CONTAINER SHIP UPDATE

NEXT GENERATION ULCS
SHIPMANAGER FOR MAERSK LINE
MEGA BOX SHIP STUDY
## CONTENTS

ULCS - the next generation will be Suezmax ........................................ 4  
Be the best at building container ships ........................................... 10  
Maersk Line implements ShipManager ......................................... 14  
Concept design assessment ......................................................... 16  
New DNV GL Class Rules for Container Ships ............................. 20  
WIV class notation ..................................................................... 22  
Whipping - simulation based analysis .......................................... 23  
Fire safety of container ships - an area of concern? ...................... 26  
Experts on line 24/7 ................................................................... 30  
Successful surgery ..................................................................... 32  
New version of ECO Insight ......................................................... 34  
Raising The AIS Data Treasure ..................................................... 36  
Energy efficient operations - what matters ................................. 40  
ECO Retrofit service .................................................................... 44  
LNG-fuelled turbine-powered mega box ship study ................. 46  
Recent deliveries ....................................................................... 52

Front cover photo: © DNV GL/Vladimir Tonic

---

**YOU CAN'T MAKE A VOYAGE SHORTER, BUT YOU CAN MAKE IT MORE EFFICIENT**

DNV GL supports you in assessing and implementing new technologies and processes that improve the efficiency of your fleet. We apply our specialised expertise to ensure you comply with all regulations while both staying ahead of the competition and benefiting the sustainability of your business. Can you afford anything else?
LEADING THE WAY

The new DNV GL rules for container ships have just been published. This is a major milestone for us. We have brought together the best from two legacies, maintaining legacy GL’s well-proven container ship standard and enhancing it with research and innovation. We strongly feel this is a class standard for the future, building on the best from the past.

Does size really matter? Looking at the recent decade, one should think so. Hardly ever have we seen such an increase in ship size like the ultra large container ships being built in recent years. In the 1970s, the focus was on big tankers, with everyone talking about the ‘one million dwt tanker’ - which never happened. In this issue, we look at what the next generation of ULCS may look like and you can read about the Suezmax ships.

China plays a significant role in container ship building. Hudong-Zhonghua is a leading player and we talk to Mr Lou Danping, Vice Chief Engineer in this issue. DNV GL has had a long and fruitful cooperation with this shipyard, which we have seen grow and expand in recent years. We appreciate our good relationship with the yard, and we wish for a continued success in the future.

And there is more of interest, with efficiency and performance enhancement being highlighted on the following pages. Whipping on container ships is in focus and both DNV GL’s class notation “WIV”, as well as the underlying analysis approach are highlighted in this issue. This is state-of-the-art technology.

Hopefully, you will find the article on the parametric study of container ships’ main dimensions of interest. Getting it right from the start is a prerequisite for a successful design. There will be new designs coming out - for smaller ships too - and this may be a good starting point.
ULCS - THE NEXT GENERATION WILL BE SUEZMAX!

The increase in the maximum length and beam of ULCS (Ultra Large Container Ships) has stalled for the last five years. However, it has been considered what the next generation of ULCS will look like. DNV GL has carried out a study to investigate which dimension it would be most efficient to increase. It turns out that the main particulars of the next-generation ULCS will be seriously affected by size limits imposed by the Suez Canal.
The maximum capacity of container ships has grown quite substantially during the last couple of years. After an initial order for twenty 18,200 TEU ULCS in 2011, today more than 100 vessels of this size or with even higher capacity are on order or in operation.

ULCS promise to reduce slot costs due to the “economy of scale” factor and most liner companies engaged on the Far East – North Europe trade are keen to operate this size of vessel in order to catch up with the prime movers, which have enjoyed the expected slot-cost advantages for some time now. However, recently some concerns were raised in the industry about whether the trend for ever-larger vessels will continue or whether we have already seen the maximum size of ULCS. These concerns were apparently fuelled by concerns about the stability of freight volume growth, the need to utilize the increasing numbers of ULCS as well as the increasing infrastructure investment costs to allow ports and terminals to handle ULCS.

Nevertheless, the ULCS size is expected to grow further, but maybe at a more moderate rate than in the last decade.

