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Procedia - Social and Behavioral Sciences 48 (2012) 3471 – 3481

Procedia
Social and Behavioral Sciences

Transport Research Arena– Europe 2012

“On-Board STS-Crane on a catamaran container vessel as combination of jib- and gantry-crane serving small ports, improving logistic efficiency."

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Abstract

The 7FP-Project “EU-Cargoxpress” developed a concept of an innovative, sustainable catamaran cargo-vessel with an on-board-crane able to serve small coastal and fluvial ports without proper Ship-to-Shore (STS) cranes.
The crane as part of a covering multifunctional “sail-wing” is hinged in a moving and revolving Superstructure, covers the whole vessel length and cantilevers over the perimeter of the vessel.
The goal is to accelerate the movement of container and general cargo from the vessel to the port and making maritime transport more competitive.

"Keywords: Cargo-Catamaran; On-board STS-Crane; Short port stay; High loading efficiency; Ship-port-interface"

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doi:10.1016/j.sbspro.2012.06.1311

Fig.1: 3D overview of new cargo-vessel with cantilevering on-board crane. Source Innovacion Logistica SL (ILCX)

1. Introduction, Background and Objectives of the paper

1.1 Introduction

EU-Cargoxpress developed a sustainable and competitive container and general cargo vessel aimed at a partial replacement of coastal European and African cargo-flows from road towards maritime transport. This paper describes as part of the overall project the development of a more efficient onboard Ship-to-Shore crane and its potential to shorten the vessels port stay.

The goals for the new crane include:

- Fast transfer of container and project cargo from vessel to quay without external support
- Low crew operations
- Autonomy to load/unload in small ports without shore support

The next natural step is the construction of a full-scale experimental prototype to run a normal coastal cargo-traffic and gain experience in daily operation at sea and in port.

1.2 Background

The current road-transport connects all Europe to the last corner and supplies cargo even to coastal port cities and factories, if not situated on an island. Even shipyards receive most of their material and heavy equipment by road-transport.

On the other hand, the maritime transport has reached only few of all accessible coastal and fluvial ports. All of them are embedded in surrounding towns and close-by hinterland with populaces from 10.000 to more than 500.000. The project counted more than 1.200 ports in Europe and Africa, with 560 viable for maritime cargo transport.

The question arises, why most ports and port-towns are disconnected from the modern cargo-flow through maritime logistics and the trucks deliver by road, saturating the limited street and highway-capacity, while the Ocean surface is literally empty from logistic hardware.

One typical circle argument used is, that small and medium ports do not invest in cargo moving hardware, see Fig. 2a, because there is not enough cargo-movement.

Fig.2a: Ship – To – Shore Cranes. Source: Wikipedia.

Fig.2b: Feeder vessel with on-board jib-cranes source: Dokmar Maritime Publishers B.V. 6th Edition.

Currently some feeder vessels are equipped with on-board jib-cranes (1) (2) mounted in centre-line or on the vessels side, Fig. 2b. They are able to unload container and short project cargo in ports without external crane support, as long as the capacity and reach is sufficient.

The main advantages are proven design and function.

Their disadvantages are:

- Need of counterweight like ballast water to avoid excessive heel of the vessel
- Reduced area of action and cantilevering
- Slow action due to turning of crane and cargo during unloading
- Difficult control of container positioning due to insufficient overview of the operation.

Nevertheless, they present a viable solution.

A third solution is the employment of mobile-cranes accessing the quay area. They are flexible in moving along the vessels side, but very slow, expensive and cumbersome to position.

1.3 Objective to improve Crane productivity, shortening port stay

The whole process of moving cargo from the vessel to the final destination consists of various steps. Focus is laid here on the movement of cargo from Ship to Shore and the storage next to the vessel on the quay. Especially the former has main influence on the time the vessel needs to stay in the port. Other time consuming issues (for instance administrative, crew, supply, small maintenance) are not discussed deeper in this coherence. It is assumed that these issues can be carried out before and during normal loading and unloading procedure.

