Greening of surface transport through an innovative and competitive CARGO-VESEL Concept connecting marine and fluvial intermodal ports

Executive summary:

The 7thFramework Program under SST.2008.5.2.1 Innovative product Concepts

Innovative surface transport products and system concepts (vehicles, vessels and infrastructure) strengthen the competitiveness of European industry meeting customer requirements, changing markets and environmental challenges and to develop projects and technological advances for a more sustainable and competitive surface transport.
EU-CARGOXPRESS developed eight promising and challenging technological breakthroughs:
- General arrangement in form of a Catamaran Cargo-Vessel
- High stability without ballast water
- Electric drive system with tanks and machinery in modular containers
- Sustainable propulsion support by a large Sail-Wing and Solar Panels
- On-board Ship-to-Shore Crane to handle container and XXL cargo alike
- Fast turn-over in small coastal and fluvial port-towns to reduce road-transport
- Fulfilling the Clean Ship-Concept (North Sea Foundation and T&E Brussels)
- Lightweight hybrid hull design and Serial construction

The vessel's energy efficiency results in more than 50% reduction of fuel consumption and CO2 emission, using LNG piston machines only 36% of the time.

Short sea shipping is an industry with a bright future, considering the ever-increasing attention to environment and the improved logistics versus congested roads. The cargo/container vessel fleet has come to an age, in general, where renewal is required. CargoXpress will represent a necessary leap forward for more industrialized and environment friendly maritime transport.

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

Project Context and Objectives:

1.1 Basic motivation for the Project

The motivation for the Grant-Proposal were:

The 7thFramework SST.2008.5.2.1 Innovative product Concepts

The plans and actions of the European Commission to move a substantial part of the road traffic towards the Motorways-of-the-Sea, containing Short-Sea-Shipping (MoS) maritime links.

The White Paper for Transport.

The iniciative LEADERSHIP 2015 of the EU-Commission proposing the construction of new standard vessels.

The fact, that the current European cargo-fleet for MoS cannot offer the necessary capacity and uses outdated and energy intensive technologies.

From a cost- and time efficiency standpoint the existing vessels cannot compete with the large series of road cargo vehicles like MAN, SCANIA or Mercedes.
The objective of EU-CARGOXPRESS was to develop a new generation of competitive CARGO-VEssel for accelerated maritime and fluvial shipping using innovative concepts and technologies; in order to support the greening of surface transport and prepare for fast and efficient modal shift in the ports.

1.2 The context and the expected operations theatre for the projected vessel

The Consortium of scientists, engineers and economists based their R&D effort in the context known during the Grant-Application, the changes experienced in the 32 month project elaboration and the expected operations theatre (future context) between 2015 as first launch of the new technology and 2030 as possible end of this product generation.

The different contexts could be grouped as follow:

A: Policy of the EU Commission
   - The initiative LEADERSHIP 2015 of the EU-Commission proposing the construction of new standard vessels.

B: Background of knowledge of potential efficiency reserves

MARINTEK elaborated a list of relevant technological drivers for a sustainable and competitive vessel. This list represented the state of knowledge and expectation for potential efficiency reserves to achieve the goals of the project.

Literature research produced 50 technology drivers and possible alternatives. All areas of action from propeller blade design over ballast water reduction and wind-propulsion with expected savings ranging from 2-70% were evaluated.

Backed by strong support from the Commission all efforts undertaken had to be seen in this context. Maritime transport can only alleviate road-traffic within a distance of 200km along the coastal or navigable fluvial line and around the large over-sea Container Terminals.

The project studied over 1200 ports in Europe and Africa and found 560 port/towns without any maritime cargo-transport, but apt for small cargo vessels having proper loading gear to serve these towns and the hinterland.

This is a market of 36 million to 64 million of humans with all their buildings, industries, agriculture and recycling needs. The direct delivery by see or river into the heart of the town would reduce substantially coastal road-transport.

The conditions to select the 560 candidates from the list of 1200 were:

- Min 200 m quay or berth length
- Min 2000 m2 space behind the quay
- Access to regional road-system
- Min water-depth in low tide 5m
- Eliminating ports over 150,000 inhabitants

The projects advance has to be seen too in the context of the success-story of the Ryanair, serving hundreds of small airports in a very cost efficient manner. CargoXpress could become the Ryanair of the sea.

D: The expected faltering fuel supply due to overexploitation of reserves and exploding demands of the newcomers India and China for their huge population and demand on mobility and progress.

Although there is still some discussion on the speed and impact of fuel resource depletion, the general scientific forecasts point clearly towards higher prices per ton of liquid fuel. These forecasts do not anticipate the rising competition for the remaining resources, because some transport sectors like road and air-transport have very little chance to employ sustainable energies and will pay prime prices to keep working. Maritime transport on the other hand can rely on wind or solar power.

E: The restrictive environmental regulation due to the excessive emissions of CO2, NOX and SOX by current energy converting technologies. The most challenging regulations affect the SOx and NOx emissions, which have to be reduced in the ECA regions already by 2015 and globally by 2020. If the non-compliance will be charged with additional costs, the whole cargo-fleet has to be refurbished by adding cleaning devices or by changing to LNG or replaced, a task impossible to fulfill within the following years. Otherwise the competitive advantage to road-transport is reduced.

F: The on-going crisis in the shipping market brought during the project a different background to the project. Hundreds of vessels were scrapped or laid idle and the rates for chartering halved. In this context proposing bold changes for technology is not an easy task. Although the nature and regularity of shipping-cycles described by M.Stopford are well understood, the pessimistic investment environment prevailed.

G: The outdated current vessel-fleet as a defining context was discovered late during the project. More than 10,000 vessel of the fleet of (500-25,000GT) container and cargo vessels are over 15 years old, 6,500 of them over 25 years. All these vessels were built before the fuel-crises and environmental awareness. All are at the end or over their expected live span.

1.3 Objectives for this EU-Project

Within this context, the project concentrated on issues, which have the major impact on future sustainable and green maritime transport in line with EU strategy. It investigated alternative energy forms, usage and conversion, best low resistance hull forms, materials to lower the lightweight of the vessel, innovative cargo loading equipment and port interface processes. This Concept promises to be very competitive to the ever growing road transport in coastal areas.