DNV GL has studied possible options for further increasing ULCS capacity with a focus on two areas:

- A possible increase in the transport efficiency (needed propulsion power per TEU) of larger ULCS, with increased length, beam and draft for an assumed operating profile and for a range of homogeneous container weights, also considering typical infrastructural limitations imposed by seaways and ports
- The structural feasibility of possible future designs

Transport efficiency of next-generation ULCS

Using a DNV GL in-house methodology called “Concept Design Assessment” (please refer to the separate article on this subject), 21 variants of possible future ULCS designs with different lengths, beams and drafts have been analysed:

- Three different lengths - the present 24 bays, 26 bays and 28 bays
- Three different beams the present 23 rows, 24 rows and 25 rows
- Three different draught conditions - 15 m, 16 m and 17 m

For all variants, 12 tiers of containers in the hold and 11 tiers on deck were considered, corresponding to a ship depth of about 33 m.

The following parameters were then analysed for all variants:

- Nominal container intake
- Deadweight at draft conditions 15 m, 16 m and 17 m
- Lightship weight, corrected to take account of the results of the structural feasibility study
- Main engine power demand for a speed range from 12kn to 21kn

The selected key characteristics of the chosen designs are shown in table 1.

Further, for each of the designs, the possible loading capacity with a homogeneous intake of 8t, 10t, 12t, 14t and 16t per TEU has been calculated, initially based on the available slots and DWT. It was then checked whether the resulting loading condition would provide sufficient minimum stability. In cases where this was not achieved, the amount of ballast water needed to achieve a minimum GM of 0.6 m was calculated. If the remaining available deadweight was not sufficient to load the required amount of ballast water, the corresponding number of containers was virtually replaced with ballast water.

![Table 1: ULCS design options](image-url)
An "Average required ME power demand" for each of the variants was then calculated based on an operating profile with an assumed speed distribution as shown in table 2.

<table>
<thead>
<tr>
<th>Speed</th>
<th>kn</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time share</td>
<td>%</td>
<td>5</td>
<td>10</td>
<td>35</td>
<td>35</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2: Assumed Operating Profile

In the next step, the “Average required ME power demand” per TEU for each of the considered homogeneous loading conditions was derived.

Finally, the results were normalized and the difference in percentage was calculated for all variants in relation to the selected “base case” - the design with 24 bays and 23 rows at 16m draft.

The results are shown in table 3.

Table 3: Benchmarking of design options against the base case

Table 4: Infrastructure limitations of selected ports

What can be concluded from this analysis?

- Increasing the draft improves the transport efficiency of all variants for most homogeneous loading conditions.
- Increasing the beam by one or two rows but maintaining the length only improves the transport efficiency for the condition with low homogeneous container weight.
- Increasing the length by one hold (two bays) but maintaining a beam of 23 rows improves transport efficiency by about 5% for all loading conditions. Increasing the beam in addition increases the capacity but has no positive impact on transport efficiency.

- Increasing the length by two holds (28 bays in total) in connection with increasing the beam to 25 rows would increase transport efficiency by about 8% - 11% depending on the average weight of the containers.

Infrastructural limitations on the Far East – North Europe trade

Most container ports in Asia do not impose any restrictions on ULCS dimensions. It is mainly ports in Europe that have limitations, mainly due to the fact that some of them are located in tidal waters at the mouth of, or even many miles up, a river.

Major ports with limitations are given in table 4.
As can be seen from table 4, a maximum length restriction of 400 m is nowadays imposed in several ports in Northern Europe.

The port of Hamburg seems to be in a particularly challenging position here. However, plans to enlarge the available turning basin are expected to be implemented by 2017.

Furthermore, it is believed that ULCS with a length of up to 430 m which are specifically prepared for efficient manoeuvring (e.g. with sufficient bow/stern thruster power or twin propeller propulsion, strong and sufficient tug pushing areas and bollards/checks for towing lines, etc.) could be handled in areas where the ship length is currently limited to 400 m.

Several North European ports also have a beam and/or draft restriction. The number of ports which can serve as the final loading or first discharge port is assumed to decrease if ULCS dimensions increase in the future. This will impose limitations on the set-up of networks/possible sequence of port calls for ULCS, but will probably not stop the growth in ship size.

The Suez Canal also imposes restrictions on the maximum main dimensions of ULCS, as has already been reported in “Container Ship Update 2014”.

The present common maximum draft for ULCS designed for the Far East - North Europe trade is around 16 m, which could be utilized at least for the final loading and first discharge port. For the considered main dimensions, the limitations of the Suez Canal are as per table 5.

