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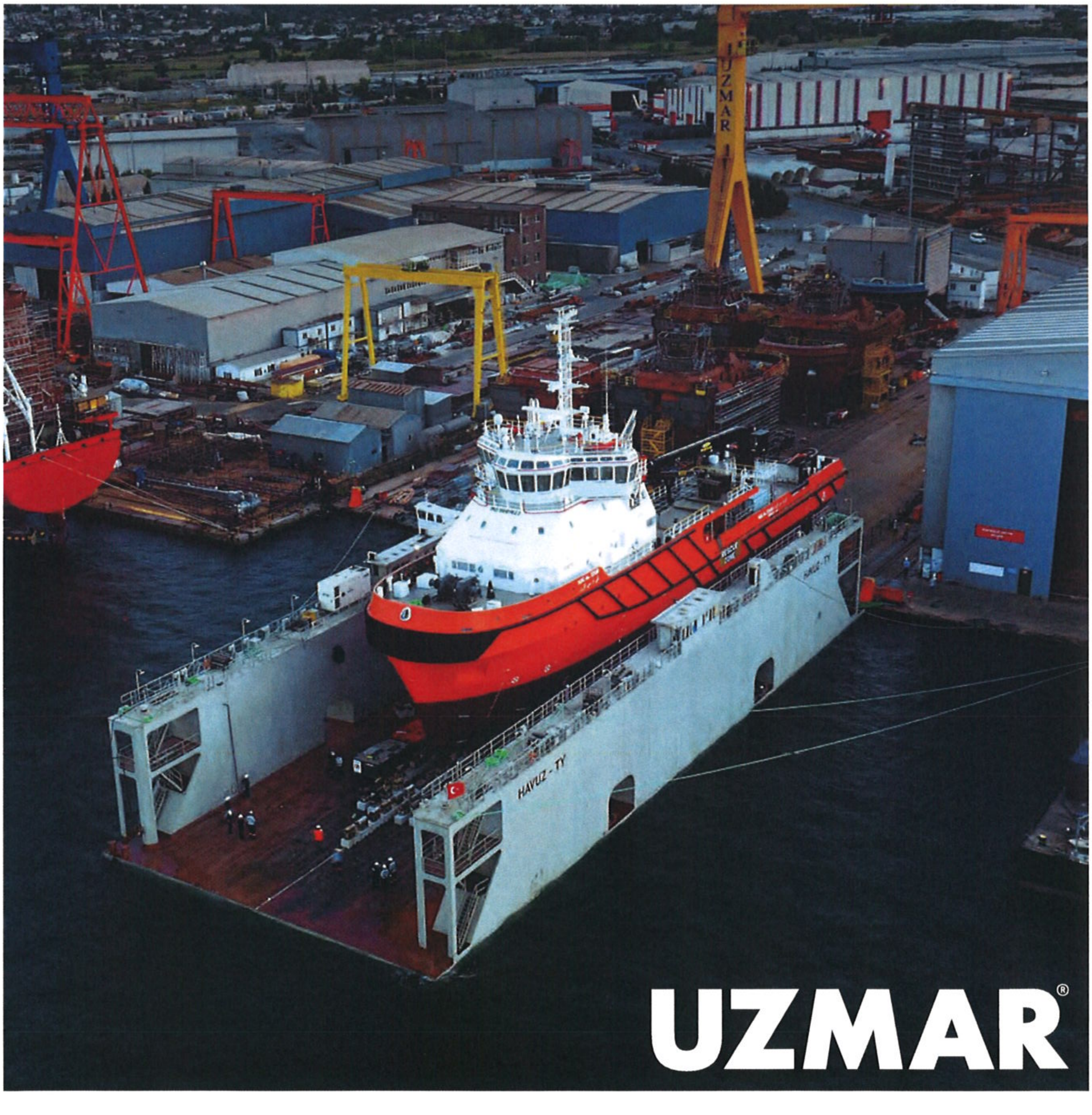
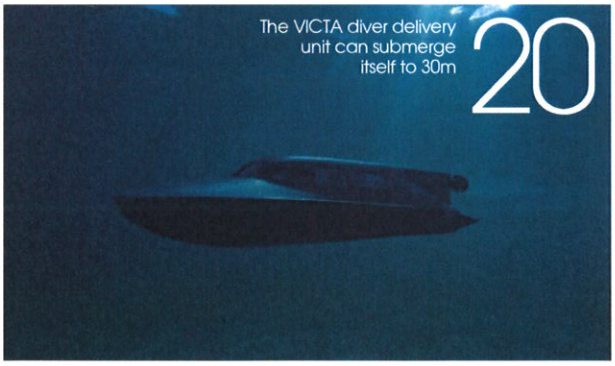


