

# THE NEXT REVOLT

Could present-day technology improve the cost and effectiveness of short-sea shipping while enhancing safety and environmental performance? Yes, it could! Taking current technology to the extreme, DNV GL has developed a revolutionary concept for an unmanned, zero-emission short-sea vessel.

## REVOLT IN BRIEF

### Specifications

- Service speed: 6 knots
- Range: 100 nautical miles
- Cargo capacity: 100 TEU
- Route: coastal traffic
- Port stay: 4 hours on average
- Power demand:
  - 50 kW in calm sea
- Unmanned operation
- Inclined keel
- Straight bow
- High efficiency propulsion system
- 2-blade propellers
- Podded propulsion for increased manoeuvrability
- Retractable bow thruster for port manoeuvring
- Extended cell guides

### Economic benefits

- Increased safety
- Increased situational awareness
- Lower operating cost
- No direct emissions
- Ballast-free design
- Smaller wetted surface
- Lower need for rotating machinery
- No cavitation
- Fast cargo handling
- No manual lashing

### Power supply

- Requires re-charging facilities in every port



Unmanned and fully battery-powered, DNV GL's zero-emission design could revolutionise short-sea shipping.

The EU's road network suffers from chronic congestion. Yet, road usage for cargo transport is steadily increasing, leading to heavier road wear, more accidents and higher emissions. The population growth in urban areas expected over the next decades will without doubt compound the problem, causing the demand for transport to exceed the capacity of today's roads.

To alleviate these issues, governments all over the EU are trying to move some of the freight volume from the road to waterways and railways. In the short-sea shipping segment however, profit margins are

small due to high energy and operating costs as well as high taxes.

These circumstances prompted DNV GL Strategic R&I to design a new ship concept specifically for short-sea shipping with the objective of encouraging a modal shift from road to sea. By taking the design and applied technologies to the extreme, the DNV GL engineers want to launch a new discussion within the community while upholding DNV GL's maxim of a safe and sustainable future for shipping.

The innovative ship concept "ReVolt - the unmanned, zero-emission, short-sea ship of the

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Photos: ©Toftenes Multivisjon

> future” is the result of a multi-disciplinary, team-based development project at DNV GL based on an assessment of current requirements along European short-sea routes. Nevertheless the concept could be implemented in other coastal regions around the globe.

### Defining the operational profile

ReVolt’s operational profile was established by analysing Automatic Identification System (AIS) data from vessels operating in the Norwegian Economic Zone (NEZ) in 2012. The relevant routes consist of individual legs of less than 100 nautical miles. The ship type and cargo capacity, which is within the 100-TEU range, were obtained by pairing the AIS data with DNV ship register data. From this information the requirements for the ship concept were derived.

The vessels evaluated in the AIS analysis had an average service speed of 8.7 knots. For ReVolt it was decided to reduce the required speed, to 6 knots to allow for more efficient propulsion solutions. As a consequence of this low speed the logistics chain will have to be redesigned entirely to account for longer transit times. However, implementing a “conveyor belt” logistics concept with frequent departures and short, four-hour-average port stays could create the right conditions for transferring appropriate cargo types to this mode of transport.

### Design characteristics

The hull of the vessel was designed to optimise ship efficiency, fulfil all applicable safety and operational requirements and enable operation without ballast water.

At the ship’s slow cruising speed, the resistance to overcome will consist primarily of hull friction and occasional external forces acting on the vessel. The wave-making resistance will be modest. For this reason a straight vertical bow design was chosen to minimise resistance across the entire operational profile. In addition, a sharp waterline creating a piercing effect is favourable in adverse wave

conditions. CFD calculations for the chosen design showed a low calm-water resistance of 50 kilowatts. On the other hand, the added resistance in waves and wind resulting from the low cruising speed was shown to contribute a relatively large portion to the vessel’s overall resistance. Resistance calculations incorporating met-ocean data sets from the intended route revealed an average ship resistance of 120 kilowatts.

An investigation into the possible use of composite materials was also carried out. While the lightweight material would reduce the wetted surface when compared to normal steel, the resulting draught reduction would require a smaller-diameter propeller, thereby compromising the ship’s propulsion efficiency. Therefore a steel hull, which is also less costly, proved to be the best solution.