<table>
<thead>
<tr>
<th>Row</th>
<th>Beam [m]</th>
<th>T max [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>58.6</td>
<td>17.16</td>
</tr>
<tr>
<td>24</td>
<td>61.1</td>
<td>16.46</td>
</tr>
<tr>
<td>25</td>
<td>63.6</td>
<td>15.42</td>
</tr>
</tbody>
</table>

Table 5: Present maximum Suez Canal dimensions

It is understood that the Suez Canal Authority plans to increase the water depth in the Canal from 66 feet to 72 feet; however no detailed information can be retrieved with regard to the schedule and how this will impact the allowable beam/draft matrix.

Current Suez Canal limits allow passage for ships with a beam of up to 59 m beam and a draft of up to 17 m. Increasing the draft by about 1 m results in an increase of roughly 20,000 DWT with the same length and beam. This reduces the required average propulsion power per TEU by roughly 6% for heavier containers but is slightly disadvantageous for lighter boxes.

Wider vessels could face limitations on their maximum draft. However, whether or not this leads to a real limitation for the owners depends very much on the current loading condition. When passing through the Suez Canal, vessels might have a somewhat lower draft, as they had in the final loading port, due to the fuel oil consumed during the voyage.

Another limitation on the infrastructure side is the available shore crane technology in the ports along the trade route, with regard to both the outreach of the cranes and the height of the boom, which may limit the number of tiers that can be carried on the deck of a ULCS.

Unfortunately, it is not easy to obtain a detailed overview from public sources. However, it is understood that most ports on the Far East - North Europe trade have upgraded their gantry cranes in the meantime, so that vessels with up to 25 rows across can be served. Nevertheless, in some ports crane height may still be a factor limiting the number of tiers that can be stowed on deck, in particular when considering a design with a depth of around 33 m.

**Structural feasibility study**

For all the design variants given in table 1, a structural analysis of the mid-ship section was carried out in order to check the section modulus and whether the vessels could be designed and built in line with the current design principles/structural arrangements, materials and technologies.

The maximum plate thickness considered was 90mm of steel with a yield strength of 460 N/mm² (YP460) in the deck area. In the bottom area the aim was not to use steel with a higher strength than 355 N/mm² (YP355).

The still-water and wave-bending moments which need to be considered for the strength analysis always have a linear relationship with the ship’s breadth and a quadratic relationship with the ship’s length. Obviously, due to this physical relationship with the vertical bending moment, increasing the container capacity by an additional bay affects the steel weight much more than by introducing an additional row.

Consequently, for the longer variants with 26 bays, considerably more steel had to be placed in the upper deck area to fulfil the necessary section modulus requirement and this increased the steel weight and building costs.

However, this was not sufficient for the ultra-long variants with 28 bays and their structural arrangement had to be modified in the deck area. A second “strength coaming” on top of the sheer strake had to be introduced to fulfil the necessary section modulus requirement, see Figure 1.
Consequently, particularly for the variant with strength coaming, the neutral axis of the cross-section was shifted upwards and resulted in higher hull girder stresses in way of the double bottom. To maintain the use of steel with a yield strength of 355 N/mm² (YP355) in the bottom area, the plate thicknesses had to be increased here too.

To cater for additional stress components, e.g. double bottom bending, which are normally analysed during later stages of the design process using FEM-based methods, the section modulus at the outer bottom has been dimensioned with a minimum margin of 13% for all variants.

One option to reduce the weight of the longitudinal structures by about 4% would be to introduce steel with a yield strength of 390 N/mm² in the outer bottom in the mid-ship area. However, this introduces other challenges and would require further investigation.

Table 6 shows the described effects for selected variants.

Based on the mid-ship cross-sectional analysis, the deadweight of the variants in the parametric analysis discussed above was adapted.

When studying possible variations in draft, it was found that increasing the scantling draft from today’s 16 m to a possible future 17m only has a marginal impact on the steel structures.

<table>
<thead>
<tr>
<th>TEU</th>
<th>Bay</th>
<th>Rows</th>
<th>Bottom with YP355</th>
<th>Bottom with YP390</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moment or section modulus</td>
<td>Bottom thickness [mm]</td>
</tr>
<tr>
<td>20300</td>
<td>24</td>
<td>23</td>
<td>100%</td>
<td>24</td>
</tr>
<tr>
<td>22200</td>
<td>26</td>
<td>23</td>
<td>117%</td>
<td>28</td>
</tr>
<tr>
<td>23300</td>
<td>26</td>
<td>24</td>
<td>123%</td>
<td>29</td>
</tr>
<tr>
<td>26300</td>
<td>28</td>
<td>25</td>
<td>146%</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 6: Structural and weight characteristics
Conclusion
From a study carried out by DNV GL, it can be concluded that the next generation of ULCS can be designed, built and operated without major changes to the design concept/structural arrangement of present large container ships.