- STS-Crane, Fig. 2a: Between 20 and 25 movements per crane-hour are normal for a traditional

container terminal
- Onboard-jib-crane, Fig. 2.b: According to the report "Benchmarking Container Terminal Performance" (Rotterdam, 2003) the productivity when using a ship's gear, may be of about 8-15 movements/hour

The difference averages 11 movements per hour and converts (using single cranes) to:

- Additional port time of 4,2 hrs with 100 movements (around 170 TEU, depending on the mix 40/20-foot container)
- Additional port fees, depending on the port
- Additional shore-manpower and energy

These numbers multiplied over the lifetime of the vessel diminishes the operator's benefits.
But in time of rising fuel-prices, he looses additionally the flexibility for lower the vessel-speed to the next port and thus saving on fuel. Depending on the vessel-hull form, size and payload, reducing the speed from 13 to 11 knots, (3,7 km/h less) the hydrostatic resistance (Pe) is 47% lower. As an example for a 200 TEU feeder vessel:

100 miles sailing with 13 miles/hr requires approx. 5,3 t fuel

100 miles sailing with 11 miles/hr requires approx. 3,3 t fuel.

In the paper: "Preparing for high fuel cost and environmental restrictions with a 200 TEU container-vessel using wind and solar energy, saving over 50% with a new operation model" this is described more in detail. See TRA 2012 conference papers.

Loading-technology matters!

The project studied a way to apply the more efficient Ship-to-Shore crane concept onto a cargo-vessel serving containers and large project cargo alike.

2. Applied R+D methods

2.1 Basic cargo-transfer

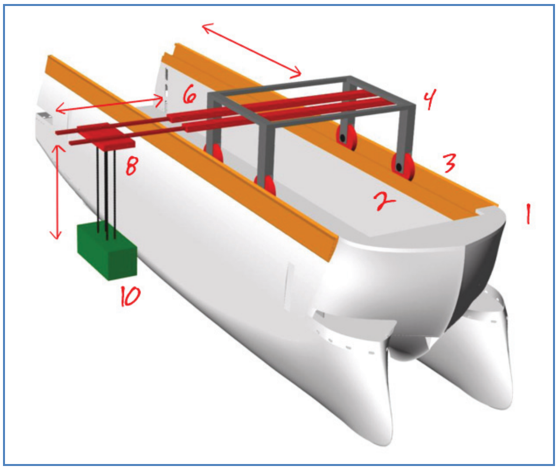
Logistic engineering has developed all kind of equipment to transfer cargo from ship to shore:

- Lifting cargo with jib-cranes and STS cranes plus different means of attachment
- Moving cargo by transport-belts or roller-lines into the cargo-bay
- Driving trucks or trailers into the vessel on different decks like in Ro-Ro-vessels

Most of these except STS cranes are slow or cumbersome. Ro-Ro systems have the inherent disadvantage of transporting the 7-10 t trailer or truck additionally to payload and requiering lots of deck space for moving and positioning in decks.

Normal STS cranes have a limited clearance between the colums, designed for extra long containers. Large project cargo cannot be loaded by this equipment, it needs extra jib-cranes or mobile-cranes on shore.

The following simplified model helps to understand the way a different solution was developed.



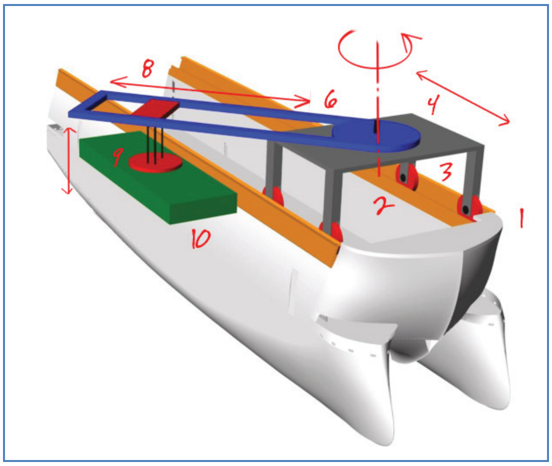


Fig. 3a: Gantry type crane on-board. Source: ILCX. Fig. 3b: Jib – Type Crane onboard. Source: ILCX.

