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Towards a carbon-free future

Travelling fascinates us. It opens our eyes and provides us with fresh ideas and experiences one can simply not get at home. One must, however, not overlook the fact that travelling also increases our carbon footprint and has an overall negative impact on our environment.

So, should we all stop travelling and stay home instead? I believe most of us would rather like to see a world where we can maintain or even improve our current lifestyle but do it in a sustainable way.

Enjoying a holiday onboard a cruise ship is done in a moderately closed environment where the parameters of environmental impacts are relatively easy to define and measure.

As a marine consulting company, we know that when something can be measured, there is always room for improvement. It is also clear that things cannot be turned around overnight. Elomatic is committed to innovating and accelerating the development of new zero-emission technologies for ships and shipping. Minimizing waste produced at different stages of shipbuilding and operations is a key element in reducing harmful effects on the environment as well.

This edition of the Top Engineer magazine has a special Marine theme. We invite you to join us on our journey towards a carbon-free future.

I hope that you will enjoy this edition of the magazine and look forward to your feedback.

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Improving ship hull hydrodynamics

ELOGRID utilised in bow thruster tunnel openings

Text: Juha Tanttari

Ship hulls are equipped with thrusters that allow lateral ship motion, for example, in harbour manoeuvring. The propellers that induce the force are mounted inside tunnels in the bow section or, in some cases, in the stern section. These tunnels increase ship resistance, which can be reduced with the use of grids set in the openings.

Thruster tunnels are necessary to improve ship manoeuvring but adding these tunnels to a nicely shaped ship hull can contribute to additional resistance, which is reflected in ship fuel consumption.

The additional fuel consumption depends on the hull shape and varies from 1% per tunnel to 3% per tunnel. In some cases, the additional resistance contributed by the tunnels can be as high as 10% of the ship hull’s total resistance. This means that a relatively large amount of money will be spent on fuel while also producing additional CO₂ emissions.

The additional resistance can be reduced with the use of vertical grids set orthogonally to the streamlines close to the hull surface.

With good dimensioning, these vertical bars can decrease the additional resistance from tunnels easily by 50%, which results in noticeable improvements in fuel economy. A drawback of such vertical grids is that they reduce thrust forces up to 10%. The vertical bars work as stators in two narrow sectors of the circular flow path, and mixers in most of the opening. The blade profiles are not designed to increase the thrust forces and static pressure is elevated on the wrong side of the blades.

ELOGRID

A new grid design for thruster openings has been developed in order to
reduce the additional resistance from tunnels while at sea and to improve the thrust forces induced by the propeller when manoeuvring.

The additional resistance is decreased, in principal, in a similar way as with vertical grids. The turbulence length scale at ship service speed with the boundary layer development speed determines the distance of the plates needed to prevent main bulk flow entry into the tunnel surfaces. Most of the tunnel resistance is created by pressure forces contributed by the flow into the tunnel.

The thrust forces are increased using the grid stator effect. The propulsion induces swirling with higher circumferential velocity, which is decreased and aligned more axially with the use of stator blades. At the same time, the static pressure is elevated resulting in improved thrust forces on the ship hull. Instead of causing forces that work in the opposite direction than propulsion, ELOGRIDs are designed to produce thrust forces that work in the same direction as the propulsion. That is made possible with radial blade profiles designed to keep the boundary layer attached to the blade suction side.

When stator blades are designed to provide thrust forces, instead of reducing them – the thruster capacity can be elevated. Compared to open tunnels, the additional forces can be 5%, and compared to conventional grids with a 10% handicap, the addition can be as much as 15%.

Considering ship performance, this update to tunnel openings provides lower fuel consumption at sea and improved manoeuvrability in harbours. The better manoeuvrability is available at higher wind speeds, and results in faster turning times. Dynamic positioning can be improved, and the elevated propulsion efficiency produces less noise. In newbuilds, the grids allow smaller thruster sizes as well in some cases.