The broad usage of this standard CARGO-VESSEL (Truck of the Sea) is planned between the Years 2015 and 2030. This period will implement stricter environmental regulations, forcing the use of less and partly sustainable energy in order to reduce greenhouse gas emissions as well as to follow the Clean-Ship-Concept avoiding ocean contamination 4.
The objectives of the DOW were amplified by focusing on the replacement of the outdated current vessel fleet and not just competition to road-transport. Replacing outdated technologies generally saves on fuel and reduces emissions.

In the Description of Work (DOW) the proposal EU - CARGOXPRESS set-out to deliver an innovative Concept of a new generation of intermodal and competitive CARGO-VESSEL - defined to such a detail, that a group of engineers and operators can build a full scale CARGO-VESSEL serving as an experimental prototype without further investigation or studies.

The EU-Commission has specific goals about maritime transport; on these we have based our design and desirable performance.
By 2050 reduce EU CO2 emissions from maritime bunker fuels by 40% (if feasible 50%)

This ambitious goal would need around 2,000 - 3,000 new vessels. The current fuel consumption of 5 MW vessels is around 6.000 tons per year, depending on the ratio travelling/port-time. For 3,000 needed vessels, this would account for 18 Mt per year.

EU-CARGOXPRESS will include sustainable energy and will reduce fuel consumption for some transport scenarios greater than 25 % compared with conventional solutions.
- Around 4,5 Mt of fuel per year using a competitive innovative technology compared to traditional vessels.
- Around 4,0 Mt of truck-fuel per year of shortening road transport due to accessing small ports.
- Around 1,8 Mt of truck-fuel per year for generally replacing part of road transport by maritime transport.

Total fuel savings goal is 10,3 Mt/year which accounts for 0,63 % of total EU25 energy consumption per year.

The objective was to develop a vessel-concept prepared for the time between 2015 and 2030, the expected increase in fuel-prices and planned environmental restrictions ready for a standardised serial production.

Objectives extracted from the White Paper on Transport 2011:
- Make transport more sustainable
- Cut down oil dependency. Challenge is to break transport system dependence on oil without compromising mobility.
- By 2030 the goal from transport is to reduce GHG emissions to around 20% their 2008 level.
- New technologies for vehicles will be key to lower transport emissions.
- Establish a system that supports European economic progress, and enhance competitiveness.

Project Results:

2. Main S&T Results / Foreground
Introduction

After 32 months of R&D work, the Engineers, scientists and economist of EU-CARGOXPRESS are proud to present various innovative breakthroughs for the maritime transport industry.

The concept of a new container and general cargo vessel is the sum of various innovations and can be manifested in one serial vessel all at once or implemented in parts into the broad maritime design of new cargo vessels.

The following headers separate the innovative concepts:
- General arrangement of the Catamaran Cargo-Vessel
- High stability without ballast water
- Electric drive system with tanks and machinery in modular containers
- Sustainable propulsion support by a large Sail-Wing and Solar Panels
- On-board Ship-to-Shore Crane to handle container and XXL cargo alike
- Fast turn-over in small coastal and fluvial port-towns reduce road-transport
- Advancing the Clean Ship-Concept
- Lightweight hybrid hull design and serial construction

2.1 General arrangement plan of the Catamaran Cargo-Vessel

The Situation

The design of maritime vessels for passenger transport and the cruising industry has undergone a technological quantum leap in the last decade. This change resulted from different hull forms, efficient propulsion systems, use of different lightweight materials and modern surface design.

In contrast, the building of cargo and feeder vessels suitable for the Motorways of the Sea (MoS) has undergone only a weak technological development in the last decades. Besides some minor improvements, the naval industry mainly copied existing designs.

The Challenge

Develop a new class of small and medium Container and general Cargo Vessels in multihull configuration with large cargo-bay and on-board Ship-to-Shore crane able to serve small ports.

The General Solution

The consortium developed a 200 TEU catamaran type CARGO-VESSEL able to access small coastal and fluvial ports. This allows distributing the containers from the large international Terminals into the fine fibre of the coastal network. Goal is to reduce considerably the current road-transport with heavy trucks or trailers, which jams the mostly poor traffic – infrastructure of those regions.
The crane is integrated into a 1200 m² Sail-Wing, which can be lifted by hydraulic means to act as a sail in conditions up to 30 knots of wind. Superstructure, bridge and Sail-Wing are mounted onto a table which moves along the vessel's centreline. The Superstructure turns 360 degrees in the z-axis, allows the crane to cover the whole vessel and perimeters and adjust the Sail-Wing to optimum wind-angles.

Important R&D achievements

A: Innovative hull configuration and tank testing

Multihull vessels present a special challenge for the design of the hulls. The stability of the vessel increases considerably and in this case ballast water is not needed. Disadvantages are increased wetted surface, higher construction cost and Gross-Tonnage (Port and Channel fees).

The Consortium did build three scale models to test the towing tank resistance in different speeds, hull-forms, with self-propulsion and different heel-angles to simulate the conditions while sailing with side-wind.

Resistance values were very good and gave input data for dimensioning the energy and propulsion concept.

B: general Arrangement Plan of a catamaran container vessel

SDC, the partner for Naval Architecture Calculations developed the general arrangement plan and stability and longitudinal stress calculations for the new vessel.

Trim, heel and impact stability were investigated considering the HSC Rules. The requirements of the HSC Code were fulfilled and the functionality assured.

The original goal to produce a vessel with under 4m draught has not been reached fully due to large propeller diameter and low resistance hull configuration (low fuel consumption).

Investigating 560 possible small ports, the consortium found generally sufficient channel depth to accommodate this vessel.

2.2 High stability without ballast water

The Situation

Current mono-hull feeder or general cargo-vessels have an underwater-body in V or U-Form and need ballast tanks and ballast water to stabilize the vessel, even with full payload.

Larger Ro-Ro vessels with high decks are having an active ballast water-system pumping ballast to stabilize when in high sea.

This ballast system needs special surface protection, pumps, sensors and filters and periodical inspection
and maintenance. Considerable expenses amount over the lifetime of the vessel.

Besides these costs the added draught due to the weight increases the hydrodynamic resistance.

The Challenge

Assure sufficient stability for the new Cargo-Vessel while loading and in “sailing conditions” with strong side wind.