Fig. 3a: To copy the main advantages of the shore based gantry crane we install on the walls of the vessel (1) on top of the cargo-deck (2) a set of rails (3) to move a gantry-bridge (4) along the mid-ship axis. The gantry-bridge has sufficient height to move a high-cube container (10) plus spreader plus runner over the rails (3) into the cargo-bay.

The gantry-bridge carries right-angled a cantilevering rail-system (6) with runner (8) and container (10). The process of loading and unloading of containers resembles shore-based gantry-cranes, if proper control is guaranteed.

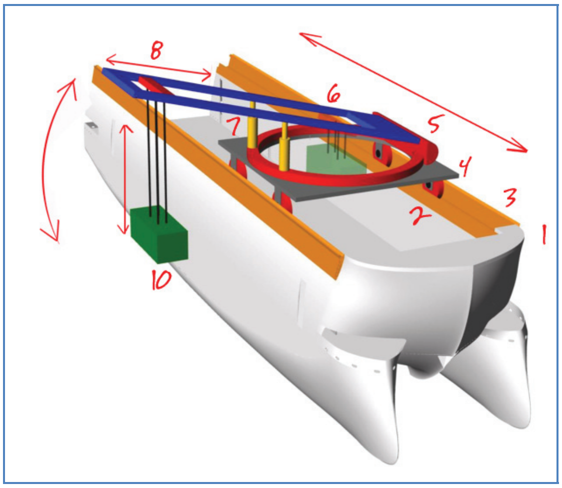
The advantage of this system is: High speed and simple well-known design.

The main disadvantages are: Unable to load large cargo with orientation parallel to mid-ship axis and need of telescoping cantilevering rail-system (6) to get a certain reach onto shore, a difficult technical task.

Fig. 3b: To load large project cargo a Jib type crane (6) on top of a moving gantry bridge (4) would be acceptable. It requires generally a rotating load-platform.

The advantages of this system are high flexibility to accommodate project cargo into the cargo-bay, the positioning of the Jib in sailing direction and simple well-known design.

The main disadvantages are: Slow movements, extra turning and not efficient for container.



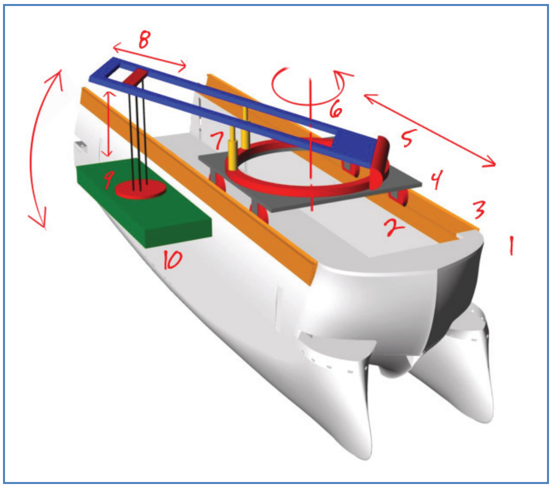


Fig. 4a: New onboard Crane working in Gantry-mode. Source: ILCX

Fig. 4b: New onboard Crane working in Jib-mode. Source: ILCX

A solution, where the advantages of both systems can be combined, consists in a gliding table (4) with a large opening in which a platform (5) is turning (jib-function). On this platform a cantilevering crane plume (6) is hinged and lifts, as needed depending on the cargo height.
In container transport it works as a gantry crane as shown Fig. 4.a.