About the author, see p. 17.
Managing large cruise

Case: Global MV Werften, Germany

Text: Vesa Haapala
Images courtesy of MV Werften

Modern cruise ships inspire awe with their sheer size and scope of grandeur. The design and construction of such vessels is a highly complex process, which requires precise management. Key factors that affect whether such projects are successful include, among others, how distributed design and changes are managed and how committed project participants are to working towards achieving common goals. The design and construction of a Global-class cruise ship for MV Werften in Germany is highlighted in this article as an illustration of how such projects can be managed.

The need for skilled and motivated persons cannot be overemphasised in large cruise ship design projects. It is also crucial to get these people to cooperate and work towards achieving the joint goals of the project. In large projects where design teams are potentially scattered around the globe, this is no simple task. Cruise ship design is also markedly different from the design of traditional trade vessels, which highlights the need for designers that have proven experience of actual cruise ship design.
Global Class Vessels 1 & 2
- Some of the biggest cruise ships in the world: 204,000 GT, 342 m long, 46.4 m wide,
- Passenger capacity: standard 5,000, max. 9,500
- Global 1 delivery: 2021
- Global 2 delivery: 2022

Elomatic scope
- Total project size: 650 man-years
- Basic and detail design
- System engineering
- Site assistance during construction
The Global-class vessels are being built at MV Werften shipyards in Wismar, Rostock-Warnemünde (pictured) and Stralsund, Germany.
One often reads about the crucial role of decision making in project management. On large and distributed cruise ship design projects, the speed with which decisions can be made is of critical importance. The project management team needs the ability and confidence to make quick decisions and avoid unnecessary bureaucracy. In this regard, a strength of the Finnish corporate culture is its very low hierarchy, which supports fast decision making. 

It is also important for responsibility and decision-making powers to be clearly allocated at different levels. Some decisions are taken by the shipowner or shipyard’s top management, while others are taken by project managers or persons responsible for systems. There needs to be clarity as to who can make decisions regarding what in order to avoid any misunderstandings.

Managing design of Global-class cruise ship

The design of the largest cruise ship ever built in Germany is progressing at a rapid pace. The Genting Hong Kong-owned MV Werften shipyards in Wismar, Rostock-Warnemünde and Stralsund, Germany will build these high passenger capacity class ships for Dream Cruises.

The first ship in the series, Global 1, will be completed in early 2021 and its sister ship, Global 2, about one year later. The exceptionally extensive joint project between Elomatic, MV Werften and engineering company Deltamarin has brought together a large number of German and Finnish shipbuilding professionals over the last three years.

It all started with the signing of an agreement between MV Werften, Elomatic and Deltamarin in the summer of 2016 for the design of the first Global cruise ship (see the info-box on previous spread). From the outset, the spirit of the agreement was that Elomatic would act as the design department of the shipyard, and not as a traditional subcontractor.

The project is a bold undertaking by MV Werften, as it has not previously built such large cruise ships. The project participants together developed new ways of managing distributed design and of working as flexibly as possible. The project timetables were very tight right from the start and development work was conducted during the project, which placed further demands on the flexibility of the parties and their ability to make quick decisions.

Basic Design

In the basic design phase, the biggest challenge is usually finding different technical solutions so that the ship fulfills the contractual requirements. The design of a prototype cruise ship is always very turbulent: all project participants such as the shipowner, shipyard, equipment suppliers, turnkey suppliers, architects, as well as the classification society and authorities have to work together to ensure that the ship is completed according to the goals set, cost efficiently and within the agreed timeframe.

Modern design systems enable more efficient design that allows for the needs of different disciplines to be taken into consideration and possible contradictions and problems to be identified at a very early stage. The role of persons responsible for systems is crucial in basic design. They have special expertise in the systems they are assigned to. It should also be noted that basic and detail design have overlapping schedules to some extent, which is challenging. Basic design should be able to produce sufficient initial data so that detail design can be conducted as planned.

The basic design of Global 1 was started in 2016. At the same time, more people were recruited and the internal instructions were updated to meet MV Werften’s requirements. The ramp-up project was challenging, but also interesting because everyone had a positive attitude and a common goal.

The total workload for basic design is close to 200 man-years and Elomatic is responsible for approximately 420 basic design documents. Partners from Elomatic’s subcontractor network from Poland and Croatia have also taken part in the basic design.

