Photo: First of the series, mv Vertom Patty, under construction at the shipyard in Kampen (courtesy of TB Shipyards).

ENERGY TRANSITIONS AND GROOT SHIP DESIGN

Groot Ship Design (GSD) is a naval achitectural design bureau in the north of the Netherlands working on a global scale with different types of seagoing cargo vessels up to a size of approximately 20,000 TDW. All projects are aimed at better fuel performance and fewer harmful emissions. GSD also works on wind-assist propulsion using modern, industrialised sails, often in combination with alternative fuels to further reduce emissions. For wind-assist expertise, GSD counts on a close cooperation with Blue Wasp Marine BV.

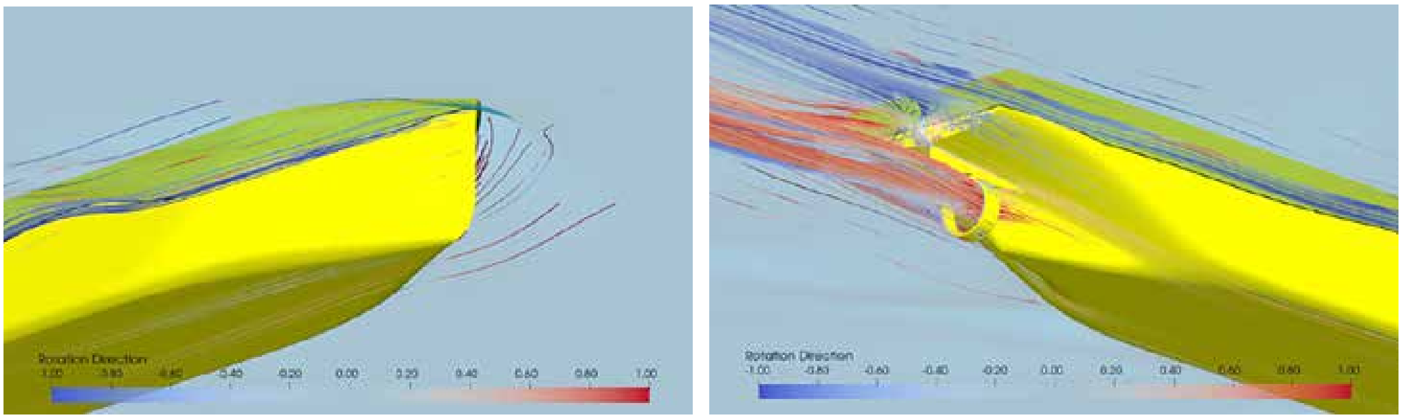
The design process and optimising the energy balance on board vessels starts with a good and realistic operational profile containing parameters such as: speed and draught for the expected load cases; time in port, transit, manoeuvring and at anchor/loitering; required autonomy (sailing range/ bunkering intervals); port or waterway restrictions (draught, length, beam, air draught); and auxiliary power for cargo systems (reefer containers, cargo pumps, ventilation and cooling).

In 2009, GSD developed and implemented the Groot Cross-Bow, a hull shape with vertical bow and wave piercing abilities. The Cross-Bow results in improved performance in heavy sea conditions. Together with the hull shape, a large diameter propeller was utilised running in a nozzle. The propeller/nozzle combination provides additional thrust at lower speed (important in more severe conditions with less main engine power installed).

Design considerations for greener ships

Every year, GSD runs between twenty to forty design projects (from rough concept to tender package). Since 2018, there is an increase in projects being contracted and proceeding to yard numbers (actual new building). Some of the design portfolio highlights are:

- Shipowners/ship operators (clients) try to be “future proof”, but their experience is related to the present market and their present fleet. They are therefore often not aware of the options and improvements available. GSD will assist in preparing a design fitted with the latest technology related to alternative fuels like LNG, bio diesel, electric power storage, wind-assisted propulsion, methanol, ammonia, hydrogen and combinations of these alternatives. It can be concluded there will be no general substitute to fossil fuel oil available on the market. Each future vessel will most likely be dedicated to a trade or operating profile, and as a result, the accompanying fuel/propulsion plant will be decided depending on the availability and expected costs of the alternative fuels.
- For every new design, it makes sense to optimise the hull shape to lower resistance, optimise propeller diameter/propulsion plant and as a result be able to install the lowest possible propulsion power. GSD uses in-house computational fluid dy-



Examples of a hull shape for the Groot 5200XL series, designed and arranged in-house and validated by MARIN.

namics (CFD) software to evaluate the new hull form. Alternative propulsion systems like WASP (wind-assisted propulsion) will also have influence on the selected hull form.