In case of loading/unloading large units of project cargo, the platform (5) turns (jib-function) and deposits the cargo into the free space of the cargo-bay, Fig. 4.b.

2.2 The concept of loading through the turntable shown in the following image

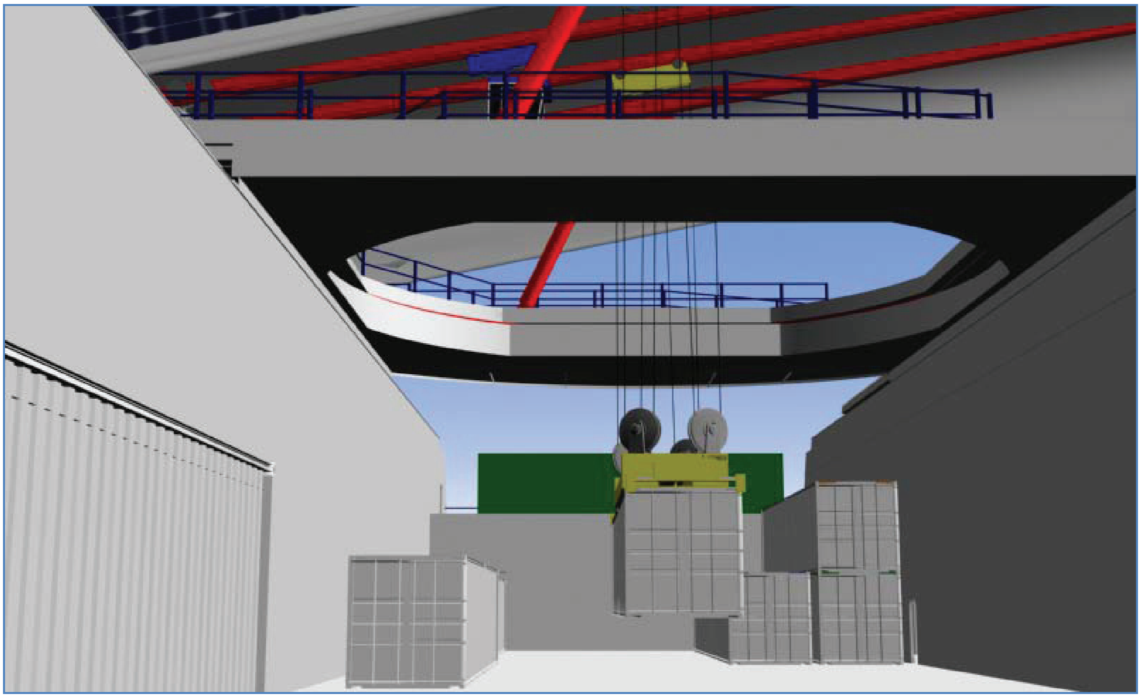


Fig. 5: Loading container through the large opening of the new onboard Crane. Source: ILCX