It appears likely that the beam will be increased to 24 rows in the next step, increasing the nominal capacity by roughly 1,000 TEU while keeping the fuel costs per TEU almost unchanged.

By increasing the maximum draft of the 24-row-wide ULCS from 16 m to 17 m, the deadweight capacity can be increased by about 10%, which increases the fuel efficiency - in particular for heavier containers.

If an even higher nominal capacity is required than a lengthening of the vessel by one cargo hold (2 bays = 26 bays in total), this would result in a TEU intake of about 23,300, with fuel costs per TEU reduced by roughly 4.5%. A general arrangement for such a concept is shown in figure 2.

The infrastructure of seaways and ports is not believed to impose barriers to this development that cannot be handled.

By increasing the beam to 25 rows and length to 26 bays, the capacity of a ULCS could reach 26,300 TEU. However, such a design would be restricted from entering a number of ports and would not be able to pass through the Suez Canal with its current restrictions in a fully laden state. This would also require a new structural design concept, introducing "strength coaming" on top of the sheer strake. That is why it is not likely that such a size of vessel will be ordered in the near future, even though it would promise another 3.5% reduction in fuel costs per TEU. A general arrangement for such a concept is shown in figure 3.
On 29 October 2015, a naming ceremony was held by Hudong-Zhonghua Shipbuilding (Group) Co., Ltd for an 8,888 TEU container ship built for OOCL.
The vessel, named Hu Chi Minh City, is the final one of a series of eight ordered from the shipyard by OOCL in the early 2000s. It is also the last of a long series of such container ships ordered from the shipyard by a number of liner companies since this ship type was successfully developed in 2003.

**Leading in the construction of container ships in China**

Hudong-Zhonghua has been a pioneer in the construction of container ships since the late 1990s and is now one of the leading container-ship builders in China.

By building container vessels of 1,700 TEU, 2,700 TEU, 4,250 TEU and 5,688 TEU successively in the late 1990s and early 2000s, the company has accumulated abundant experience of designing and constructing container ships and cultivated a great talent pool in this field.

“Hudong-Zhonghua’s container-ship-type development over a 10-year period was an epitome of the Chinese shipyards’ growth from small-scale to big, from weak to strong, and from learning to creation in the container-shipbuilding market,” says Mr Lou Danping, the Vice Chief Engineer of Hudong-Zhonghua.

“It should be noted that, in 2003, Hudong-Zhonghua started to research into and develop large container ships in cooperation with DNV GL and later on successfully created the innovative 8,530 TEU container ship. CSCL has ordered five of these vessels, while Greece’s Costamare has ordered one and OOCL has ordered nine. With the recent delivery of the latest newbuilding vessel, the long series of orders for this type of container ship placed at the industry peak time in 2007 has now been completed,” adds Mr Lou.

During the years of volatility in the world shipping market, Hudong-Zhonghua has carried forward its good traditions and
FACTS ABOUT OOCL

OOCL offers customers comprehensive coverage of east-west trade corridors, providing customer-centric solutions and one of the best quality services in the industry. Regular services connect Asia, North America, Europe, the Mediterranean, Indian sub-continent and Middle East. Regular loops to Australia and New Zealand complete our coverage in Asia-Pacific.

OOCL is a member of the Grand Alliance and G6 Alliance. With approximately 240 vessels providing operational efficiency and competitive service networks, the G6 Alliance offers comprehensive coverage in the Asia/Europe, Asia/Mediterranean, Asia/North America and Europe/North America trades.

OOCL’s extensive coverage of Asian ports is unmatched and we are renowned for being a leading container transport and logistics service provider for China.

Trend development in container-ship type

“Capacity turns out to be a key focus area for container ships because it directly decides the owner’s financial return. It determines the break-even point, especially when oil prices are high.”

