Building to IMPROVE standards

An innovative concept of a large ro-pax vessel is one of three new ship designs emerging from the EC-backed IMPROVE project.

Supported by the European Commission, the three year 'IMPROVE' ship design research project is approaching the half-way stage in its bid to deliver a rationale for making decisions pertaining to the design, production, and operation of three new ship generations.

Coordinated by ANAST, University of Liege, IMPROVE involves 17 partners, including Aker Yards of France, Uljanik shipyard of Croatia, Szczecin New Shipyard of Poland, owners Grimaldi, Exmar, and Tankerska Plovidba Zadar, Bureau Veritas, two ship design companies, two engineering companies, and two software companies, as well as WEGEMT (European Association of Universities in Marine Technology and Related Sciences).

The team hopes that the project's results will help the European shipbuilding industry to claw back market share it has lost to yards operating on a lower labour cost base, such as those in China.

IMPROVE aims to use advanced synthesis and analysis techniques at the earliest stage of the design process, considering structure, production, operational performance, and safety criteria on a concurrent basis. The ship types are new generations of LNG gas carriers and chemical tankers and, as the focus of this article, an innovative concept for a large ro-pax vessel.

Over recent years, Uljanik Shipyard has designed several car-carriers, con-ro, and ro-pax vessels for different shipowners. Its enduring association with Grimaldi provides the bedrock for the development of the new ro-pax vessel, whose evolution has already gone through general and structural analysis. The shipbuilder has performed extensive multi-objective structural optimisation of a ro-pax structure using OCTOPUS-MAESTRO software, with a view to developing a ship design promising minimum cost, minimum weight, and maximum safety measures, while also satisfying structural constraints: yielding, buckling, displacements, and ultimate strength of hull girder and ship panels. Meanwhile, large operational savings are predicted due to a novel propulsion concept.

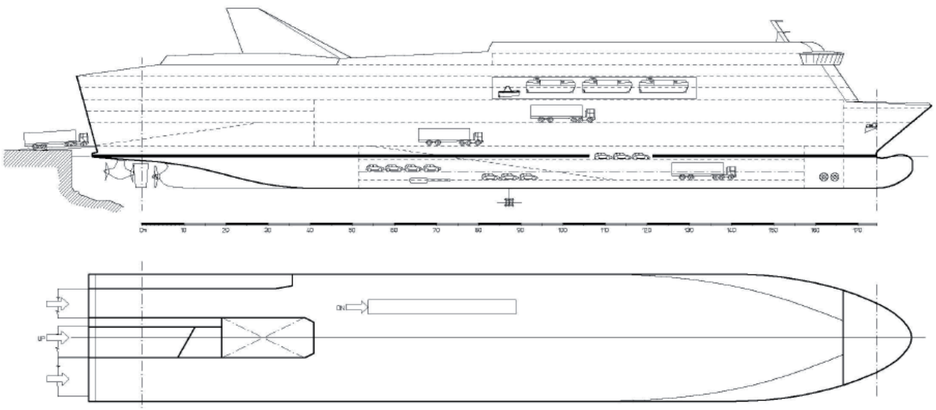
The main dimension criteria envisage a ship with a maximum length of slipway ≈ 230m, and maximum breadth given as 30.40m.

From the owner's point of view, the new vessel will be developed for Mediterranean Sea operations and general design requirements including: load carrying flexibility; a perceptible improvement in operational performance and efficiency when compared to existing ships; design for the redundancy and simplicity of systems; an increase in ship's manoeuvrability; optimised sea-keeping performance; maximised comfort and minimised vibrations.

There is also a specific requirement for an 8% increase in carrying capacity (lane metres) on the tank top, to be achieved by decreasing the length of the engineroom. This involves developing a 'pre-formed' new design for the stern part of the ship.

Uljanik's design objectives are to develop a ro-pax ship taking into account large variations in seasonal trade (summer 3000pax, winter 100pax). The monohull ship is to feature a superstructure constructed of steel or composite (no aluminium).