- Alternative fuels have a huge influence on the arrangement of fuel tanks as certain fuels require cryogenic tanks, like LNG, and other fuels like methanol are very hazardous and require double-walled tanks. Other fuels, like ammonia, are very hazardous as well and require special safety precautions. Each alternative fuel or form of energy storage, like batteries, has its own set of safety measures, which all influence the design of the ship. Each set of fuel will also influence piping and ventilation systems required as well as safety systems like fire suppression systems.

Every year, GSD runs between twenty to forty design projects

- A large battery package, permanently located in the vessel (energy storage), gives a different behaviour compared to liquid fuels. The battery package does not change weight during the transit operation. The battery weight is the same, fully charged or not. For a small bunker tanker design, the total weight of the battery package was estimated to be about ten per cent of the total light ship weight (LSW), resulting in an alternative vessel arrangement.
- Fuels like LNG and H_2 (hydrogen) stored in large tanks (fixed, integrated tanks or containerised, mobile tanks) require considerable space and will reduce the paying cargo capacity, compared to a similar vessel with conventional fuel and machinery. The type of vessel, for example a passenger vessel and certain types of offshore support vessels, is also important for the choice of alternative fuels and propulsion. These types of vessels often have large void spaces not normally utilised and can in this case be used for the more voluminous alternative fuels.

GSD design and newbuild highlights

- The Hanse ECO design for Arkon Shipping has resulted in five yard numbers under construction in China. The first vessel, the Wilson Flex I, has already been completed and is in operation. The vessel is designed with a hybrid propulsion system, including a main engine able to run on variable speed driving a fixed pitch (FP) propeller and a shaft generator (permanent magnet machine) mounted to the front of the engine. This configuration allows minimum use of the auxiliary generator sets.
- Electric bunker tanker design. For a Japanese client, GSD made the initial design for an electrically driven bunker tanker, able to sail and operate in the bay of Tokyo. The owner adapted the design and incorporated local equipment, building standards and started construction of two vessels. The first vessel, Asahi, was delivered at the end of March this year and after an intensive test period has been in operation since.
- The Vertom 7000 design has been created for the owner Vertom and is being executed by Thecla Bodewes Shipyards. In total, Vertom ordered six such vessels. The diesel-electric vessels have one to four generator sets and just a single propeller. Together with the Dutch companies Eekels and Vertom, GSD implemented an electric propulsion type based on standard com-

Wilson Flex I in Harlingen, the Netherlands.

Electric bunker tanker for a Japanese client.

The Williwaw design seeks to reduce CO_2 emissions by at least fifty per cent.

ponents with two electric motors mounted to a single gearbox, which drives the single propeller in a nozzle. The total system is energy efficient, fully redundant up to the gearbox and future proof. Future proof because in the future, one or more generator sets can be swapped for new powering technologies (that is, a generator set running on alternative fuel, an H_2 unit or battery pack). The electric system installed can "swallow" them all. The Vertom 7000 design is a front-runner project showing the possibilities of a single propeller MPV with an electric drive system.

- The Canopée is currently under construction at the building site of Neptune Marine Projects in Poland. It is designed as a RoRo vessel for transportation of Ariane space cargoes from Europe to South America. Due to the nature of the voyage, it was decided to add a large WASP system. The vessel will be fitted and operated with four large sails/wings provided by AYRO from France. In favourable conditions, the power reduction in the traditional propulsion (the vessel is provided with a twin propulsion system) can be significant. Canopée is considered to be one of the first modern dedicated cargo vessel designs with WASP on this scale. It is expected that it will act as a showcase for the use of WASP on a large scale.
- Williwaw project: In July 2022, GSD in close cooperation with Zéphyr & Borée and Blue Wasp Marine won the project for a next-generation container vessel (600 TEU capacity) utilising wind as dominant means of propulsion. The objective is to reduce the CO_2 emissions by at least fifty per cent compared to conventional market standard transport solutions. "Williwaw" means a sudden blast of wind descending from a mountainous coast to the sea. This project will make use of an optimised hull shape (designed to improve sailing behaviour), superstructure forward and will contain six large-area wing sails. Methanol will be the fuel for the propulsion system. The building yard has not yet been appointed and it is expected that at least ten vessels are required to fulfil the actual transport needs.
- In 2018, GSD introduced the first standard design for a basic, but very efficient multipurpose vessel/mini-bulker for traditional shortsea operations in Europe, the Groot XL series. This series now includes the sizes 5200/5900/6600/7300 DWT (tonnes deadweight, cargo weight). The hull of the series was developed in-house and fully optimised by CFD. A traditional propulsion plant with a single main engine/propeller powers the vessel. Although this does not sound very spectacular, the designs are very efficient, combining an enormous hold/volume (very suitable for light bulk cargoes), ice class (Finnish Swedish 1A or 1B) and a relatively low installed engine power. The design is adapted to accept one or two WASP units on the foreship to further reduce propulsion power when in operation (when the owner decides to do so). At the moment, approximately twenty such vessels (in various sizes) are under construction.