Mr Lou Danping, Vice Chief Engineer of Hudong-Zhonghua

More large and specific container ships to be built in China

Container-ship newbuilding in China has shown an impressive growth rate over the last few decades. Mr Lou foresees that this growth will continue in the years to come. He points out that many Chinese shipyards have updated both the hardware and software at their facilities in recent years. “They are thus capable of building large and ultra-large container ships. They have also made substantial progress in design and building techniques. Some Chinese shipyards have won orders for mega vessels of 18,000-20,000 TEU which will further contribute to their proficiency in design and construction.”

The big ships require special technology for handling the special building materials, such as HT47 steel. Mr Lou believes the Chinese shipyards that take orders for mega container vessels must have already started their research into and application of materials and engineering techniques like welding. The greater demand for materials will drive domestic steelmakers to study and develop relevant products.

In parallel, some Chinese shipyards are dedicated to constructing small container ships, like shuttle ones. They are become more mature and specialized and are increasingly recognized by international ship owners.

By designing and building large and ultra-large container ships over a decade, China has provided products to most major container-ship owners across the world. As Chinese shipyards have accumulated experience of building mega ships, the building cycle has shortened and delivery competency has improved. “I believe more and more international owners will place their orders with Chinese shipyards. China will be one of the top options for owners building mega vessels and thus China will enjoy an even larger market share in this segment,” says Mr Lou.

“Capacity turns out to be a key focus area for container ships because it directly decides the owner’s financial return. It determines the break-even point, especially when oil prices are high.”

Mr Lou Danping, Vice Chief Engineer of Hudong-Zhonghua

Focused on innovation. By taking account of new characteristics in the operation and design of container ships, the company has developed 10,000 TEU, 13,500 TEU, 14,500 TEU and 20,000 TEU mega ships. CSCL has ordered four 10,000 TEU ships and COSCON has ordered five 14,500 TEU ships, again demonstrating the company’s market competitiveness in the design and construction of large container ships.

The company is fully capable of developing world-class large and ultra-container ships on its own thanks to its 20 years of experience in the design and construction of such ships. “Looking into the future, Hudong-Zhonghua will continue to optimize its present ship types and develop new mega ships to meet market needs and provide owners with new-generation, more advanced and environmentally friendly vessels. This will further consolidate the company’s dominant position in the design and construction of mega container ships,” says Mr Lou.

More large and specific container ships to be built in China

Container-ship newbuilding in China has shown an impressive growth rate over the last few decades. Mr Lou foresees that this growth will continue in the years to come. He points out that many Chinese shipyards have updated both the hardware and software at their facilities in recent years. “They are thus capable of building large and ultra-large container ships. They have also made substantial progress in design and building techniques. Some Chinese shipyards have won orders for mega vessels of 18,000-20,000 TEU which will further contribute to their proficiency in design and construction.”

The big ships require special technology for handling the special building materials, such as HT47 steel. Mr Lou believes the
"But I think the present 20,000 TEU vessel is big enough. The decisive factor for whether the container ship scantling will become even bigger is, of course, the economy, because larger box ships need larger and more stable cargo flows. As the world economy slows down, container volume growth is also being cut, so container ships will not become much bigger very quickly.

"Besides, the facility limits, such as the port capacity, crane workload, etc., and the clearance conditions of fairways and bridges will constrain the expansion of container ship size."

The impact of the EEDI on container ships is much less than for other types of vessel. To meet the EEDI requirements, all research institutes and shipyards should strengthen their studies of energy-saving solutions. However, these are conventional methods and have a very limited effect in the current circumstances of increasingly improved ship performance.

"We need a breakthrough in technology and materials that can substantially improve the energy savings and emission reductions. I believe in applying new energy, such as LNG," stresses Mr Lou.

FACTS ABOUT HUDONG-ZHONGHUA

With a shipbuilding history going back over 80 years, Hudong-Zhonghua is a core enterprise in the China State Shipbuilding Corporation (CSSC). It has an annual shipbuilding capacity of over 2.2 million tons and an annual turnover of 19 billion RMB. Over the years, Hudong-Zhonghua has built more than 3,000 vessels of various types and made breakthroughs in many fields in China.
Maersk Line has placed the largest ever order for DNV GL’s ShipManager software and is implementing it at a very ambitious rate.

Maersk Line, the world’s largest container shipping company, has chosen to implement DNV GL’s maritime software solution ShipManager on its owned fleet of 275 vessels. By April 2017, nine legacy applications will be replaced by one and 8000 Maersk employees will be using ShipManager around the world. At a DNV GL Software seminar held in Hamburg recently, Sebastiaan Van den Wijngaert, Senior Project Manager at Maersk Line IT, spoke to Container Ship Update about why Maersk Line chose the DNV GL’s software and what challenges the company has faced during the implementation phase.