Important R&D achievements

The new concept spaces the Demy-Hulls 14m apart for the 84m vessels, which gave enough stability in the occurring load-moments for trim and heel.

- Trim loading: All cargo-vessels over 80 m length have a load-distribution calculator on board, which assures the perfect desired trim.
- Trim sailing: With the sail-wing up and especially during aft-wind, a momentum of around 2400tm tends to produce a negative bow-trim. This will be corrected by moving the whole Superstructure with the sail-wing some meters towards stern.
- Trim general: This innovative concept allows trim-corrections during the voyage by replacing cargo in longitudinal direction with the on-board crane and/or moving the superstructure along centreline.
- Heel loading: Cantilevering the crane over the quay and loading a 32t container plus 10t spreader plus the weight of the crane-plume generates a heel of 2-3 degrees, well under the max 5 degrees recommended.
- Heel sailing: With the sail-wing up and specially during 30 kn side-wind, a heel of maxim 8-10 degrees was calculated, well under the common heel of the former large clippers up to 30 degrees.

Towing-tank tests measured the resistance during 8 degrees of heel and showed an increase of 10%, but the wind-energy is free of charge, so the losses do not matter.

The simulations and following tank-test assured the viability of the No-Ballast-Water Concept and it was interesting to observe other development-teams starting to design similar solutions.

This conceptual change of vessel-stability needs intense training of the naval design sector.

Source ILCX.

The main advantages are less fuel consumption and CO2 emissions and savings on inspection, maintenance and front-up investment in ballast-water systems.

CargoXpress fulfils the Clean Ship Requirements.(North Sea Foundations Utrecht and T&E Brussels)

2.3 Electric drive system with tanks and machinery in modular containers
The Situation

Current Mono-Hull vessels have the main machine and fuel tanks located deep down and aft in the hull. This allows for short direct connection via shaft to the propeller and adds ballast weight to the deepest possible location.

Furthermore, the machine rooms are not fit for cargo storing, because they are located beneath the superstructure and not accessible by loading gear.

This design-principle requires the investment in a fully equipped machine room fit for longer human presence mostly in a multiple level arrangement in a narrow and dangerous working environment.

The basic consequence beside the cumbersome installation and time needed for completion in the yard is the rigid and change adverse system. Technology and energy-supply are changing fast and after 5-8 years after choosing the system to design and build, the vessel will start running with sub-optimal equipment or energy-form. (2 years lost already before sailing due to long design and building period.)

This requires after 12-15 years a major overhaul of machinery and tanks - opening the steel-decks, removing the superstructure etc. The cost for this dry-dock work and the loss of income is considerable.

The Challenge

A: Develop a flexible energy and energy conversion system, which can include sustainable energy and adapt easily to load-changes.
B: Develop a system easy to install, maintain and change, which allows the operator to adapt to changes in technology and energy availability.

Important R&D achievements

A: Electric drive system with input of around 50% of sustainable energy

A range of possible energy converters and means of energy storage has been investigated and a hybrid solution including LNG Gensets, Solar Panels, Sail-Wing, electric Shore Connection, Battery packs and Azimuth thrusters was recommended. Permanent magnet generators (PMG) and motors (PMM) enabling a direct electric propulsion line without frequency converter will be used to reduce electric losses.

The main reasons for the recommended systems are:
- The combination of variable energy-input from sustainable resources (wind and sun) and uses of conventional energies demands a highly flexible system, reacting rapidly to the different load conditions.
- The buffering of energy in large battery-sets (greater than 1MWh) recharged by surplus energy and on board produced as well as onshore produced green energy.
- The conversion of conventional energy (LNG) by 2 Gensets with permanent magnet generators.
- The flexible energy and conversion system for different operators in different climate and load conditions (custom-built).
B: Modular containerized energy storage and conversion

Due to the high stability of the Catamaran solution and the electric connection machine-propeller, the concept allows for placing the energy storage (tanks and batteries) as well as the energy-conversion (Gensets) on a higher, easy accessible level.

Furthermore the desire to get interchangeable units and reduce considerably the construction time in the shipyards, guided the engineers to develop a set of modular containers with the respective equipment ready to use inside. These containers can be lifted to their location on board and connected (plug-and-play). In case of maintenance or repair, the container will be interchanged in port with a second unit.

- The modules come pre-assembled and tested from the supplier, no lead-time in yard.
- Modules are easily interchanged, when the energy market or changes in machine technology are promising a better overall efficiency.
- No need for specialized crew on board, because all maintenance and repair is done separated from daily operations on-shore.

This is a novel approach to resolve multiple problems at once and will require more detailed investigation, especially on secure mounting and vibration problems and interchange of full LNG tanks instead of refuelling by hose connection.

Electric drives are adaptable to modular equipment installations, meanwhile direct mechanical drive between LNG engines and propellers would require deep in the hull the traditional machine room.

2.4 Sustainable propulsion support by a large Sail-Wing and Solar Panels

The Situation

A: The expected faltering fuel supply due to overexploitation of reserves and exploding demands of the newcomers India and China for their huge populace and demand on mobility and progress.
B: The restrictive environmental regulation due to the excessive emissions of CO2, NOX and SOX by current energy converting technologies.

Currently the international publications show many ideas how to power a vessel with the energy of wind and sun. Many of these articles have little scientific background, the expected output from to be installed sails or solar panels do not seem to bring a savings potential over 5%.

The Challenge

Develop, quantify and test the usage of sustainable energy on-board and study the total systems requirements resulting from this equipment.

Important R&D achievements
A: Proposal of an innovative, easy to handle sail-wing for harvesting wind-power

Already the visionary proposal for the Grant-Application mentioned the use of a large sail with the onboard crane combined.

During the project this sail-wing was enlarged and exposed to multiple simulations in the ETSIN-Madrid. For this endeavor it was necessary to study the average wind-conditions in 6 operations-areas from the African West-Coast to the Baltic Sea and plot the results against anticipated shipping routes occurrences.

Different profiles of the sail-wing were developed and checked for performance.

Combining both calculations produced a list of average achievable thrust in kN, which gave the sustainable wind-power in kW and the percentage of occurrence.

The important fact is, that this sail produces in 50% of the voyages 700kW - pure propulsion power - without losses by energy conversion in the piston machine, in the drive train or propeller.