20-39 Features



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Hiroshima calling

Pushing in a new direction

LNG has overcome a number of its previous hurdles, making it an attractive alternative to fossil fuels. Romania-based naval architect Ship Design Group explains how it has developed the concept for a gas-powered inland pushboat for the Danube River

Rated more than 4,100kW, the proposed LNG inland pusher would be one of the most powerful vessels of its type on the Danube River

With the advent of regulations tailored to protect the environment, compliant and efficient propulsion solutions are one of the greater challenges faced by ship designers.

The EU has put forth its Stage V Non-Road Mobile Machinery emissions standards, pushing inland ship operators to consider diesel particulate filters for existing engines, while ship designers and engine manufacturers have to look towards modern propulsion solutions for newbuilds. An INTERREG project called Grendel was devised to lead to the improvement of environmental and economic performance of the Danube fleet, and to aid the transition towards the new regulations.

As a partner in the project, Ship Design Group was tasked with developing concept designs for retrofitting inland pushers with engine after-treatment systems and with the development of a concept design for an LNG-powered pusher (see Technical Particulars, page 26).

Following that, the initial design requirements and restrictions were put in place with the help of NAVROM, another partner in the project. One important aspect was the owner's requirement for increased propulsion power, which would allow for greater transport efficiency and manoeuvrability on the Danube. Other than standard inland vessel rules, specific rules would have to be followed due to the use of LNG, in the form of ES-TRIN part II for fuels with a flashpoint lower than 50°C and Bureau Veritas' NR529 notation for Gas Fuelled Ships.

Safety considerations

When designing and operating an LNG-powered vessel, a number of safety barriers have to be kept in check. Among the most significant are:

- LNG piping and related material should be certified for cryogenic temperatures, since the gas is liquefied by cooling it down to -160°C;
- The gas in the storage tanks vaporises and the pressure inside needs to be released: as such, pressure relief and bleed valves become an integral part of the system and lead to additional restrictions since the released gas needs to be controlled;
- The placement of the LNG tank, the processing unit and additional parts of the system have an impact on the distribution of the hazardous areas and the general arrangement;
- The ventilation system needs careful consideration, to prevent the accumulation of gas pockets;
- Gas safe spaces are clearly delimited and the LNG tanks and piping should be protected from damage;
- Conventional ship systems need to be reassessed in conjunction with the LNG systems;
- The general arrangement should lead to a proper degree of safety in terms of access points, accommodation layout/placement and general minimisation of risk.

A critical decision in the early design stages was the definition of the engine room, which can be treated as: a hazardous area of the Emergency Shut Down type, with special constructive measures and equipment – difficult to implement in a small inland ship; or as a Gas Safe compartment, with double-walled LNG piping and engines. The latter solution was selected for the project.

Propulsion and power

One constant RPM and two variable RPM pure-gas engines were chosen for propulsion and power generation, with a PTO attached to the central shaft line. Nozzle propellers will increase thrust at lower speeds, the fixed-pitch side propellers will add to the reliability of the system and the controllable-pitch central propeller will lead to flexible operation. The propeller nozzle is integrated with the hull for added structural strength and lower draught.

Manoeuvring capabilities were assessed for typical inland convoys, which led to a design with double side-rudders, no central rudder and two hydraulic tunnel thrusters powered by the central engine through an HPU.

The 5,500hp (4,101kW) pusher is one of the most powerful on the Danube River. Resistance calculations were performed with several typical convoy considerations. Estimate speeds were in the range of

8km/h (4knots) upstream and 14km/h (7.6knots) downstream, with respective ranges of 1,200km and 3,150km. An assessment of the operational profiles leads to a year-round fuel consumption of 3,150m³ of LNG fuel.

