When inland shipping entrepreneur Wilco Ooms started planning his new vessel in 2004, his vision was to create a ship with less fuel consumption, less emissions, a greater carrying capacity and a smaller draught than what is currently the norm in the 110 metre length by 11.40 metre beam imposed by the European waterways.

To achieve this goal, Ooms realised that he needed to start with a clean drawing table, where hull design, propulsion arrangement and the shape of the hold could be matched together to obtain the optimal compromise. As a basis for the optimisation, the usage profile of Ooms’ current ship, called Carpe Diem, was analysed. One fact became clear instantly: at 40% average loading, the propulsion installation was not as efficient as could be.

**Hull shape**

The hull design of inland barges is often considered as a given, as it has evolved for decades into the most used form today, with full bow sections and deep propeller tunnels in the aft. These propeller tunnels and their walls on port and starboard ensure proper immersion of the large propellers when the barge is sailing in light-loaded condition, which is about 10% of the time in Carpe Diem Shipping’s calculations. During the remaining 90% of the time however, the propeller tunnels are a source of extra resistance. Especially when heavily loaded in shallow water, and water for the propellers has to come from the sides, not from below, the deep propeller tunnels prove to be a less-than-ideal hull shape.

The hull of Semper Fi was designed in collaboration with the Dutch maritime research institute MARIN. An analysis with Computational Fluid Dynamics (CFD) software showed various points of higher pressure on the hull, which were eliminated by increasing the bilge radius in the foreship and tightening the bilge radius in the aft, where the parallel midship transitions into a pram-type stern with fairly flat V-shaped sections. Upon completion of the hull design, a model was tested in the towing tank for verification.

**Propeller efficiency**

Instead of looking for propeller efficiency in a large propeller diameter, Ooms opted for azimuthing Veth-Z-drives with counter-rotating propellers, as applied in river cruise vessels for many years. Where normal propellers in this range have a diameter of about 170 to 175 centimetres, the propellers on Semper Fi have a diameter of 150 centimetres forward and 135 centimetres aft. Because the aft propellers rotate in the opposite direction as the forward-facing propellers, a lot of the rotational energy – normally considered a loss – is converted into forward thrust. Martin van der Jagt from Veth Propulsion: “When all losses and benefits are taken into account, the Z-drives have an efficiency that is about 3% higher than a standard in-line propeller shaft installation. We see an evolution towards rudderpropellers throughout the inland shipping sector, with half of the hulls for inland barges currently on order designed for the use of either Z-drives or L-drives. For river cruise vessels, that ratio has been at 90% for many years, because of the silent operation, space saving design and improved manoeuvrability.”

Another benefit of the CFD calculations was that streamlines could be computed, not only on the hull surface – as they can be made visible with paint stripes during towing tests – but also at various distances from the hull. Based on these results, it was decided to mount the azimuthing thrusters, not flush with the bottom plating, but at a five degree angle towards the plating. This ensures that the propellers are positioned perfectly perpendicular to the flow, which enhances their efficiency. During operation,

**The hybrid propulsion system with Z-drives, along with an optimised hull shape, will reduce fuel consumption in several loading conditions**
Focus

Geo

system with diesel-electric assistance. After propulsion arrangement: basically a direct drive cells. The final choice was made for a hybrid fuel (LNG + diesel) engines to hydrogen fuel options were considered, ranging from dual For generating the propulsion power, all – Less entrapped water means a weight saving – More suitable for use in a dynamic positioning system – The thruster is also effective when the vessel has forward speed; – Due to the slender foreship of Semper Fi, tunnels in the side would have generated significant added resistance; – Very suitable for use in a dynamic positioning system. To keep the number of strategic subcontractors to a minimum, Carpe Drem Shipping sourced almost everything related to propulsion from Veth Propulsion, including the Scania main engines and generators, two 330 kW electric motors, two Veth hybrid Z-drives, the bowthruster, three water-cooled variable frequency drives, the exhaust treatment systems and the complete propulsion and power control system. Hybrid DD - DE