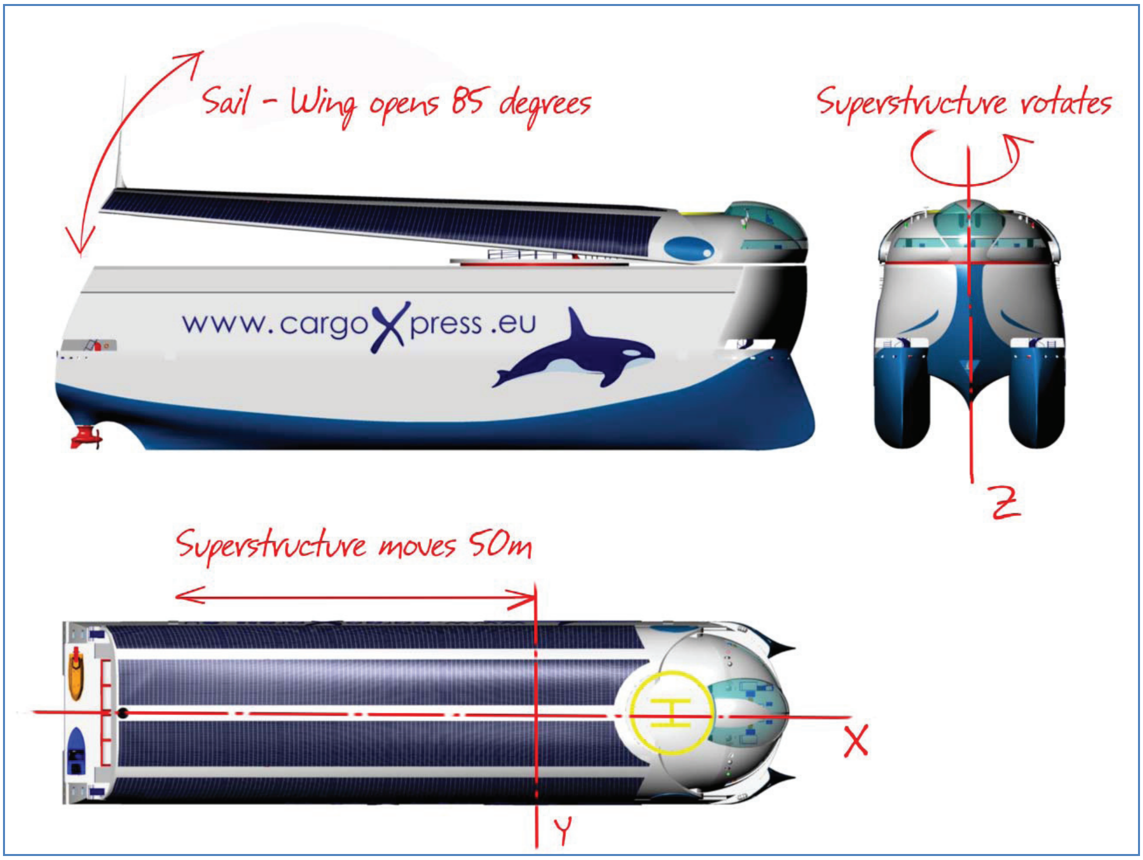


Fig. 6: Basic cargo-vessel concept with multifunctional Superstructure. Source: ILCX

The large flap hinged to the Cabin-Platform, Fig. 6, has the functions:

- Serving as support-structure for the cantilevering onboard crane
- Serving as hatch-cover for the cargo-bay in bad weather or for delicate cargo
- Serving as a sail-wing for wind harvesting up to 700 kW
- Serving as a solar collector in southern regions
- Serving as cargo-bay-lid, improving overall structural stability, when clamped down in extreme situations

Challenges towards the new system:

The concept-design for the moving and revolving Superstructure, Fig.7 shows very large building blocks, so-far unknown in traditional vessel building. Revolving bridges have been built in ferries, but the combination of so many functions into the Superstructure seems to be innovative.

<u>The consortium is aware of the outstanding engineering challenges for building the cantilevering crane-sail-wing on the structural side, as well of the mechanical challenges to turn the Bridge-Platform within a 20m-table bearing.</u>

Moving the whole Superstructure along the ships centreline is a known technology by bridge-crane builders.
Forces and moments have been evaluated and submitted to finite element calculations.
In the phase of a prototype design, those calculations will have to be refined.