The basic design stage is one of continuous change. In order to be successful, the communication between the different parties should be very close and flexible. Communication on the Global project is handled by e-mail, Skype, telephone, and often also by organising joint project meetings where all participants are physically present.

Elomatic makes use of MV Werften’s document management system as well as its own in-house EloDoc system. Initially, coordinating the systems was challenging, but once these challenges were overcome documents could be mass-driven. This guarantees the availability of the latest documents.

Detail design

The purpose of detail design is to produce materials for production according to the quality and schedule required.

Keeping to the timetable can probably never be emphasised too much in detail design; production does not wait. Change management has a significant role in this regard. Usually, the greatest challenge is prioritisation: Which changes can be incorporated in the materials without endangering the timetable, and which changes can be handled later via change management? Efficient change management requires a strong ability to react to resource needs, prioritisation, fast decision making and a working system that is used to manage change.

The detail design for Global 1 began in the fall of 2017. It will continue until the beginning of 2020, and for Global 2 until early 2021. MV Werften requires 3D models to be more detailed than is generally the standard in the industry, which has turned out to be a clear success factor on the project. It allows
Building progress: On 1 March 2019, section 50 was lifted into the dock at the Rostock-Warnemünde yard.

The interior of a standard cabin on board Global-class vessels.
By distributing design, possible resource risks are shared and the best experts for different design areas can be selected.

any discrepancies and contradictions to be detected already during the design stage. The challenge is to update and maintain the model in the design phase, which for prototype vessels is usually a rather turbulent period.

Exact models also require considerable design capacity and the ability to prioritize activities to ensure that they serve the next phase. The most important detail design task is to deliver the right documents for the production needs according to the schedule and to meet the required quality criteria. Elomatic has delivered over 1,000 detail design documents to the customer out of 2000, within the agreed schedule.

Distributed Design

In distributed design projects, it is extremely important that partners (subcontractors) are chosen based on their ability to manage the project. It should be established early in the contractual phase whether the party has the ability to manage the agreed design work. A common understanding regarding the work scope is required, otherwise a significant amount of time is wasted later handling additional work requests, which hinders project progress.

By distributing design, possible resource risks are shared and the best experts for different design areas can be selected. Design is conducted entirely via the 3D model, which means that designers do not physically have to be in the same place. The correctness of the model is verified with 3D audits.

For subcontracted work, the workload should be as steady and long as possible, which commits the subcontractor to the project. Subcontractors man the projects for their own areas. The implementation thereof is monitored in weekly reporting either in conference calls or face-to-face meetings. Very often, if the end result is not as agreed, the reason can be found in the lack of support that partners received.

In addition to designers, coordinators have a significant role in detail design where they supervise and manage subcontractors’ activities. The better this is done the better the chances of success in the project. The best way to guide partners is to send a coordinator to their office.

In a project as large as the Global project, distributed design management plays a vital role. The project team includes ten partners, from one-man operators to partners abroad with more than 20 designers. Much of the co-ordination and hull design has been done at Elomatic’s Gdansk office. The project is organised so that each disciple has its own manager who has to supervise and guide the partners. Guidance requires a very proactive approach and continuous monitoring and verification. A realistic assessment of the degree of readiness is also essential. In the Global project, there are department-specific monitoring tools, from which the information is fed into the client’s own systems on a weekly basis.

Change management

Changes cannot be avoided in prototype cruise ship design projects. The manner in which changes are managed has a significant impact on whether the project succeeds. MV Werften has a well-developed process for change, but because some changes are made at Elomatic’s or its partners’ sites, Elomatic’s own internal process for prioritising change management and managing resources has also been used.

Any late changes that affect the cost and/or schedule are recorded in the system. Change management is handled separately by a designated person. This allows the management to respond quickly to changes, without disrupting normal design work. They are able to share and predict design capacity and report systematically to the customer, which promotes transparency and removes any reporting uncertainty.