For generating the propulsion power, all options were considered, ranging from dual fuel (LNG + diesel) engines to hydrogen fuel cells. The final choice was made for a hybrid propulsion arrangement: basically a direct drive system with diesel-electric assistance. After Geo Focus and Duendes, Semper Fi is the third ship this year to be featured in Maritimen by Holland Magazine with such a propulsion layout. The advantages are clear: the smaller main engines are properly loaded in the most common sailing scenarios, and there is no conversion loss in this operating range as in a pure diesel-electric installation. When heavy loading, wind or current call for more propulsion power, one or two gensets can add power through an electric motor on a power-take-in shaft. In light-loaded conditions, both main engines can be turned off and the entire vessel can be run from a single generator, roughly half the size of a conventional main engine. Ooms will experiment by varying the angles between the thrusters and the centreline. It is expected that particularly in shallow waters, where more water comes from the sides and less from the keel, it may be advantageous to angle out both thrusters, even when sailing straight ahead. In a later phase, such an angle could be set automatically, based on the depth readings.

Bowthruster

A lot of thought was also put into the selection of the bowthruster. The Veth Compact Jet thruster came out as the winner of the vetting process. Albite more expensive than the typical tunnel thruster, this thruster, often found on river cruise vessels for its quiet operation, presents some significant advantages:

- Less entrapped water means a weight saving of about ten tons;
- The thruster is also effective when the vessel has forward speed;
- Due to the slender foreship of Semper Fi, the bowthruster, three water-cooled variable frequency drives, the exhaust treatment systems and the complete propulsion and power control system.

Hybrid DD - DE

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Subcontractors and suppliers of equipment fitted on board the Semper Fi - YN 1023

A.A. Vink, Sliedrecht: outfitting shipyard
All Pumps Holland, Nieuwland: pumps
Beerens, Werkendam: masts; wheelhouse stairs
Blokland non-ferro, Sliedrecht: box coolers; oil coolers; expansion tanks
BP Bunkerstation Papendrecht, Papendrecht: bunkering; various supplies
Caldic Technics, Rotterdam: Stamford alternator and shaftgenerator
Castrol Marine, Rotterdam: lube oils
Centraal Bureau voor de Rijn- en Binnenvaart (CBRB), Rotterdam: consultancy
ClimaLogic, Sliedrecht: airco and ventilation fans
Discom, Alblasserdam: silencers
Dockmarks, Zwijndrecht: signage; communication; website
DP Chartering (Danser/Pro-log), Zwijndrecht: freighter
E.B.R., Lage Zwaluwe: wheelhouse management
EFM, Meppel: insurance
EMS, Alblasserdam: electrical installation
Germanischer Lloyd Netherlands, Schiedam: classification
ING Groningen, Groningen: financing
Jiskoot & Van Weel, Rotterdam: design & engineering; hull construction
MARIN, Wageningen: CFD calculations and tank testing
Miron, Alblasserdam: sanitary installation; floor heating
Nelf Marine Paints, Marrum: paints
Pinta Nieuwburg Unisol, Ridderkerk: insulation
Veth Propulsion, Papendrecht: Veth hybrid z-drives, Veth compact-jet thruster, Scania main engines and gensets, VFDs, E-motors, exhaust treatment systems
Willemsen Interieurbouw & Scheepsbetimmering, Huissen: carpentry
Wijk Van, Werkendam: car crane; anchor chains; mooring winches

Conclusion
Ooms took his time to develop the concept for the Semper Fi, and it shows. Every component on board was carefully considered for its cost, efficiency and weight. The end result is a fuel efficient inland barge with almost invisible exhaust fumes and a practical and spacious cargo hold. Ooms is wary of making bold predictions about projected fuel savings, but he has promised to make a comparison with the Carpe Diem, which has similar characteristics and operating profile. A subsidy from Agentschap NL was indispensable to give this prototype ship her green credentials and Ooms believes that in future vessels, the extra investment cost will be reduced to € 400,000 to € 600,000 for the same results.

Bruno Bouckaert