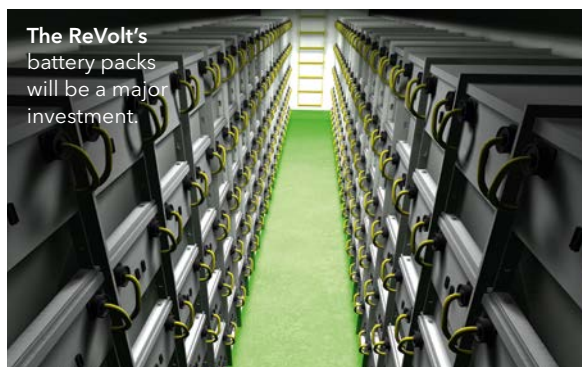
The propeller design for the ReVolt was largely based on efficiency considerations since most of the normal design constraints were irrelevant due to the low vessel speed. Since cavitation will be negligible, the number of propeller blades was reduced to only two. This in turn reduces viscous losses in the propeller considerably. For the final design a propulsion efficiency of 76 per cent was achieved.

ReVolt will operate independent of tugs and needs good manoeuvrability. Because of her hull shape a podded propulsion system was chosen over conventional shafted propulsion; this also reduces the number of rotating parts on the ship. The design calls for two stern pods as main propulsion units plus one retractable bow thruster for manoeuvring.

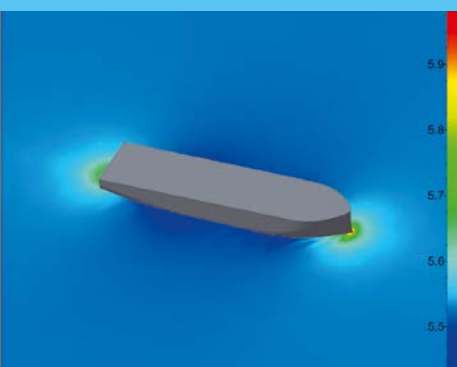
A fully battery-powered solution was selected for the ReVolt to maximise efficiency, eliminate emissions and reduce the number of rotating components requiring maintenance. Provided that the batteries can be charged with hydropower, a battery-based propulsion system will be highly efficient and clean. The energy loss from the water reservoir to the propeller is estimated to be as low as 40 per cent. By contrast, comparable diesel-powered ships may suffer well-to-propeller losses of up to 85 per cent. Furthermore, using renewable energy to charge the batteries makes ReVolt a zero-emission ship. And finally, batteries represent a low-maintenance solution for an autonomous vessel designed to require as little human interference as possible.

### Autonomy through simplicity

The safety record of the shipping sector today is relatively poor, with 900 fatalities per year on average – a figure 90 per cent higher than for comparable land-based industries. Studies show that as many as 85 per cent of accidents in shipping are the >



The ReVolt’s battery packs will be a major investment.



CFD analysis of the ship's resistance. (left)

Raised hull sides and cell guides in the cargo hold (above).

The on-board batteries will need to be recharged at every port (below).

AIS plot of the proposed trade route for ReVolt (right).



Photos: DNV GL, ©Toftenes Multivisjon

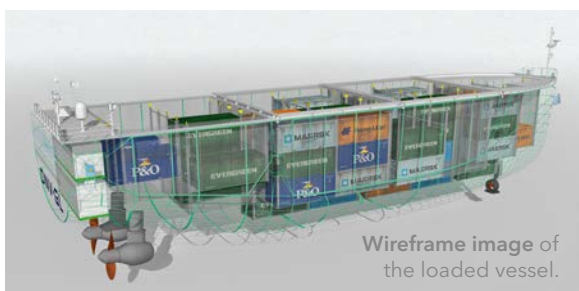
> result of human error. DNV GL has set the goal of reducing the number of fatalities in this industry to a level equivalent to land-based industries. If this ambition is to be met, the accidents caused by human error must be addressed in multiple ways, for example by introducing automation to support or replace human action.

Ship maintenance chores are a major portion of a ship crew's activities. So when a ship operates with a very small crew or entirely without people on board, how can the vessel be maintained? One strategy is to minimise the required maintenance effort, and this



#### FACTS & FIGURES

Main particulars	
LOA	60.23 m
LPP	57.23 m
Beam	14.5 m
Depth	
Draught (full)	5.02 m
Draught (ballast)	3.35 m
Service speed	6 kn
Capacity	
Cargo capacity	100 TEU
Deadweight	1,250 mt
Cruising range	100 nm
Machinery	
Battery	3,000 kWh
Propulsion	
Azimuth pods with 2 blades (3 m diameter)	2
Retractable bow thruster	1



is precisely what the designers of ReVolt did. Since the equipment most prone to technical breakdowns is rotating machinery, ReVolt is a ballast-free, fully battery-powered, unmanned vessel with the smallest possible number of rotating components. In fact, the only rotating machinery on board are the components associated with the propulsion pods and bow thruster and are located outside the ship's hull.