Choosing ShipManager
Recent and upcoming regulations were a key motivation for choosing a new Ship Management system, Van den Wijngaert explains. “We chose an off-the-shelf solution, because we wanted to move away from too much customization and ensure that our application lives up to the industry standard and benefits from regular updates.” Maersk Line will be using five integrated ShipManager modules: Technical, Procurement, Project (dry docking), QHSE, and Analyzer.

An additional factor was that ShipManager packaged all necessary processes into one system. “Our seafarers really appreciate this, as it simplifies their work and it makes on-boarding people easier,” he says. Previously Maersk Line used nine applications to manage core ship management processes. “Our old legacy applications were not fully integrated, required a high degree of manual data transfer between applications, and there were divergences between what ship crews and on-shore staff would see on their screens. That needed to change,” he adds.

The Analyzer Module will improve reporting on factors such as compliance, safety, maintenance, and spend per vessel. “The module uses data collected by the ship owner, such as information about technical maintenance, procurement, and QHSE (quality, health, safety, and environment) and enables the customer to benchmark a vessel against others in their fleet, in order to make more informed business decisions,” explains Rune Lyngaas, Head of Product Management Maritime Software at DNV GL – Software. “The Analyzer holds great potential for our business, as it will give our fleet managers a level of transparency they never had before,” Van den Wijngaert adds.

A solid roll out process
The roll out for the project is ambitious. After starting with an implementation-quota of ten vessels per month, Maersk Line decided to speed up the process even further as the designed roll out process proved to be working very well. 42 ships have been completed so far, 15 of those in October alone. With a target of equipping 65 vessels by the end of the year, the members of the Maersk Line roll out team really have their work cut out for them. The Maersk Line project team includes 30 specially trained seafarers, who travel from ship to ship, staying for three weeks to install the software correctly, check for synchronization issues, and
train the vessel crew in using ShipManager. To ensure it all runs smoothly, Maersk Line is also carrying out quality assurance checks throughout the implementation phase.

“We are very happy with our current progress. We are constantly optimizing our data extraction, adaption and migration, and updating our installation package as we go along,” Van den Wijngaert says. The greatest challenge he is facing in the project is managing the data migration.

The data volumes are immense. The entire Maersk Line fleet represents more than 1.8 million components of technical management data that needs to be extracted from the Maersk Line system and imported into ShipManager. “We carry out a complex analysis for every single vessel, as no two ships in the Maersk Line owned fleet are exactly the same. Even sister ships only have about 90% of elements in common due to replaced equipment of a different type or changes to the vessel design,” Van den Wijngaert explains. Every nut and bolt, piece of equipment, and each repair or paint job needs to be considered to get a full picture of a vessel - that amounts to about 100,000 elements per ship. “Previously, this data was stored in an older application, where the data structure was not kept fixed over time, resulting in a complex and inconsistent structure. Thankfully we have found a way of unravelling it,” he adds.

“The so called ‘Master Vessel’ concept is a way for us to make sure that we can introduce each of the vessel’s elements into the fleet equipment register,” Van den Wijngaert explains. The Master Vessel is a virtual twin of all ships within a vessel class that feeds all elements and equipment into the data migration tool. This tool contains essential information for the construction of the final ShipManager vessel kit installed on board. Maersk Line is close to automating Master Vessel creation – this will enable them to considerably speed up the process for creating vessel kits (ship specific installation DVD or USB-stick, containing the ShipManager application and database).

Cooperation on improvements

“DNV GL has been very cooperative and proactive in developing a number of enhancements to close functional gaps that still exist in areas such as procurement and technical management,” Van den Wijngaert states. “We have learned a lot from each other during the course of this project and will continue to do so as we go ahead,” he adds.