The concept vessel would also be hydrogen-ready, enabling it to upgrade to full zero-emission status at a later date

Hazardous areas

A hazardous areas plan was put in place from the beginning of the project, since it has a significant impact on the layout of the vessel. The aim is to keep the engine room, superstructure and accommodation away from gas-related equipment and to better plan the position of openings and passageways.

Three types of hazard area are defined according to IGF, each with specific restrictions and definition. From the hull design standpoint, the most significant detail is the strengthening of the midship area, where the LNG gas is stored to minimise trim effects.

However, the piping is where special care was needed, due to systems interfering with the LNG system.

Tank sounding and tank ventilation systems were designed with consideration of the hazardous areas. These systems should not connect different types of hazardous areas, nor lead to transportation of gas in unintended locations. The HVAC system is critical, since careless placement of air intakes may lead to accumulation of gas in non-hazardous areas.

The bilge system posed several challenges. To collect the accidental drainages of LNG gas, the ship structure underneath would have to be built from a material capable of withstanding cryogenic temperatures, or a stainless steel (or equivalent material) drip tray would have to be provided. A stainless steel drip tray with level and temperature alarms was selected, with a manual overboard discharge pump.

One essential aspect is that this part of the installation needs to be independent of the rest of the bilge installation. In the same manner, the bunker station drainage had to be led overboard through a pipe, since leakages would expose the hull plate to cryogenic temperatures, and a water spray installation was provided for cooling the LNG tanks and surrounding areas in case of leakages, preventing rapid evaporation.

Tanks and exhaust

One of the critical systems aboard the vessel, the fuel gas system, has specifics such as double-walled piping, ventilated space between the two pipes and a gas valve unit which directs the flow of fuel and stops replenishment in case of emergency by discharging the LNG gas into the atmosphere, cutting engine supply. The LNG tanks feed fuel into a tank room where it is vaporised and fed to the engines. The engines have to be certified in order to comply with the Gas Safe criteria established.

Careful consideration was also necessary for the exhaust system. The exhaust pipelines require a ventilation system to clean them when the engine is not running, to prevent the accumulation of gas. The system also needs to be sturdy enough and have safety valves that can withstand the over-pressure generated from explosions of gaseous LNG which might escape from the engine. The exhaust pipelines generate a hazardous area around the funnel, which needs to be considered when positioning the engine air-intake grills. One particular aspect related to LNG-powered engines is their large cylinder capacity, which, in combination with the minimum number of engine start-ups required by regulations, leads to very large compressed air cylinders.

TECHNICAL PARTICULARS

Ship Design Group's LNG-fuelled pusher

Length, oa	42m
Length, hull	41.5m
Breadth	13.5m
Depth	3m
Design draught	1.85m
Scantling draught	2m
Air draught above baseline	9.4m (adjustable wheelhouse)
Engine(s)	3 × 1,460kW@900rpm
Gearbox	1:2:548 ratio
Shaft generator	100kWe
Gas generator	100kWe
Side thrusters	42" (1,067mm), 2 × 250kW
Propellers	2 × fixed-pitch / 1 × controllable-pitch, dia. 1.8m
Hydraulic unit	600kW
LNG pack	2 × Bilobe tanks @ 110m³ each

Future-proof technology

The design process has led to a modern vessel with up-to-date technologies, flexible both in operation and in design variations. The vessel concept can transition towards zero-emission regulations since it is also hydrogen-ready.

Propulsion, anchoring and manoeuvring design led to a robust and powerful vessel, well suited for shallow-draught inland navigation. The composite cover protects the LNG tanks from accidental damage, while the solar panels atop can cover the vessel's hotel energy needs. The hazardous plan is essential for all the design stages, while the hull and piping design bring to light particularities specific to the usage of LNG as propulsion fuel.

LNG is in the process of overcoming economic hurdles and for the time being it is a future-proof technology with regard to current and upcoming regulations. It has overcome challenges that new fuels are facing, such as bunkering and storage, with supply chains improving constantly. The last hurdle is community perspective, and the concept presented goes to show that inland applications for the technology are feasible and practical. ***SBI***