In terms of autonomous navigation, an integrated system comprising ECDIS, GPS, radar, cameras, LIDAR and other sensory equipment has the potential to create complete situational awareness around the vessel. All of the required technology is available off the shelf today.

ReVolt's autonomy concept takes the applied technologies to the extreme, and DNV GL believes that many intermediate development steps, such as condition and sensor-based monitoring, enhanced navigational assistance and remote operation, will have to be taken before unmanned ships can become a reality.

#### Operational and cost efficiency

Since ReVolt sails at relatively slow speed it is essential to avoid wasting time in port. By using state-of-the-art technology in automatic mooring systems, such as grip-arm and vacuum-based mooring, ReVolt will be moored quickly without the need for ropes and winches, which are highly dependent on manual assistance and regular maintenance.

By raising the hull sides and cell guides to full container stack height, cargo handling can be accelerated while eliminating the need for stevedores and manual lashing.

To ensure fast transfer of cargo from the ship to other modes of transportation, the shoreside facilities in ports need to be highly efficient. This can be achieved by building dedicated terminals with easy access for trucks.

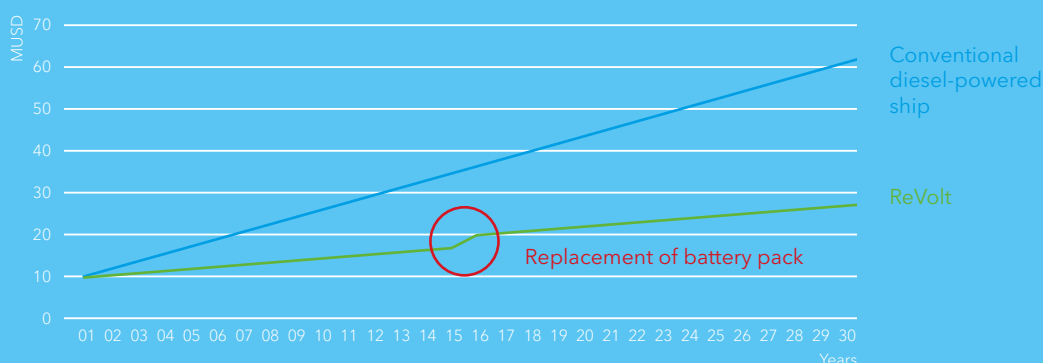
The ReVolt is unique in terms of both safety and environmental performance. However, the question remains whether all this can be achieved at a reasonable cost. The autonomous capabilities of ReVolt significantly reduce or even eliminate the need for crew facilities, a superstructure and auxiliary machinery, leaving more space for payload. The battery pack on board ReVolt is, however, extremely capital intensive with an estimated cost of 1,000 US dollars per kWh. And, due to the performance degradation of batteries, the need for a replacement pack means that this cost will be incurred twice over the estimated lifespan of the vessel (30 years).

As battery technology matures, battery costs are likely to drop significantly. Taking into account local incentive programmes such as the Norwegian NO<sub>x</sub>-



The ReVolt model demonstrator is used to learn about the possibilities related to autonomous navigation.

ReVolt's lifetime cost will be significantly lower than that of a conventional vessel.



fund, the CAPEX of ReVolt is estimated to be equal to that of a conventional ship with equivalent cargo capacity.

But where ReVolt will truly excel is the cost of operation. Her energy, maintenance and crewing costs will be far below those of a diesel-powered ship; how much, will depend on the shoreside infrastructure needed to enable autonomous operation.

As a result, ReVolt will be profitable from day one. Over her lifetime the ship will save about 34 million US dollars in operating costs compared to a conventional vessel. Future governmental emission reduction incentives may further increase the margin. A detailed 1:20 scale model of ReVolt has been built to demonstrate the ship's autonomous capabilities and test other design features.

DNV GL uses this scale model to learn about the challenges and opportunities of autonomous navigation

and pave the way to a future where autonomy is part of the solution for better safety at sea.

#### A vision for the future

ReVolt is a vision for the future and will not be built until several of the technologies involved have matured. However, the vessel could conceivably be built and operated using current technology. ReVolt is intended to serve as an inspiration for equipment manufacturers, shipyards and shipowners as they endeavour to develop new solutions towards a safer, more sustainable future.

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