Ultimate vessel dimensions are to be optimised to improve the hydrodynamics, while a slow-speed main engine has been pre-selected to improve maintenance and consumption. The criteria also dictate: minimum height of deck transverses; an improvement in design using existing and improved tools for early design phase; rule calculation – simplified CAD modelling, leading to simplified FEM and LBR5 modelling; minimum weight of freeboard deck transverses; minimum height of deck No3 and deck No4 transverses; accurate calculation at the early design stage of building tolerances and deformation constraints; superstructure decks effectiveness in the longitudinal strength to be considered; web frame spacing and longitudinal spacing to be optimised, while there are to be no pillars in cargo space.



'Standard Ship', the existing ship or yard prototype.

Further objectives include the minimising of maintenance costs over a 25 year lifetime, while the design must also take account of the probability of a potential conversion after 10 years due to new Rules or comfort standards (that is the ship's design must be flexible enough for easy conversion). Cargo handling will be of the traditional type – stern door and internal ramps. One aspect of sea-keeping will be defined by the fact that no fin stabiliser is envisaged, instead there will be internal active stabiliser tanks.

With these parameters in mind, Uljanik also has other expectations for IMPROVE. Among its goals are: reducing production costs by 10%; reducing fuel oil consumption by 12%; and reducing maintenance costs by 10%.

Uljanik is committed to simplifying the production process, through standardisation and an increase in subassembly activities, and to cutting hull erection time on berth from 18 to nine weeks (plus three weeks for finishing). It also envisages reducing the number of erection blocks from 330 to 130 blocks, with all parts to be painted before erection.

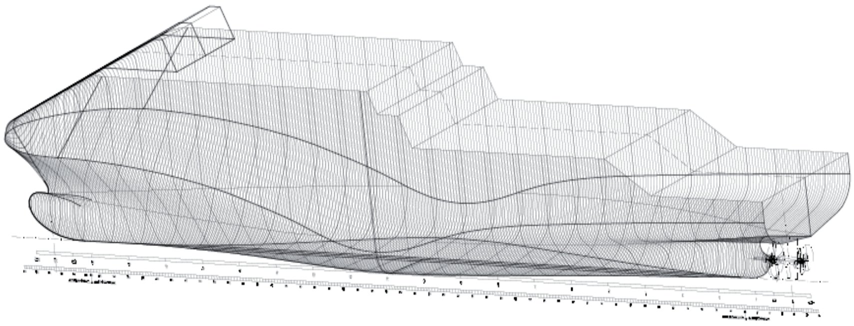
For the new design, extensive structural analysis (global and detail FE analysis) are being performed to evaluate structural feasibility and eliminate hard spots regarding stress concentration problems.

Sophisticated solutions

The arrangement of cargo space without pillars requires sophisticated structural solutions. Reducing the height of the deck structure is also a very demanding task, but can result in many benefits regarding general ship design, eg:

- Lower VCG (better stability)
- Reduced light ship weight (increased deadweight)
- Smaller gross tonnage

The challenge is to improve Rule structural design at the early stage of design (concept stage), to find optimal design solutions using IMPROVE tools, and continue the design process in the preliminary stage (where more detailed FEM calculations are performed) with the better starting point/design.



Body lines of 'New Ship'.

Regarding the general ship design the other targets are:

- Selection of resistance-friendly hullform
- Smaller propulsion engine for same speed
- Reduced fuel oil consumption
- Selection of hullform in order to reduce length of engineroom (increased length of cargo space)

The design methodology in the IMPROVE project defines three design levels as the project unfolds:

- STANDARD SHIP is the existing ship or yard prototype
- NEW SHIP, which has been designed during the first period of the project. The design has been realised mainly using existing methodology and includes improvements to the main dimensions, general arrangement, hydrodynamics, and propulsion
- IMPROVE PROJECT SHIP, which will be obtained from the Level 2 design using multi-criteria structural optimisation including the production and maintenance models

