should be compatible with existing lo-lo terminal infrastructure. Other loading variants are also possible, but may require a different envelope layout. The critical components of this concept are the link between the 'engine' and 'cargo' modules; and whether the engine unit should be capable of solo operation.
2. Modular Ship: Similar to Concept 1, this design also features a buoyant cargo envelope, but consists of multiple packages. Minimising ballast draft is a key feature of this solution. The ballast draft is minimal, because the packages are buoyant. The package adds buoyancy to the ship, and is an integral part of the vessel. The ship must be able to operate without any packages onboard. The 'engine' is a platform for the buoyant cargo packages. Direct inland barging of the packages is an essential part of this system (TU Delft, 2007a).
3. 'Flo-Bo': A hybrid float and ballast on/off system. The cargo is transferred between the ship platform and barges by means of an encompassing floating dock. The cargo is stacked onto pallet-frames, either on the barges or possibly directly onto the dock itself by conventional lo-lo means. The barges transfer their cargo packages to the dock through a ballasting operating which is repeating by the ship; it enters the dock, is loaded by way of ballasting down the dock, and then sails. The ship platform does not need to be in port whilst the barges are loaded, significantly reducing loading time, it also does not need the capability to ballast itself down as required for Flo-Flo or Bo-Bo. Turnaround time could potentially be reduced further by having two docks, allowing the ship to offload cargo in one dock and be loaded from the second dock rather than waiting for the complete loading and unloading cycle to be completed.

4. 'Mega pallet': The idea of this concept is a scale increase in transfer operation. By the introduction of a 'mega pallet', i.e. a bundling of containers or bulk tanks, a reduction in ship loading and unloading time should be achieved through heavier but fewer lifts. The concept is based on a conventional ship, and cargo transfer could be a LoLo or RoRo operation. This concept could also be used to transfer cargo from quay to envelope for the concepts described above.

CRITICAL TECHNOLOGIES: PERFORMANCE ANALYSIS OF SHIPS

The performance parameters of the ship design must take its broad operational spectrum into account. Traditionally, a ship would be designed for one trial speed and draught; however, the nature of this concept means that a much wider range of operating conditions must be considered and optimised. The use of modular components will also contribute to the wider application of the concept. The operational life cycle spectrum must be established during the hydrodynamic design of the vessel; for Create3S it is foreseen to establish such data with voyage simulations. The balance of the investments and operational revenues and costs can be addressed in scenario simulation, using the program Gulliver developed at MARIN. This software allows the user to simulate several years of operational service, including encountered weather conditions. A key element of this analysis is the way the master

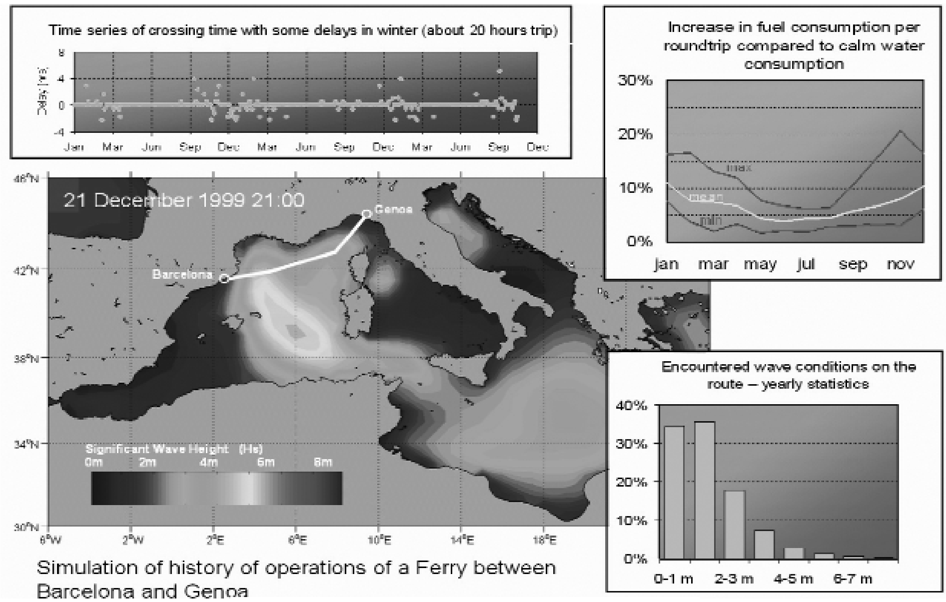


Figure 1: Voyage simulations example.

handles the ship in adverse weather: giving priority to short-term revenue (speed, reliability) or long term cost reduction (careful sailing without damage). Figure 1 gives an example for a ferry operation between Barcelona and Genoa; voyage simulations offer opportunities to develop short sea shipping, providing statistics on a roundtrip schedule, or analysing which vessel has the lowest fuel consumption and highest reliability. It is the authors' view that there is much to be gained by evaluating future operational performance in advance; therefore this 'design for service' will be carried out at the preliminary stage of the design.

ENVIRONMENTAL SUITABILITY

The requirements for the vessels being developed throughout this project cannot solely focus on becoming cost effective. As environmental laws and regulations continue to evolve and become increasingly complex, new and challenging considerations need to be implemented in order to ensure compliance. Consequently, knowing and understanding how multimodality will affect the environment becomes of prime importance when producing the desired services without incurring unnecessary costs, and avoiding doing damage to the environment. Therefore, the project will also look at the environmental impact of the new modular concept that has been previously explained. Generally speaking, short sea shipping appears to be the most environmentally friendly transport mode (Benvenuto & Figari, 1999). In addition, accounting external costs of transport due to such as noise, accidents and congestion, shipping outperforms road transport to an even greater degree (IWW/INFRAS, 2004). Environmental impacts of shipping can be sorted into six main categories (Cabezas-Basurko et al., 2007):

- Airborne emissions from consumed hydrocarbon fuels, cargo emissions and noise.
- Waterborne emissions as a consequence of underwater noise, antifouling coating leakage and illegal spills and discharges.
- Operational spills: routine discharges of oily waste, ballast water from marine shipping and wastes.
- Accidental spills of oil, toxics or other cargo or fuel at ports and while underway.
- Invasions of invasive species due to mainly ballast water in marine shipping and fouling on hull and anchor.
- Other emission, such as wash due to waves produced by the movement of the ship. Usually, the wash is more predominant on high-speed craft.

SSS will also generate environmental impacts of a different nature; the increase of SSS will enlarge and increase the construction of more port and inland channel infrastructures. Life Cycle Assessment (LCA) is the most popular technology for assessing the environmental impact and there are good examples of its used in shipping (Fet, 2002). Therefore, this will be the mean that the project will use for analysing the environmental impacts of the proposed multimodality idea. Resources consumption, waste production and environmental impacts of different solution presented on the project will be investigated. There will be also a comparison with the conventional transport modes in order to see whether in reality SSS is the best solution for sustainable development. The commercial LCA tool SimaPro will be used on the project for this aim. Environmental benefits, jointly with the life cycle cost analysis and the risk assessment of the alternatives will give a clear idea of the benefits of using this innovative ship concept and their contribution towards a sustainable future.

CONCLUSIONS

This paper outlines the work at the early concept and preliminary design stages for an innovative new class of short sea vessel, part of an EU-funded project, CREATE3S. Within this project setting the starting point at the cargo logistic chain has been explained; from this requirements for the harbour and ship will be deduced. The concepts considered so far have briefly been described, and critical technologies have been addressed. Incorporating operational conditions and environmental impacts of the vessel into the design at an early will ensure holistic whole life design of a useful, fit for purpose vessel.

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