About the author

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Vesa Haapala has 20 years’ experience in ship design, processes and production. Vesa started his career at Elomatic in 1998 as a designer. He was later promoted to project manager. From 2006 to 2017 he worked at the Turku shipyard in Finland in hull production as a project and department manager. He returned to Elomatic in 2017 and is currently the project manager on the Global project.

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Analysing ship aerodynamics

Making the case for CFD simulation

Text: Juha Tanttari
Images courtesy of Meyer Werft

All ships are required to undergo wind tests during design to ensure crabbing capabilities, manoeuvrability, and seakeeping performance. In some cases, smoke dispersion and passenger comfort also need to be analysed. Instead of conducting model scale testing in wind tunnels, computational fluid dynamics (CFD) can be used to achieve results that are more accurate.

Wind load tests are nowadays required to ensure the desired crabbing capability for ships, i.e. the ability to move sideways without forward movement. The side forces applied by the wind or sea currents on the ship need to be offset by side thrusters or another propulsion force to ensure manoeuvrability and seakeeping performance. The load tests can alternatively be conducted with CFD simulations.

Ship aerodynamics is still commonly analysed with the use of wind tunnel tests. Wind tunnel tests must be conducted on a model scale of 1:100, which means a much lower Reynolds number compared to the actual size of the ship. To compensate for the size and improve the Reynolds number (speed x size / viscosity), the wind tunnel air speed should be elevated or gas viscosity reduced.

Model scale tunnel tests lack the precision required by the actual scale Reynolds number, even though attempts are made to compensate for it with wind tunnel speed or viscos-
It is also relatively challenging to achieve a tunnel wind speed profile that corresponds with the actual sea profile. More accurate results can be achieved with full-scale CFD simulations.

Making use of CFD simulations

Simulations are typically performed at least for wind loads and smoke dispersion. For cruise ships, the comfort level is also of interest and car deck ventilation analysis should be included for ferries.

A CFD simulation model includes the ship superstructures with all aspects that impact aerodynamics. The level of detail must be high enough to detect all the flow conditions of interest, while keeping the model size compact in order to calculate it in the time schedule required. The size of the surrounding area taken into the model is usually a few square kilometres.

Typically, simulations are performed for two main cases: for the ship at service speed and in port. One wind speed from all directions is sufficient with 15° staggering for the wind resistance coefficient. In most cases, ship symmetry can be taken into account to check dispersion and comfort values.

Most simulations are run as steady state calculations (RANS), while in some cases time dependent data is ensured with DES (detached eddy simulation).

Several parameters are required to achieve the required level of information from simulations. The wind speed is given as the typical standardised sea
Figure 1. Pressure contours on ship superstructures.

Figure 2. The sea wind velocity profile used in ship aerodynamics simulations.

Figure 3. Typical coefficients for wind loads.
wind profile, with the reference speed set at 10m altitude. The ship speed can be included with a moving reference frame, or alternatively by taking into account the wind speed relative to the moving ship. Smoke dissipation from each funnel and ventilation inlets is taken into account as designed for both main cases.

Wind velocity and turbulence parameters are considered for the wind profile, while the ambient temperature is given as constant according to the ship specifications. Real fluctuating wind conditions are simplified using constant wind conditions instead, with a sea wind profile.

Below altitudes of 50 m, the simple power law is empirically valid for both sea and land conditions and is generally used in emission dispersion studies. If greater altitudes are needed, log-law relations can be used, which are valid up to 2000 m. The power-law wind profile is shown in Figure 2, where \( U_{10} \) is the wind profile at 10m altitude and \( z \) is the distance from sea level.

The velocity increases rapidly after 10 m, which results in the emissions being emitted higher, transported further away, and mixed more with the surroundings than emissions at lower levels. Therefore, it is crucial that the emissions are emitted as high as possible. This can be done by increasing the emission velocity or increasing the temperature of the emissions.

The velocity distribution around a ship is shown with streamlines in Figure 3. The wind angle is 45°, and part of the wind starts to circulate in the ship direction. This starts to disperse the emissions and transport them further away downstream. The ship distorts the surrounding flow field, leaving larger areas where air circulates slowly. If the emissions are transported to these areas, they do not disperse effectively in the surrounding air and can be transported back to the ship decks. It is crucial to prevent this from happening by elevating funnel discharge above the ship boundary layer.