Nevertheless in the following detail planning especially the sail-wing must be recalculated:
- Allowable deflection in wind-gushes and while cantilevering with maximal load
- Minimizing weight, to reduce the whole Super-Structure weight for reasons of stability and mass during moving and turning.
- Minimizing construction and maintenance costs
- Maintenance procedures of gliding elements between platform-ring and Table / Table-Top Rail.
- Behavior in extreme cross-sea and wind-conditions.

The future development of this 700 kW machine will require top-engineering effort and special attention from Class, because this is a total new area for traditional shipbuilding.

The innovative sail-wing provides at once the following functions:
- Wind-propulsion
- Carrier of 1200m2 Solar-Panels for energy harvesting as an option in southern operations areas.
- Hatch-cover for the cargo-bay
- Crane-plume for STS-Crane
- Lid on cargo-bay in extreme weather conditions to improve overall resistance.

B: Proposal of covering the sail-wing with solar panels

The possibilities of on board production of green electric energy from sun are limited depending on the operation area. Therefore, supply of electric energy from onshore green sources is included. Such on board and onshore green energy will be used for charging the batteries.

It will be desirable to have an extra battery-set of around 500kWh located in the Superstructure to avoid losses of energy-transmission through the platform-table set-up.
The large on-board energy storage in battery-sets allows to access small ports without emissions.

2.5 On-board Ship-to-Shore Crane to handle Container and XXL Cargo alike

The Situation

All mayor and middle-sized Container Terminals are equipped with these gantry cranes, in large terminals hundreds of them. They are exclusively handling standard ISO Containers from quay to the vessel and reverse.

For large Container vessels various cranes are working in parallel.

Their main advantages:
- Transfer time ship to shore on average around 1,5 min.
- Huge throughput per day due to precise container positioning
- No turning of containers due to parallel handling pattern
- Safe and reliable process.

Their main disadvantages:
- Investment cost up to 7M per STS crane
- Costs of moving one container around 50-200 depending on the port or Terminal
- Port based trained personnel needed
- Unable to lift XXL-Cargo due to their limited with.

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

But in time of rising fuel-prices, the operator loses additionally the flexibility for lower 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, which reduces fuel and CO2 emission accordingly.

For the objective of the EU-Project small ports need to be developed for direct cargo-flow into the port-town. They need ways to handle container and general cargo from ship to shore and back.

The Challenge

To develop an on-board STS-Crane as efficient as a shore-based STS-Crane with loading capabilities for containers and XXL Cargo alike.
Important R&D achievements

A: Proposal of an on-board Ship-to-Shore crane-loading container in gantry mode

The crane moves over the whole length of the cargo-bay, not being disturbed by a traditional Superstructure. This permits to serve and retrieve cargo even in very confined small coastal or fluvial ports, working over Bow, Stern or sides.

A novel three-point attachment crane allows handling very large and cumbersome project cargo without support from shore-based crew.

The combination of the four functions of the Sail-Wing-Solar-Hatch Cover-Crane unit saves on weight and building costs, but poses at the same time a bigger engineering challenge to satisfy the needs of each function. In the detail-phase of the preparation of the first vessel, special attention will be placed on this development.

2.6 Fast turn-over in small coastal and fluvial port-towns reduce road-transport

The situation

Currently a few big and medium container terminals receive the containers and deliver the last leg of the voyage to the final customer by truck (10 to 500km of distance) or for larger distances by train.

This leads to partial saturation and jamming of road-transport due to increasing Inter-EU-Cargo-Transfer and insufficient funds for better road-infrastructure.

Maritime transport can only alleviate road-traffic within a distance of 200km along the coastal or navigable fluvial line, but this area has special needs, because the coastal road-infrastructure is deficient and should serve other purposes, like tourism and neighbourhood development.

The Challenge

Develop maritime cargo delivery into the heart of the small port-town to reduce substantially coastal road-transport.

Important R&D achievements

A: Defining the possible volume of additional maritime transport

The project studied over 1200 ports in Europe and Africa and screened them for their ability to be connected by maritime transport. The results were 560 port/towns without any maritime cargo-transport, but apt for small vessel with proper loading gear to serve these towns and the hinterland:

- Mostly ports with few fishing vessels or leisure vessels
- No cargo-loading infrastructure
- Surrounding port town with an average of 65,000 inhabitants
- Additional hinterland from 0-100,000 inhabitants
- An average traffic of 50-150 TEU per day, depending on the town and industry

This is a market of 36 million to 64 million of humans with all their buildings, industries, agriculture and recycling needs. For the R&D dimensioning process a goal 50 TEU/day and port was extracted, 25 imports, 25 exports (could be partially waste for recycling).

Subsystems in normal Container Terminals with all used equipment and processes and their impact on total costs and lead-time are:
- Ship-quay Loading/Unloading Subsystem
- Internal Handling and stacking Subsystem Yard
- Land Reception-Delivery Subsystem

For all three systems the project proposed procedures apt for this new maritime transport market.

B: Proposal of a novel Ship-Quay Loading/Unloading Subsystem

Using the results from Task point 5.6 the processes at the Ship-quay Loading/Unloading Subsystem was studied and developed. It showed clearly the advantage of an on-board STS-Crane. Unlike a jib-crane, it can unload parallel to the whole vessel length and thus reduce considerably the port time without waiting for port support.

Placing and storing containers or trucks parallel to the cargo-vessel allows for uncoupling the vessel-operation from the yard-system.

C: Internal Handling and stacking Subsystem Yard

Large and medium container terminals require immense storage places for unloading a 10,000 TEU vessel. The storage time reaches easily 6 days and a special organization is needed to locate the containers. As small ports do not receive large quantities at once, the internal handling can be planned much easier.

Most of the containers should be loaded directly onto trucks or stationed in front of a Port-Distribution-Centre, PDC, where they will be emptied and the cargo regrouped for the last leg of transport into town, see next point. The whole process should be organized for fast throughput without delay to eliminate the disadvantage of maritime transport the long port-delay.

D: Land Reception-Delivery Subsystem

The location of Port-Distribution Centres (PDC) and partly warehouses right in the port area within the reach of the yard equipment would be the perfect logistic solution. The reach-stacker could transport the container within the distance of 100m to the PDC, where the cargo will be taken from the container and
commissioned for storage or immediate delivery by small truck into the town or to out-of-town facilities.