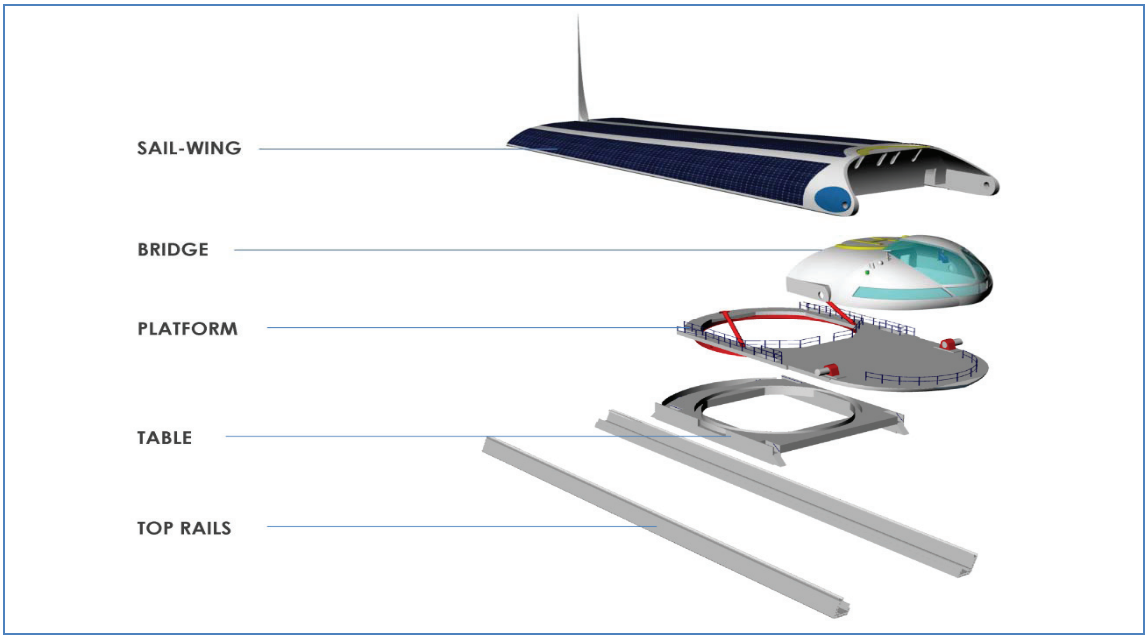


Fig. 7: Some basic structural building blocks for the whole Superstructure. Source: ILCX

Fig. 7 shows the concept resulting from the above-mentioned schematic solutions. The lower vessel is not included. The Top Rails will be mounted on the sides of the cargo bay walls reaching from bow to stern. In the Top Rails glides the Table, which carries the whole Superstructure.

The Table has a large inner groove, which takes the ring of the Platform and the turn-motors. The Platform carries on the frontend the Bridge with the necessary equipment for the whole Superstructure and crew quarters. On the Platform are pivoting points, where the Sail-Wing is attached. Telescopic cylinders will lift the Sail-Wing for crane operations and for wind harvesting.

By turning the Superstructure, the Bridge can be positioned into the necessary view-direction towards the quay while mooring and towards the port-exit for departing.

2.2 Application of this onboard crane in small ports

In large container terminals the loading of containers will be done by the terminal STS cranes or at separate berths with the vessels own onboard crane. This decision depends on the terminal, the local organization and availability of berths.

In small and medium ports, the vessels will unload/load by its own means.

The containers can be positioned beside the vessel with a normal reach-stacker for the yard service. This vehicle will later, after departure of the vessel, distribute the container towards a waiting area or directly on a truck for delivery.

Type of equipment	Container	XXL Cargo	Moves/h	Operation area	Yard-support
Shore based STS	Yes	No	20-25	Large ports	Necessary
Shore Mobil crane	Yes	Yes	8 to 15	Large/small ports	Necessary
Vessel based jib-crane	Yes	No	8 to 15	Small ports	Necessary
Vessel based STS	Yes	Yes	20-25	Small ports	Not necessary

Table 1: Comparison of different crane-equipment for port unloading. Source: ILCX