**Wind load**

Wind load coefficients can be defined based on the force components and moments on the hull at the given wind speed, taking into account the longitudinal and transversal projection areas for the ship geometry.

The ship’s crabbing ability is highly dependent on side forces applied by the wind. The allowed wind speeds are determined based on these force coefficients and the moment coefficient with the specified thruster power available.

Typically, the highest coefficient values are detected for wind directions from the ship shoulder (~50–55°). Relatively large force fluctuations are typically due to unsteady downstream drag forces.

**Emission dispersion**

All gas flows to or from the ship are included in the modelling: ventilation in/out, galley, boiler, main engine, auxiliary engine, and AWP depending on the ship equipment. The flow rates, gas temperatures or number of engines in use is dependent on the main case definition: the power demand or ship use is different for service speed and port conditions.

Different emission types produced by the ship in service or port have different threshold limits, ranging from 10–3000 ppm; no exact values can be defined for the limits, as they vary from case to case. Sewage emissions are usually required to be low, so their thresholds are 10–100 ppm. For boiler emissions, the limit can be around 1000 ppm or more. The values are therefore relative to the emission values. The main engine concentration limits are dependent on fuel or flue gas treatment, the highest concentrations are allowed for LNG up to 3000 ppm.
Figure 4. Main engine emissions at service speed of 22 kn.

Figure 5. Comfort level on an aft sun deck.
CFD simulations are done to identify the worst-case conditions where given limits may be exceeded and to help find solutions to avoid high concentrations. Ideally, emission plumes should move away from the ship. However, in some cases, emission concentrations around the superstructures remain above permissible limits. In such cases, alternatives for improving dispersion should be analysed in order to find a solution. Simulations reveal these conditions quickly and allow the required adjustments to be made to the ship design. Typical solutions may include increasing the emission injection rate or increasing the height of flue gas pipes to force emissions higher, thereby ensuring that emissions do not land on the ship decks.

Figure 4 illustrates a main engine emission dispersion at the threshold limit of 100% and 50% concentration and at service speed with a forward wind. By testing all scenarios with different wind directions, the worst cases can be identified and the ship design, operating conditions or pipe setup can be optimised. At service speed and with a relative fore wind, the emission plume behaves as designed. The emissions are dispersed in the surrounding air where the cloud ends and the concentration is below the threshold limit of 2500 ppm outside the cloud.

Ensuring the required comfort level

The comfort level on a ship’s outer decks is of interest in cruise ships, where passengers spend a lot of time outside. The level of comfort regarding wind conditions is specified according to the use of each location on the outer decks. The most demanding locations are pool areas, sun decks and restaurants.

The wind speed and turbulence on outer decks are used to measure the comfort level experienced by passengers. Comfort can be assessed via the comfort level parameter, which takes wind circulation on the decks into account with the aid of turbulence parameters. This parameter describes how well the ship structure protects the passengers from outside wind, which can be very uncomfortable. The higher the parameter value is, the more uncomfortable people feel in that region. The values range from 0-1, where 1 corresponds to conditions similar to those outside the ship and 0 to an area that is fully protected from outside wind conditions.

The ship comfort levels on an aft sun deck are shown in Figure 5. There are small areas where the comfort indicator is high, indicating higher levels of discomfort, but in the major areas the comfort levels are in the desired range and no extra modifications are needed to the sun deck design.

Summary

Full-scale ship wind tunnel tests can be run with the use of CFD. It provides more realistic results for all ship outer deck aerodynamics compared to model scale tunnel tests.

The aerodynamic analysis can include many features of interest; most typically wind loads, smoke dissipation and comfort values, but helicopter landing platform wind conditions or car deck ventilation can also be analysed – all elements concerning wind impact on ship use or operability should be considered. The CFD model can include the environment to some extent as well, such as harbours or other vessels to combine the interaction of separate structures and see the vessel’s impact on its surroundings – such as smoke dissipation in a harbour.