The problem in most small ports is the reduced available space:
- Expensive space in prime locations.
- Obsolete warehouses or utility buildings occupy space on or near the quay.
- Missing urban concept for a logistic port.

These problems could be overcome seeing the advantage of revitalizing the port and with subsidies to reduce road-transport towards the town.

There will be two main possible material flows towards the final customer, full containers on large trucks or split-cargo on small town-delivery vehicles.

Small ports will have to install a closed area for security and safety reasons. A gate with supervision will check on truck entrance and exit. Before the gate a waiting area will allow for some 10-20 containers trucks to park.

The reach-stacker loads the container from the place besides the vessel directly onto the truck. This can happen while the vessel unloads or afterwards.

With a strong agro- or industrial structure of the port or hinterland, more full-container will leave or enter the port using the quick-delivery system.

Ports with mainly touristic or leisure population will receive more split-cargo deliveries.

A simple PDC-Building of 500 m² can be used to regroup the cargo from the container and load into the smaller town-trucks.

The reach-stacker carries the full container towards the ramp of the PDC, where the container will be emptied.

The PDC collects cargo from the town or hinterland for delivery to other destinies.

Besides the normal flow of commercial items or cargo the ever increasing volume of recycling material can pass through this port and be delivered via maritime transport towards a coastal or floating recycling centre. This volume of recycling transport by road could be reduced efficiently.

The conclusion of all the above-mentioned potential improvements showed the need to study more deeply processes or equipment in port-customer interchange not covered by this EU-Project. A list of needed follow-up projects was elaborated and will be discussed in the final meeting and later presented to the EU-Commission for inclusion in future calls.

2.7 Advancing the Clean Ship-Concept
The Situation

The naval industry, design, construction and operation are exposed to imminent restrictive environmental regulation due to the excessive emissions of CO2, NOX and SOX by current energy converting technologies. The most challenging regulations affect the SOx and NOx emissions, which have to be reduced in the ECA regions already by 2015 and globally by 2020. If the non-compliance will be charged with additional costs, the whole cargo-fleet has to be refurbished by changing to LNG or replaced, a task impossible to fulfill within the following years.

The Challenge

The concept of an innovative container vessel CargoXpress - must implement all of current required and planed environmental performances towards a Clean Ship.

Important R&D achievements

A: General reduction of fuel consumption in the new vessel concept

The project followed three mayor lines to reduce fuel consumption and with this goal the equivalent reduction of emissions:

- Reduction of lightweight and ballast of the vessel
- Employment of partial sustainable energy,
- Allowing to go slow steaming by reducing port-time.

Total daily consume is calculated by assuming two of these 12hrs cycles.

Batteries are charged in port preferable with green electricity and during voyage by excess Genset energy. No solar input considered.

During wind harvesting the Gensets are stopped and approximately 50-100 kW are fed from the battery to the propellers to assure proper steering.

This operation model of fast port interchange and slow steaming shows promising results. For the final customer the delivery time stays the same, but costs go down strongly.

B: Using of stored green energy for port operations/accessing and smoothing of load peeks by the hybrid concept

The goal of EU-CARGOXPRESS is to serve small and medium coastal and fluvial port-towns. Many of them are located within areas of Natural Protection or dense population. The requirements of protecting these areas from noise, air pollution and wake effects are rising constantly.

CargoXpress is prepared to travel in these areas and the manoeuvring process accessing the berth with...
reduced speed by on-board battery power. The loading/unloading procedures and other port activities are either executed by shore power connection or if not installed by the on-board battery.

The electric drive fuelled by different energy sources (LNG, Wind, Sun, and Battery) allows for very flexible reaction on load requirements. Gensets like all diesel machines run at best efficiency around 75% of peak power. All current vessel concepts loose efficiency, when the main engines have to slow down, they are starting to run suboptimal.

C: Changing to LNG Fuel

CargoXpress will be in line with the latest modernization of many vessels towards LNG fuel.

The advantages are widely known and need no further explanation.

The shown LNG consumption includes the benefit of wind harvesting and slow steaming due to fast port turn over.

CO2 reduction per year will be around 3270 tons, NOx reduction 66 tons per year and SOx will be eliminated altogether.

D: Less surface maintenance through modern materials

Surface smoothness would be an optimum, reducing hydrodynamic resistance and the need of constant repairing and re-painting.

The process of cleaning oxidised steel surfaces is a major contaminant of ocean water, which should be eliminated altogether.

E: Less cargo loss in high sea due to protected cargo bay

Current vessels, coming into bad weather or heavy sea states, are sometimes loosing on-deck cargo. Floating containers or other large objects pose tremendous safety risk for maritime transport, and are increasing the insurance rates.

2.8 Lightweight hybrid hull design and Serial construction

The Situation

Cargo-Vessels are built in European and other global shipyards mostly as one-of-a-kind projects or in very small series, if any. The predominant hull material is steel; cut and 2D bend or rolled. 3D forms are not economically feasible with the used sheet-material thickness and production numbers. Building from multiple pre-cut and pre-formed sections requires heavy logistic preparation producing extra lead-time and manpower.
The results are hull forms, with suboptimal hydrostatic performances and heavy constructions due to welding and structures supporting. The shipyards suffer from lack of know-how accumulation, low productivity and high cost for retrofitting. Only some European shipyards are successful in very special orders or maintenance activities.

Aluminum is somewhat lighter in the final weight, but required too lots of manual labor, difficult welding processes, grinding and retrofitting. 3D Bulb-Noses or heavily formed stern lines are very cumbersome to produce from many small cuts and pieces.

As the shipyards do generally build the whole vessel at their site, parallel work is very reduced and overall lead-times are long, 1,5-2,5 years. It is very common, that 95% of the vessels costs are already spent, but cannot be converted into operational income for the ship-owner, because some minor retrofitting within the machine-room takes months to complete.

The Challenges

Develop a hull construction technology with lower lightweight and better hydrodynamic performance. Develop a concept of serial production to specialize the yards and cut down of construction lead-time, thus making the vessel less capital intensive and improve competition to road-transport.