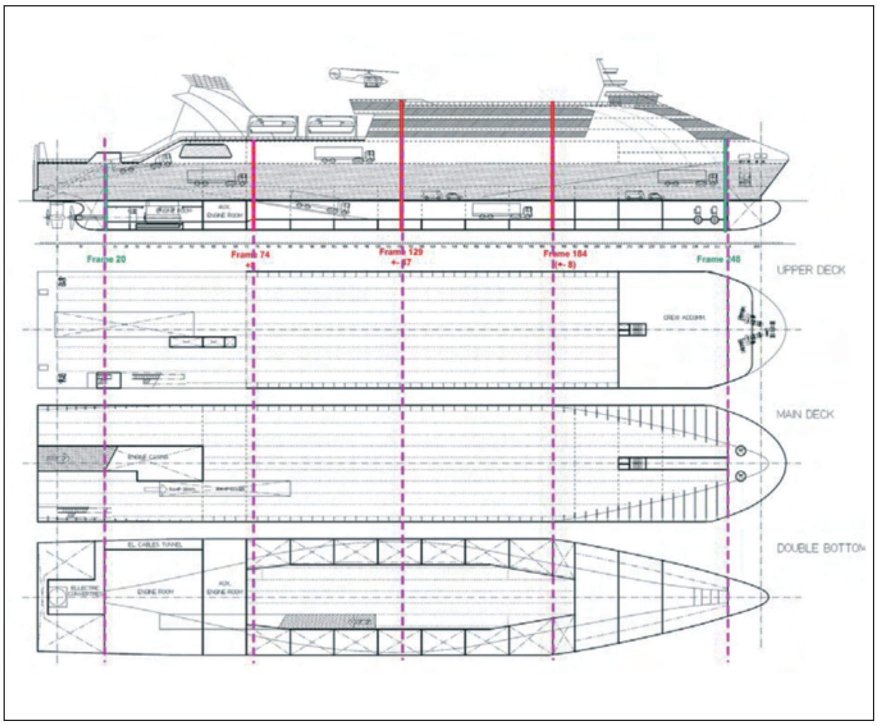
The main characteristics of the 'standard' ship are: length overall – 193m + 4m; breadth – 29.8m; draught design – 7.5m; trial speed – 24.5knots; cargo capacities – trailers 3000 lane metres + 300 cars; capacities: HFO – 1400m^3, DO – 250tonnes, FW – 1200m^3, SW – 600m^3; passengers - 350 cabins + 200 aircraft seats; crew 200 persons. This design was developed in cooperation with Siemens Schottel and Sea Trade from Oslo. Such a ship is propelled by two pods behind two skegs.

The main dimensions of the second stage 'new ship' have already been defined, with optimisation achieved using TRIDENT/SEAKING software in order to obtain minimal main engine power and sufficient stability. A new application has been developed, which finds a best combination of main dimensions in order to achieve minimal resistance. After resistance calculation, it was decided that this 'level 2' ro-pax would have a fixed pitch propeller (FPP) as main, and active rudder as auxiliary propulsion. The auxiliary propeller is to be driven by a direct electric drive of 5000kW using bevel gears at the top and the bottom of the leg (inside circular torpedo body). Planetary gears for steering are driven by frequency-controlled electric motors.

Here, the original hullform was Uljanik's biggest PCTC, which was then transformed into the new (level 2) form. In comparison with the standard ship, the new design would need almost 7000kW less power, while the weight of machinery would be reduced by 450tonnes, fuel oil consumption would be 28% lower, and finally, the propulsion system is characterised as more reliable. The index of redundancy is 100% (two independent enginerooms, two engines, two independent propulsion systems).

The main characteristics of this level 2 ship are: length overall – abt 193m; length between perpendiculars – 180m; breadth – 29.8m; design draught – 7.5m; block coefficient – 0.53; trial speed – 24.5knots; main engine power – 14,940kW; active rudder output – 5000kW.

With 18 months of the project to run, the full 'stage 3 IMPROVE project ship' has yet to emerge, although it is already known that Uljanik anticipates a 500tonne reduction in steel content over the forerunning design,



General arrangement plan with marked specific positions (characteristic sub-sections at Frs 74, 129, and 184) influencing ship zones 1-3.

and that the propulsion solution will feature a novel combination approach, using a single skeg and single pod configuration, working in combination with two-stroke engines.

The project is currently in the model integration phase (IMPROVE WP5), so the most important tasks and development of new products are forthcoming. The expected most important design goals are: 4% less lightship mass, 8% more lane metres on tank top, 9.5% less power requirement, 3.5% less machinery mass, 4.5% less fuel oil consumption, 5%-10% less cost of maintenance, 10%-15% more operational efficiency, 8% less production cost, and 11% less lead time. *NA*