Wind tunnel test run with CFD provide a fast response and assist the analysis of all factors that lead to the detected behaviour of a domain. This achieves better solutions with reduced development work time.

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Juha Tanttari has 20 years’ experience of working in fluid dynamics consulting. His experience covers a vast range of industrial segments including marine hydrodynamics and aerodynamics, project management and sales. Juha joined Process Flow in 1999, which was acquired by Elomatic in 2017. He currently holds the position of Lead Consulting Engineer, Technical Analysis.

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In 2018, the IMO and the shipping community made a strong commitment: By 2050, greenhouse gases from shipping must be reduced by at least 50% from 2008 levels. For an individual vessel, the reduction needs to be far greater. In order to achieve this goal, the journey must start now, by implementing new and existing technologies.

With these words Japanese shipping company NYK, one of the largest and most diverse shipping operators in the world, launched their challenge for CO$_2$-neutral shipping in 2050. Prior to the above announcement by the IMO, NYK and its technology development arm, the Monohakobi Technology Institute (MTI), had already approached Elomatic for a development roadmap towards more environmentally friendly operation.
Journey to a carbon-free world

Introducing the NYK SUPER ECO SHIP 2050

Text: Tomas Aminoff
Back in 2009, Elomatic conducted a technology study for NYK to reduce energy consumption and emissions. The work culminated in a futuristic container vessel, the NYK SUPER ECO SHIP 2030. This project received much attention and won awards for its environmentally friendly design. The on-board energy consumption of the SUPER ECO SHIP 2030 was reduced by 40% from the best-in-class vessel at the time.

Almost 10 years later, the time had come to update the study and raise the bar, while aligning it with and exceeding targets set by the IMO and International Panel for Climate Change (IPCC). While a wide range of vessel types were addressed, the showcase vessel for the updated study was a Pure Car and Truck Carrier (PCTC). The

Close range monitoring and awareness sensors are located on all corners of the vessels. Cargo deck ventilation fans are located behind the solar panels in the aft.
The ship is known as the NYK SUPER ECO SHIP 2050.

By utilising a deep toolbox and touching all fields of ship design and vessel operation, a 70% energy saving compared to today’s benchmark was achieved. Significantly, the potential of emission-free operation was reached, depending on the source of primary fuel.

The challenge

In essence, emission-free operation is simple: use fuel with neutral or no CO₂ emissions. The challenge is that such fuels are rare, expensive and, in most cases, difficult to store. They also tend to be inefficient from an energy efficiency perspective, when the entire footprint from primary energy to a bunker fuel on board the vessel is considered. Thus, the path towards the use of alternative fuels is via highly efficient vessels and highly efficient operation of the total fleet and its logistical chain.

To achieve the 70% reduction in bunker fuel on board the NYK SUPER ECO SHIP 2050, many large and small improvements were made. The most critical aspects are highlighted in the rest of this article.

Resistance, resistance, resistance

For a typical merchant vessel, the biggest power demand is required to overcome the resistance of the vessel. Resistance originates from the need to move the vessel through water and air, with the former being the dominating factor.

The hull volume and shape of a vessel is critical in order to reduce resistance. The hull has to provide buoyancy to carry the weight of the ship and its cargo. To minimise the volume of the hull, it is important to minimise the lightweight of the ship. The lightweight of NYK SUPER ECO SHIP 2050 was reduced by 30% in view of developments in topology optimisation, the potential of 3D printing in manufacturing and materials development.

The other purpose of the hull is to provide sufficient stability for the vessel, which is especially critical for a PCTC. Computer-controlled stability has been the norm for fighter jets for some time already. In our vision, ships will also have active devices that provide sufficient stability. In the NYK SUPER ECO SHIP 2050, this has been done with gyro stabilisers, but the actual execution can be any other active device.

The vessel is equipped with pontoons that can be deployed if required. This allows it to remain stable during blackouts and other abnormal situations. These developments will allow hull shape optimisation to be done differently, with a greater focus on resistance. Overall, the reduction in vessel resistance is 35%.

Machinery and propulsion

Efficiency is key when it comes to prime movers, power distribution and propulsion equipment.