Important R&D achievements

A: Designing, building and testing a Aluminium-Composite hybrid construction

The consortium investigated multiple combinations of material for the outer shell and supporting structures based on the experience of the participating shipyards Kockums and Fjellstrand-AS. These variants were calculated on weight and production costs and it was decided to build a hybrid form of a composite shell and aluminium structures.

Different structures from extruded Aluminium and sheet-material were evaluated. Ample work was invested in the problem of connecting shell and structure by gluing and mechanical fixing.

A series of tests with glue-only and glue-mechanic connections in medium sized demonstrators were executed and presented. A Hazid workshop with Det Norske Veritas (DNV) on these questions revealed, that no standards existed and DNV recommended going to the secure way by using a glue-mechanical fix connection.

B: Proposals and plans to build future serial vessels copying the Airbus-Concept

The project EU-CARGOXPRESS is clearly dedicated to develop a future serial vessel. After markets study (see next chapter), an average of 50-80 vessels are planned to be constructed yearly during the period of 2015-3030.

This would need a reorganization of European shipyards towards copying the Airbus-Concept. It should be
the end of one-yard-one-ship system and the beginning of specialized yards or auxiliary companies
dedicated to one of the main groups or elements:

- Demy-Hull Bow and Stern
- Middle-Hull sections
- Cargo-bay with top-rails
- Table, platform
- Sail-wing
- Energy-Modules
- Bow-Bridge Modules including navigation
- Safety-gear

Advantages of the new system:

- Optimal 3D Hull forms possible, perfect Hydrodynamic efficiency
- Serial production in large molds
- Perfect finish without excessive man Power needed
- High quality surface with low maintenance

The demy-hulls will be cut into manageable units, around 12m long. Although large composite hulls up to
60m have been built, it does not comply with the requirement of serial production. To obtain standardized
sheets of composite shells, maximum dimensions of some 12 by 10 m are already barely manageable.
The requirement of numerical cutting machines over those dimensions would inflate the tooling investment
unnecessary.

All sheets should be molded in vacuum-injection without any low-quality manual addition of frames or rips.
Easy training of the operation and maintenance crew can be obtained with serial repetition, a good
opportunity for jobs for low qualified labor.

The Consortium is aware of the drastic change required in the naval construction industry and will
dedicate much attention to training and dissemination of the new and beneficial approach.

Serial construction means to recover the competitiveness of the European naval industry.

The processes and technology exist in Europe, but only by thinking in replacing the outdated current
vessel technology the necessary capital for Investing in tooling, molds, CNC equipment, quality control
and investing in production R&D can be allocated.

Potential Impact:

3. The potential impact and the main dissemination activities and exploitation of results

3.1 The general strategic impact
EU-CARGOXPRESS developed a groundbreaking innovative concept of a future standardized and serial Cargo-Vessel. It aims at more green transport and decongesting European roads. The project fulfilled the goals of the 7FP SST.2008.5.2.1 Innovative Product Concepts in the AREA: 7.2.5.2 Competitive surface transport and services.

3.1.1 Expected Volume of new vessels

The description of the impact has to be distinguished between replacement of current vessels, which serve already to replace road-transport but contaminate more than CargoXpress (IMPACT A). From new vessels to serve small ports, so far not accessed plus new vessels to fulfill the plans of the EU to move cargo to maritime transport (IMPACT B).

3.1.2 New logistic philosophy for Short Sea Shipping (MICRO FEEDER)

Currently a few big and medium container terminals receive the containers and deliver the last leg of the voyage to the final customer by truck (10 to 500km of distance) or for larger distances by train.

This leads to partial saturation and jamming of road-transport due to increasing Inter-EU-Cargo-Transfer and insufficient funds for better road-infrastructure.

Maritime transport can only alleviate road-traffic within a distance of 200km along the coastal or navigable fluvial line, but this area has special needs, because the coastal road-infrastructure is deficient and should serve other purposes, like tourism and neighborhood development.

Currently all small and most medium sized port-towns, if not on an island, receive and deliver their cargo (container or general cargo) by road-transport.

The project studied over 1200 ports in Europe and Africa and screened them for their ability to be connected by maritime transport. The results are a list 560 port/towns without any maritime cargo-transport, but apt for small vessel with proper loading gear to serve these towns and the hinterland.

In the Baltic Sea alone, 63% of all ports do not receive currently container by sea, but by road. This road-transport damages considerably the coastal infrastructure. The same is true to the Norwegian coasts and African coasts, where road-transport is very difficult due to lack of infrastructure.

This is a market of 36 million to 64 million of humans with all their buildings, industries, agriculture and recycling needs. For the R&D dimensioning process a goal 50 TEU/day and port was extracted, 25 imports, 25 exports (could be partially waste for recycling).

Once the concept enters mainstream design and shipbuilding through the exhaustive dissemination and building of a first demonstrator, Europe will reap benefits from several advantages:

- Transportation will become cheaper and cleaner, enhancing the living conditions of the coastal and fluvial population.
Europe will become leader in new high-tech shipping technology prepared for the upcoming low-fuel, low CO2 society.
- The Shipyards will be prepared to produce serial equipment and gain special know-how in environmentally friendly products.

3.1.3 Impact as innovative boost on ship-design, production and operation

SST.2008.5.2.1 Innovative product concepts called for Innovative surface transport products and system concepts to strengthen the competitiveness of European industry meeting customer requirements, changing markets and environmental challenges.

EU-CARGOXPRESS is presenting to the maritime industry an innovative concept of a whole cargo-vessel or essential parts of it, which offers to revitalize the European shipbuilding industry and opens a brand new market serving hundreds of small coastal and fluvial ports.

The project laid the basis for a new design paradigm for the European shipbuilding and operating industry improving its global position and regaining competitiveness. Some solutions, like the modular Energy-Containers and the hybrid hull technology will undoubtedly create new spin-offs for naval construction.

EU-CARGOXPRESS developed eight promising and challenging technological breakthroughs:

- General arrangement in form of a Catamaran Cargo-Vessel
- High stability without ballast water
- Electric drive system with tanks and machinery in modular containers
- Sustainable propulsion support by a large Sail-Wing and Solar Panels
- On-board Ship-to-Shore Crane to handle container and XXL cargo alike
- Fast turn-over in small coastal and fluvial port-towns to reduce road-transport
- Fulfilling the Clean Ship-Concept (North Sea Foundation and T&E Brussels)
- Lightweight hybrid hull design and Serial construction

The vessel's energy efficiency results in more than 50% reduction of fuel consumption and CO2 emission, using LNG piston machines only 36% of the time.