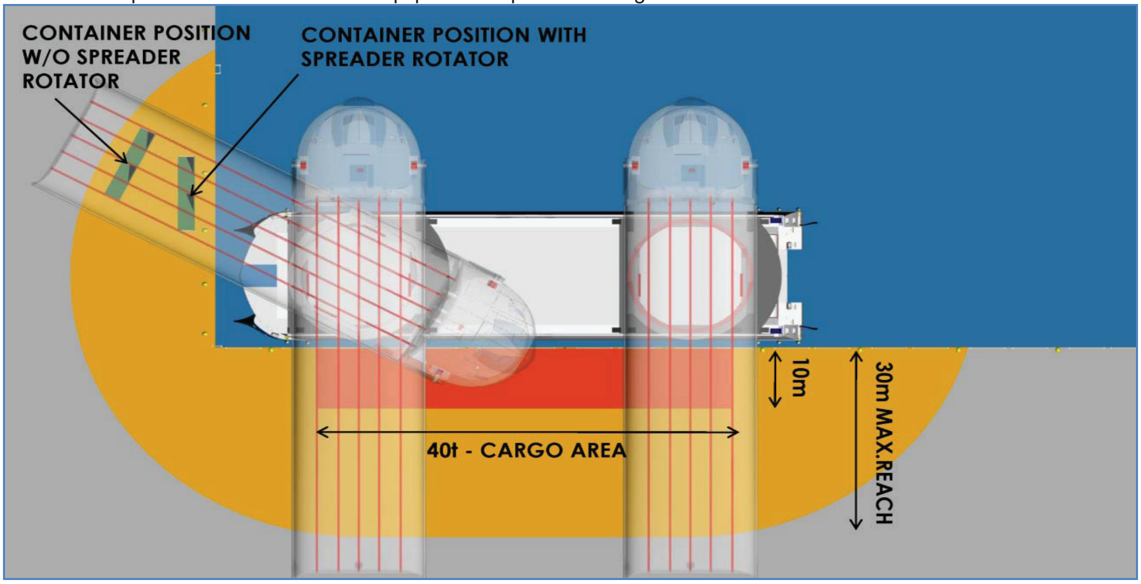


Fig. 8: Space covered by the crane of the new cargo-vessel. Source: ILCX.

This is a great advantage versus traditional feeders with jib-cranes, which could only unload/load in two areas and would require permanent clearing of those areas by yard-equipment, a loss of efficiency and increase of lead-time (not shown in Table 1).

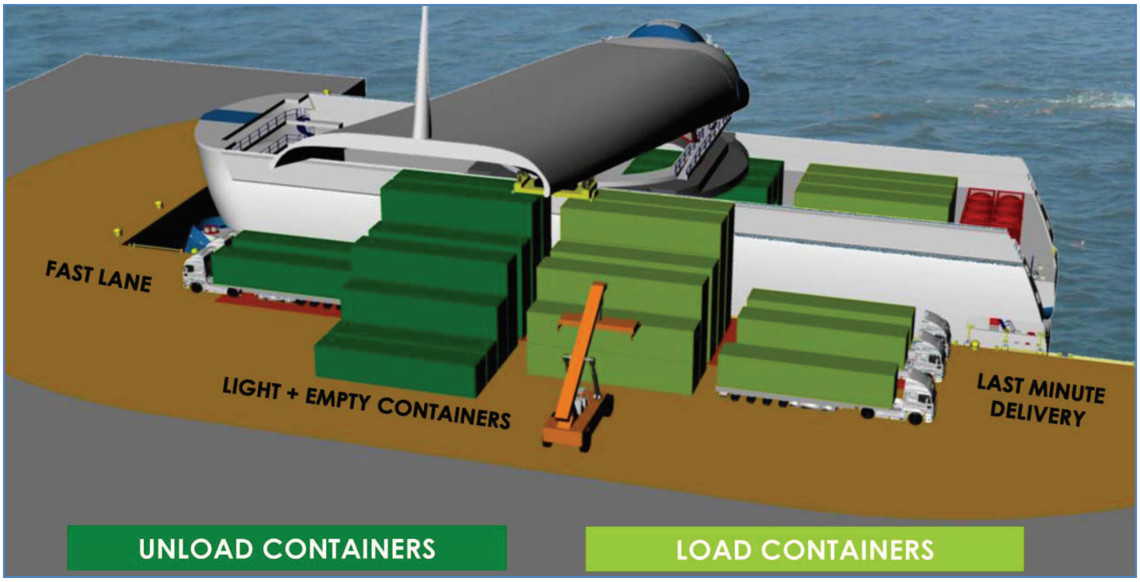


Fig. 9: Situation at loading/unloading dock. Source: ILCX.