Hydrogen fuel cells were selected as the prime movers of the vessel. Because the only bunker fuel on board is hydrogen and the prime movers are fuel cells, a lot of auxiliary equipment can be removed and the maintenance requirement reduced.

The electricity from the fuel cells is fed into a highly efficient DC grid, which distributes low-voltage electricity throughout the ship. Savings throughout the electrical distribution have been achieved by minimising electrical components, utilising permanent magnetic motors, advanced
power and consumer management and superconductive transmission.

Conventional propellers have been replaced by flapping foils that mimic the movement of dolphins to deliver greater efficiency than screw-type propellers. The efficiency gains originate mainly from the efficient blade operation of the flapping foils.

Another important aspect is the creation of renewable energy on board the vessel. By 2050, solar power will already have been the most cost efficient new source of energy at land-based installations for many years. The same will be true for maritime applications. Therefore, the ship area is optimally utilised for highly efficient solar panels that can move on two axes for the best possible efficiency. On a roundtrip basis, 15% of the vessels energy demand will be covered by solar panels.

Zero waste

One way to increase efficiency is to eliminate all sources of waste. Excess heat from machinery is already utilised today to produce electricity, but NYK SUPER ECO SHIP 2050 will go one step further. Because there is no need to use waste heat on NYK SUPER ECO SHIP 2050 to heat bunker fuel and due to its more streamlined crew, the need for heating is further reduced. At the same time, with emission-free exhaust furnaces consisting only of water vapour, the temperature of the fumes after heat recovery can be as low as desired, which means that more heat can be recovered. These two developments will increase the potential of heat recovery.

Waste cold is a new stream of waste that originates from cryogenic bunker fuels such as LNG or liquid hydrogen. Excess cold originating from the consumed fuel can be utilised in several ways. It can reduce the required power consumption on board when used for air conditioning and cold equipment in the kitchen. It can also improve the efficiency of power distribution through superconducting and reduce the surface temperature of solar panels.

Other sources of waste originating from ship operation are stored on board the vessel and offloaded in port. This not only improves the environmental footprint of the vessel, but also reduces the amount of equipment required on board and minimises the required energy and maintenance demand.

Operation

The effect of operation on emissions from shipping should not be underestimated. Weather routing, just-in-time arrival, as well as advanced power and energy management will be standard procedures by 2050. However, optimisation will be done on a larger scale. Port arrival will be optimised between all vessels heading towards port and shore-based logistical chains will be aligned with the arrival of vessels. Cargo for feeder vessels will not disembark to the port, but will be moved directly from one vessel to another. This will reduce the port stay for the vessel and the lead-time for the cargo.

Time between bunkering will be another important change in vessel operation. As most alternative fuels are more complex and require more storage space compared to current fuels, bunkering will need to be more frequent than current practice. The vessel will require an endurance of 21 days compared to several months for current vessels. This will keep the costs and space demands affiliated with liquid hydrogen at manageable levels.

Conclusion

The NYK SUPER ECO SHIP 2050 is a source of inspiration and a basis for further discussion. The vessel clearly demonstrates the importance of energy efficiency for the adoption of alternative fuels. To achieve the 2050 target, ship owners need to follow the example set by NYK and start planning already today. They need to map the availability and matureness of technology already available, that which is currently being developed, and technology that is only at a visionary stage.

The NYK SUPER ECO SHIP offers a 35% reduction in resistance and a 70% reduction in energy originating from bunker fuel. This opens the door to the use of completely emission-free and greenhouse gas free or neutral fuels, thereby achieving a truly zero emission vessel.

Watch video of NYK SUPER ECO SHIP 2050: www.youtube.com/watch?v=Jq_MDPzYTWs
In recent years, much noise has been made about digitalisation in the marine sector. The related development areas include, among others, autonomous navigation and steering for ships, as well as more advanced ship automation systems that ease the lives of crew and owners. In leveraging the benefits of digitalisation, data collection and analysis have become key focus areas.