Although the whole impact as combination of all eight breakthroughs was kind of overwhelming and will need further explication, several detail achievements are meeting open interest and acclamation.

The impact on technology development will be further augmented during the building of the first vessel. Already now links to SMEs for hybrid construction are forged and plans for cooperation are drawn. These SMEs will become specialists in different technologies and create new start-ups for future markets.

As the project presents lots of hard data on tank testing and wind tunnel testing as well as new economic ways to calculate life-cycle costs, it will generate a boost of knowledge to the EU-Industry and Operators.

3.1.4 Impact from the resulting serial construction of the standardized vessel
EU-CARGOXPRESS presents the first modular and serial vessel for the maritime cargo-industry.

Results will be already during design and building of the first prototype a tendency to specialization and standardization. Once reasonable production numbers have been reached, the impact will be further cost savings through industrial production processes with adequate tooling and forms.

This will help to give European Maritime Industry a lead in high-tech, high-investment construction and assure market positions against low-tech countries with abundant cheap human resources.

3.1.5 Impact on energy savings, the environment, CO2 reduction and climate change

A: Positive impact on energy savings versus the current vessel technology

As shown in Point 3.7 of this report the replacement of a current diesel-powered comparable feeder with the innovative CargoXpress powered by LNG Genset, Sail-Wing and Large Batteries together with slow steaming due to fast port-turnover mounts to 2.7 ton of fuel per day or 950t/year. For 660-1100 vessel being replaced (only a tenth of the whole outdated fleet) with this new technology this would amount to 0.6-1M tons of fuel per year.

B: Eliminating road-transport especially around large terminals, coastal and fluvial areas

What means competitive to road-transport?

This number depends on the mix 20 versus 40foot containers and the empty transports.

Resuming, one vessel compared to 100 trucks saves:
- 80% of fuel
- 96% of CO2
- 98% of NOx

The difference between 100 trucks on a 1000 for a 2.9 day journey over 1850km and the delivery by CargoXpress is around 45t of fuel. Working 300 days per year, these are 4.655t/year.

Total Impact A+B

Taking both effects together we expect the following quantities:
- Fuel savings between 1.6 and 2.5 Million tons/year
- CO2 reduction between 4.4 and 6.7M tons/year
- NOx reduction between 60 and 90k tons/year

These numbers fall short of the envisioned goals of the Grant-Application (DOW) because this expectation was oriented towards the year 2050. The Consortium decided to limit the expectation period to 2030, because during the project the very poor forecast data became apparent and would produce highly unpredictable results.
speculative numbers. But following a further progressive grows on demand to move to maritime transport, the envisioned goal will be reached.

A second reason was the very conservative calculation of:
- Replacement of outdated vessels estimated only 6-10% of the needed volume
- No additional savings through partial employment of the findings had been calculated
- For the small-ports/hinterland traffic over 150km distance only 16% was expected to go maritime transport

The consortium did not want to exaggerate results data, because the general quality of available statistics on transport within Europe over 150km distance is very poor.

The conservative approach comes from the learning-experience, that the Maritime Industry is very risk adverse. Before the promoters of the concept cannot show with a functioning prototype the benefits of CargoXpress, the industry will not convert to the new design culture.

C: Positive impact for small maritime and fluvial port-towns and surroundings

As small ports tend to be in the periphery of the countries their and their hinterland is often in a more depressed economic environment. Apart from touristic and some fishing income, few industrial activities take place.

Converting these ports as vital entrance terminals for cargo as the project describes would create many spin-off effects like:
- Port-distribution and collection of cargo
- Sending regional produce to the larger EU-Market
- Recycling activities
- Value-adding factory work on products for the hinterland or even the central region.
- Vessel maintenance and outfitting

As the coastal road-transport will be alleviated from heavy traffic, tourist-industry will get a big support. This is especially evident in Northern Countries, where the coastal roads are part of the beauty of the land, but not apt for heavy trucks.

D: Revitalizing European Shipyards and design Industry

The innovative concept multiplied with the conservative market forecast will produce shipyard workload of 5mhrs/year till 2030. This amounts for 11 medium sized shipyards for advanced technologies, composite, Aluminum and sail-production. The workload for the equipment manufacturers is not included. Naval design and outfitting activities will rise likewise.

E: Crew-demand on regular maritime routes

The project estimates a reduced crew-demand due to a different concept with modular energy-equipment.
The additional vessels for the new market of small port-towns will offset this reduction from 12 to 6 crewmembers.

F: Reduction of truck-drivers due to more maritime transport

One vessel of 6 crewmembers will reduce the needed 100 truck drivers for the long haul. For final delivery in the port-towns and hinterland no long-distance drivers are needed, because the routes will be maximal 50km wide. The driver can be home at night with his family and the employment of female drivers will be much simpler as today.

3.2 Main dissemination activities

A: Overview

The result of the project presented in The Final-Conference shows a very promising concept with reductions of 50% and more of fuel-consumption with equal or improved processes in the ports.

The results surpass the expectations of the promoter of an innovative cargo-vessel converting the original vision in a proven and studied concept.

Dissemination of these results is driven by strong commercial interests to spread the knowledge and to reap benefits from the R&D results:

- Selling licenses from the main concepts IPR
- Selling licenses from singular IPR
- Building and selling serial vessels with modern technologies
- Building and selling components with modern technologies
- Running logistic chains from door-to-door with these vessels and alleviating road transport
- Investing in innovative and sustainable technologies and preparing for the Low-CO2 society

B: Dissemination activities

http://www.cargoxpress.eu is oriented to 5 target-groups receiving general information and specifics for their interest.

Flyers, we elaborated a flyer, (see addendum in 6 different languages and distributed in conferences and meetings.

Full prospectus is assembling all information from the web-page and from current publications. The work on this booklet is ongoing and will be completed with the business-Plan for exploitation.

Press releases have been edited in 6 languages and distributed to the newspapers.

Conference papers see below in listings.
Conference speeches see below in listings.