Additionally space for direct truck loading or unloading is available alongside the vessel.
As the movement of the crane can be controlled using a given unloading pattern with automatic coordinates-definition x-y-z; direct truck delivery is a disturbance, because the position of the truck towards the vessel is not well defined.

The dock-space could accommodate more than half of the vessel capacity:

- Approx.100 TEU of the 32t type
- Approx. 200 TEU of the light type and empty containers

This assures that the vessel does not have to wait for Yard equipment to clear space or to bring additional cargo. Other impediments like fuelling, charging of batteries, crewing, maintenance etc should run in parallel during loading/unloading.

The autonomy by using the vessels onboard crane eliminates the current waiting time for port-owned cranes, being STS or mobile. This allows for unloading/loading at night, when normally no port-crew is available and leaving the port at short notice.

The advantages of this combination are more speed and autonomy in container handling and high flexibility in project-cargo handling.
The challenges listed in the text above are mainly technical challenges for the large turntable equipment and the lifting forces for the crane-plume. These challenges will need intense engineering attention in the next steps.

Fig. 10: View from quay to crane unloading a 40-foot container, the control cabin hanging in the middle rail. Source: ILCX

3. Conclusion

The proposed innovative cargo-vessel is a new approach towards sustainable and competitive maritime transport, serving small coastal and fluvial ports without proper loading equipment.

The article presents for discussion and feedback a concept of a novel Ship-to-Shore crane mounted on a moving and revolving Superstructure.
This crane has equivalent productivity to shore based STS cranes but with the advantage of being able to load large project cargo in jib-mode too.

The main expected advantages are shorter port stay and with this the ability to sail to the next port with reduced speed and fuel consumption. It will promote the transfer from current road-transport to maritime transport and as a by-product develop small ports and their towns.

The promoters are currently assembling resources and supporters to start detail-design and building a first vessel in 2012/13. A first operator has already been found.

4. Acknowledgements

To the EU-Commission, having the vision to accept our Grant Proposal and to our Project Officer for his engagement supporting the R+D work.
To the creativity and cooperation of the Consortium, producing this promising result.

Supporting Consortium	Country of origin	Company / Institute	
Acciona Trasmediterranea		Shipping company for freight and passengers	
Autoridad Portuaria Gijon		Port Authority with MOS knowledge	
MARINTEK		Norwegian Marine Technology Research Institute	
SDC		SDC Ship Design & Consult GmbH	
Universidad Politécnica Madrid		University for Naval Construction	
CMT		Centre for Maritime Technologies e.V	
Swerea-SICOMP		Swedish Institute of Composites	
ILCX		Innovacion Logistica SL	
Kockums AB		Shipyard with experience in composite material	
Fjellstrand AS		Shipyard for catamaran ferries in Aluminium	
KTH Stockholm		Technical University	
NTUA		National Technical University of Athens	
DNV		Det Norske Veritas as Subcontractor	

5. References

Eu-Cargoxpress 7FP, Project Nr: 233925, Images c/o Innovacion Logistica SL Ferrol/Spain
Wikipedia: Ship – To – Shore Cranes.
Klaas Van Dokkum: Dokmar Maritime Publishers B.V. SHIP Knowledge 6th Edition.
Feeder vessel with on-board jib-cranes
Report "Benchmarking Container Terminal Performance" (Rotterdam, 2003)