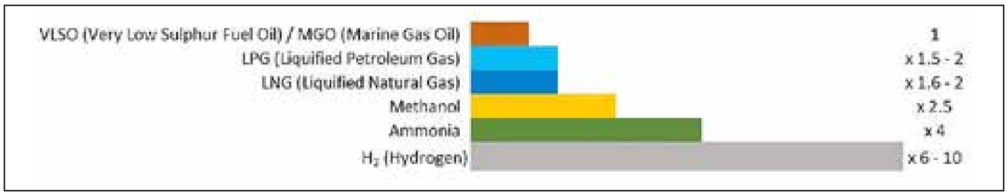
A large number of other vessels are currently under construction. GSD is not always allowed to share details of all projects.

Netherlands	8
Poland	1
India	14
Indonesia	6
China	42

Vessels designed by GSD under construction (initiated from different projects) per country.

Besides new designs and technical developments, GSD also develops tools to allow clients to make up their minds themselves about the proper arrangement and execution of their new vessels. GSD is working to launch a tool called the "vessel configurator", a virtual representation of the standard XL series, using augmented reality (AR) at SMM. Goal is to create a website on which clients can configure their own version of the Groot XL vessel they wish to add to their fleets. With this technology and presentation, ship design and shipbuilding are joining industries like the automotive industry in which these technologies are already common practice.

The "industry" also requires energy efficient and low-emission ships. Companies like IKEA, Hennessy and so on like to show themselves as environmentally friendly and like to claim that their transport chain is as well.



Alternative fuels also introduce new storage challenges. This graph shows the differences in fuel tank volume required for alternative fuels or bunkering intervals (according to DNV, April 2022).

Alternative propulsion systems

Diesel electric propulsion can give savings in fuel up to thirty per cent, but this depends very much on the operational profile. Ships that spend a lot of time manoeuvring, dynamic positioning, slow steaming and such are typical candidates for electric propulsion. Cruise ships are often prevented from anchoring at scenic locations due to the presence of coral reefs etc. and rely on dynamic positioning for station keeping. The advantage of electric propulsion is that the power plant can be in any available location on board and the propulsion thrusters can be arranged in the most favourable position reducing noise and aft ship vibrations to a minimum.

A little anecdote from a number of years ago in order to illustrate this: *A diesel electric supply vessel destined for the Gulf of Mexico (GoM) had just completed trials and was about to leave the fitting out quay in the port of Rotterdam. Engines were started, thrusters engaged and the ship silently glided out from the quay, turned around and headed out to the Nieuwe Waterweg, the North Sea and GoM. The American superintendent standing next to me asked: 'Do you hear anything?'. 'No,' I said, 'I do not hear anything peculiar'. 'Well,' said the American superintendent, 'if this was a typical, conventional (GoM) diesel direct supply vessel, we would be all wet from the propeller wash, standing here on the quay and there would be a tremendous noise from the diesels and the propellers as well as a lot of smoke from the diesels, while the ship was manoeuvring with the clutch and the traditional reversable gear box.'*

Example output of the GSD created vessel configurator.

WASP can be expected to give about fifty per cent fuel reduction in favourable conditions and some concepts are drawn as fully sailing ships. Interfacing with shoreside infrastructure and cargo handling is perhaps one of the most challenging remaining technical challenges, calling for movable systems that are more complex and more vulnerable, or otherwise restricting the dimensions and placement of WASP. Nevertheless, these are solvable problems through dedicated engineering and naval architecture.

> It is a challenge to implement new technologies and come up with an economically feasible design

Alternative fuels (replacing our traditional carbon fuels) are in the make, but not yet accessible on a large scale as we will need for efficient international shipping. Methanol, ammonia and hydrogen are expected to replace a good part of the traditional marine gas oil (MGO), marine diesel oil (MDO) and heavy fuel oil (HFO). For the actual ships under construction, the development, distribution network, and availability of prime movers/power converters is not yet sufficient. Therefore, it is expected that for the years to come, a mix of different power sources or fuels need to be implemented in the designs.

Co-creation in ship design

For shipowners, it is a huge challenge to make decisions for their current and future newbuilds. For naval architects, it is a true challenge to implement all the new technologies and come up with a realistic and economically feasible design. GSD proves every day that the company can work with shipowners and shipyards on these challenges, resulting in a good number of vessels under construction, which it calls 'co-creation in ship design'.

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