Promotion tour will start July 9th from Madrid to Hamburg aiming at convincing operators and investors to join the EEIG (See exploitation)

3.3 Exploitation of results

The results of the project are backed by sound science and test-results. In the sum of all achievable success the concept comes easily into the corner of being too fantastic, especially in an industry, where efficiency improvements of 3-5% are considered a big success.

The only final convincing argument will be a fully functional scale 1:1 prototype sailing the fluvial and coastal routes, serving small ports and documenting real-world results. This prototype will be the best marketing instrument, visiting European ports and demonstrating its functions.

Building of the prototype was not included in the EU-project and the consortium as such ceases to exist as a legal entity after project ends. So a new carrier of the exploitation has to be formed.

The promoters and the Technical Officer are creating a new EEIG (European Economic Interest Group) for the building of the first vessel following the projects results. This EEIG will be open for all partners of the EU-Project for joining and getting the benefits of the exploitation.

The promoters expect the creation of a Spin-off company with an initial crew of 25 employees.

The most pressing objective is to get contracts or letter of intends (LOI) of some operators to operate this vessel.

Two possible candidates are already in discussion and the signature of their commitment will be the starting point of all following activities.

Objectives of the Company

The creation of The Company aims at establishing a solid and promising institutional platform for the commercial exploitation of the extraordinary knowledge and know-how generated by a groundbreaking EU project for the development of a new maritime transport technology.

In light of this endeavor, the participants of will:

a) financially benefit from the successful implementation of this revolutionary innovation;

b) achieve significant image effects through the involvement in Greenhouse Gas reduction;

c) find new business fields both in manufacturing and services.

Background
The 7FP-EU-Project: EU-CARGOXPRESS (Project Nr.: 233925) will be officially finished in April 2012. As of today, most R&D results are presented. The status of the very encouraging results and performance predictions can be accessed in [http://www.cargoxpress.eu](http://www.cargoxpress.eu).

The goal of the project, to produce a concept of a future competitive and sustainable container vessel for small ports, has been more than fulfilled.

From the beginning of the EU-Project the promoters aimed at building a working vessel after this concept as a ‘Prototype’ or ‘Experimental Platform’. Now is the time to start with this phase of verification.

The Company scope

EEIG CargoXpress Maritime will be a new European Economic Interest Grouping (different from the EU-Project Consortium), which will exploit the acquired knowledge of the EU Project and background IPR for this new vessel.

EEIG CargoXpress Maritime will be formed in accordance with the rules described under the framework of the Council Regulation (EEC) No 2137/85 of 25 July 1985 on the European Economic Interest Grouping (EEIG).

First, The EEIG will:
- Define the project scope and establish the budget for the first vessel
- Acquire financial resources to build and outfit the first vessel
- Implement project management procedures to control and report on the progress.
- Subcontract relevant work like detailed ship design, naval architecture, and class-approval.
- Emmitt tenders for the construction in one or multiple places.
- Supervise the construction, test-runs and approvals
- Charter the operative vessel to a selected operator
- Scientific control of short and long-term behaviour
- Coordinate the execution of changes and improvements as needed
- Gather new IPR during operation
- Retire and sell for recycling the vessel at the end of its lifetime

The EEIG will be the owner of this first vessel with all IPR, benefits and risks.

Second, The Company will:
- Publish and market the results of the first full operations
- Sell vessels or parts of the main technology
- Plan serial production on different sites (similar to Airbus)
- Contract with long-term production partners
- Organize the logistical chains for the final assemblies
- Guaranty a permanent improvement and quality-control
- Develop further variants and sell into market
In the long term the Company will become a main actor in the market of sustainable and competitive maritime transport.

Estimates of production costs

Within the EU-Project a prudent analysis of the price per Prototype or Serial Vessel has been made. This estimation has the following tolerances:

A: Prototype

This concept has very innovative solutions, for which references from former constructions can be used:

- The Concept of a hybrid hull-construction from Aluminium profiles and preformed composite panels fastened and glued to them is new in this industry. Some shipyards do have experience with vessel made entirely from composite material and could provide numbers for the prototype calculation, but no experience for the expected simpler method of hybrid design exists
- The moving superstructure with the large Sail-Wing are an Engineering challenge,
- Modular energy equipment without traditional machine rooms are not used currently
- LNG fuel systems are slowly entering in the industry, but many questions are still open

Insecurity with new solutions tends to increase the price. Only after a profound detail design, better cost estimates will be available.

B: Serial Product

Civil shipbuilding is simply not used to serial production at large scale. Building 5-10 vessels out of one design is already considered great, even, if these builds are spread over a longer period and the last vessel will be quiet different already from the first one.

Planning a yearly production of over 50 vessels in the way Airbus is planning their series, would be a total novelty to the maritime industry. It would allow shipyards to specialize on a large component (Hull, Bow, Sail-Wing, Table etc) and develop cost saving tooling and logistics. These savings can easily account for 40% of reduction in labor and 15-20% reduction in material and overhead.

3.4 IPR

The basic European-Patent of the new vessel: 'EP 1 955 943 B1 Transportschiff, insbesondere Frachtschiff' will be part of the exploitation concept.

Knowledge culminated at the end of the project and patenting takes time, resources and need of verification, before setting the claims. That will be done but we do not have application or IPR numbers yet. There are not patents submitted regarding to the foreground generated during the project.
Future Patent-applications will be:

A: Guidance and handling of sail-wings on cargo and passenger vessels

Inventor: Innovacion Logistica SL (ILCX), Ferrol, Spain

Status of application:

The IPR is in preparation, no formal application has been submitted due to:
- On-going Background research
- Designing of the drawings
- Texting of claims
- Intend to clarify some details more precisely before submitting
- Intent for not wasting the 18 months of international grace period before the application is ripe.

Status of application:

The IPR is in preparation, no formal application has been submitted due to:
- On-going Background research
- Designing of the drawings (partially done)
- Texting of claims
- Intend to clarify some details more precisely before submitting
- Intent for not wasting the 18 months of international grace period before the application is ripe.

3.5 Time Frame

End of EU-Project: April 2012
Forming of The Company: September 2012
Funding assured (promises): December 2012
Detail-Design: January-October 2013
Building the first vessel: 2014
Test-run and debugging: July 2015
Start of operating: September 2015

List of Websites:

http://www.cargoxpress.eu/

Last update: 18 January 2013
Record number: 56088