Today’s ship automation systems have been able to capture all possible operational environment and ship status data for several years already. This has made a massive amount of data available for fleet owners. Generally, this data is not collected for deeper analyses.

Many manufacturers also send data from devices to their own cloud storage. They are naturally not interested in sharing this data with competitors. This, in turn, leaves shipowners with the headache of monitoring relevant data and alerts from many different sources and systems.

**This time 1+1 = 3**

Analysing the combined data from several systems as a whole expands knowledge of the entire fleet operation and maintenance cost structures. One can improve a ship’s operational awareness and react to related incidents or performance issues faster by capturing ship parameters such as location, speed, heading, wind, systems statuses.

However, by using a much greater amount of combined information for concurrent analysis (big data), far better results can be achieved than by following individual
Analysing combined data from several systems expands knowledge of the entire fleet operation.

measures of individual ship systems. It is, for example, possible to compare current and historical data to inform the crew of more optimal driving parameters. One can also estimate the need for possible upcoming services, maintenance or docking schedules.

When an online data connection between the ship and the shore is added, a live MIMIC-view can be achieved with all the statuses and video connections from the ship to the owner’s remote observation centre. Operators in the remote observation centre can support the crew fleetwide when needed.

Improving operational fleet costs

Data collection systems allow the monitoring of individual indicators via a dashboard. More advanced functionalities can, however, be set up so that the analysis of large amounts of data can generate more information. This includes:

- The most effective way of running a ship in certain conditions
- Service needs
- Docking planning
- Consumption in different conditions and routes
- Benchmarking different ships (or crews) with particular routes
- Service management such as inventory and purchasing of spare parts

Autonomous ships

Autonomous ship technology is a big development area in the marine industry that has been driven by digitalisation. Several companies are investigating and investing in technologies to enable unmanned ship operation.

The ultimate goal is cargo ships that can operate fully autonomously between continents. The reality is, however, that the current technology can only
The Finnish Border Guard vessels Turva, Uiskko, and Tursas run the EloWise information management system.
manage small ferries that have simple operations on short routes. Even this achievement would have been considered science fiction a few years ago.

The technology is set to develop even faster over the next 10 years and has created a new group of start-up companies, also in Finland. At the moment, several companies are researching and developing devices like sensors, as well as AI software applications for image recognition and navigation for the next generation of autonomous ship systems.

This technology will not immediately enable fully autonomous ships. Future innovations will be taken into use incrementally according to technology availability and price levels. In the first phase, a computer will alert crew members about issues it recognises in the environment. The next step will be computers that can advise the crew and guide decision-making, i.e. computers that execute actions only once the crew approves. After several small steps, the ultimate goal will be fully autonomous actions without the need of crew participation.

This final milestone will significantly affect the exterior of cargo ships as well as the interior arrangements, due to the decreasing number of crew members on board. There will be no need for accommodation areas on cargo ships as no crew members will work permanently on the ship. Much of the technology and many spaces can be removed once there are no humans on board.

Autonomous ships are observed and controlled remotely. It is essential to develop online data collection and analysis to enable advanced remote control of ships.

In addition to the real-life ship, there is need to create a digital twin to allow the ship crew and remote workers to have the relevant statuses of the ship at the same time.

**EloWise data collection and management system**

Elomatic has developed a first-generation data collection and management system called EloWise. The system has been used both in marine and shore-side industrial environments.

EloWise can be tailored for use in the digitalisation of fleets. It is simple to build up a digital twin with the EloWise system with the use of original ship design information such as the 3D model and other design documentation.

Later on, more information can be added such as 360° photos or even live video streams, if needed. EloWise can be used for handling ship automation data collection, service management tasks such as inventory control and purchasing of spare parts and a digital twin approach both onboard and onshore. Currently, EloWise is used onboard the Finnish Border Guard vessels Louhi, Turva and Tursas.

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**Digitalisation has driven the rise of autonomous ship concepts.**

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**About the author**

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Juhani Kankare has worked in consumer electronics, telecommunications and in marine electrical design. Juhani joined Elomatic in early 2019 and holds the position of Design Manager, Ship Electrical Engineering Team at the Elomatic Turku office.

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