Maersk Line and other key customers teamed up with DNV GL to develop a new risk management module for ShipManager, which was released this summer. “The new Risk Management tool helps ship owners to manage and reduce the risks the crew are exposed to every day, by sharing best practices across the fleet”, explains Lyngaas. For Maersk Line, the implementation of the new Risk Management module on their vessels is another step toward completing the replacement of their legacy applications with ShipManager. ■
In 2008/2009, when fuel oil prices rose dramatically, shipping companies became aware that the traditional way of optimizing ship hulls for only one draught (design draught) and one speed (contract speed) was no longer acceptable. This yields true in principle for all types and sizes of ships, but it became most obvious for container vessels, which started to operate at much lower speeds than before (“slow steaming”) and at smaller draughts (“partial loading conditions”) than they had been designed for due to tonnage over-capacity in some segments.
The need for optimization along a specified speed and draught range ("operational profile") is widely accepted among experts today and especially the large container ship owners consistently follow this approach. However, this is still a kind of "hydrodynamic only" based approach and does not consider the interaction with deadweight or stability issues. This "hydrodynamic only" based approach means that we minimize the fuel consumption (the cost side) while keeping the deadweight and stability unchanged (the money-earning side).

Sometimes, attempts have even been made to further reduce the fuel consumption by reducing the deadweight and/or stability. But does this approach really lead to the most economic design possible?

We at DNV GL Maritime Advisory strongly believe it is time to take a broader view of the optimization process and minimize not only the fuel consumption, but also the fuel consumption per transported cargo ton of each container vessel in order to minimize the fuel consumption per transported container.

With the Concept Design Assessment (CDA), we offer a new service to improve the starting point of a new design. The purpose is to find the most favourable main dimensions to minimize the costs per transported container for a given operational profile and specific cargo mix.

- For a given ship size, specify typically three length/breadth variations to be investigated.
- Select a range of block coefficients ($C_B$) to be investigated too.
Perform the loop over the selected main dimensions and block coefficients, estimate the lightship weight and centre of gravity, predict speed-power curves for the operational profile and assess the stability and maximum number of loadable containers for a range of container weights (8t/TEU to 16t/TEU).

Calculate the average power demand according to the specified operational profile.

Calculate the average number of loadable containers for a specified cargo mix.

Select the combination of main dimensions and block coefficients with the least power demand in \([\text{kW/TEU}]\) for the specified operational profile and cargo mix.

The whole process is largely scalable. For a rough estimate, all the parameters needed for the assessment can be derived from empirical formulas. Or, for a more sophisticated look at the interdependencies, a hull shape can be transformed from a parent hull form so that the container slots can be counted and CFD-supported power predictions can be made instead of using empirical methods. The intact and damage stability can be directly calculated using a simplified geometry model of the hull, holds, rooms and tanks instead of using GM limit curves from similar ships for a stability assessment. Preliminary mid-ship sections can be designed for each variant and used for a more accurate estimation of the weight of the steel and lightship instead of using empirical formulas. For the most promising concepts, a formal optimization process for the hull shape can also be included in the scope of work.

Despite a number of commercial projects where the Concept Design Assessment (CDA) has already helped shipping companies to decide on the most suitable main dimensions for their newbuilding projects, DNV GL undertook an internal study for a new 11k/12k container vessel development project.

The 11k/12k container vessel project

For the 11k/12k container vessel, the following variants have been investigated:

- Length/breadth variants: “19 bays 19 rows”, “18 bays 20 rows” and “17 bays 21 rows”.
- Block coefficient variants: \(C_B=0.66, 0.68, 0.70\) and \(0.72\).

The average power demand per container has been determined for an assumed speed profile, and corresponding plots nicely show the effect of the average container weight and the block coefficient on the performance of each design concept.

Conclusions for the 11k/12k container vessel project:

- For a homogenous container loading of 8t/TEU, the short and beamy concept with 17 bays and 21 rows in combination with the lowest block coefficient \(C_B=0.66\) is beneficial.
- For a homogenous container loading of 10t/TEU, the short and beamy concept with 17 bays and 21 rows is still the preferred concept, closely followed by the concept with 18 bays and 20 rows. The optimum block coefficient is \(C_B=0.68\).
- For a homogenous container loading of 12t/TEU, the three length/breadth concepts achieve almost equal performance, with a small advantage for the variant with 18 bays and 20 rows. The block coefficient should be in the range \(C_B=0.68\ldots0.70\).
- For a homogenous container loading of 14t/TEU, the long and narrow concept with 19 bays and 19 rows is the preferred concept. The block coefficient should be in the range \(C_B=0.68\ldots0.70\) or even slightly larger. This is what is typically designed and built today.
- For a homogenous container loading of 16t/TEU, the long and narrow concept with 19 bays and 19 rows is again the preferred concept. The highest block coefficient investigated here is beneficial - \(C_B=0.72\).

Note: The optimum main dimensions strongly depend on the ship size and the expected operational draught and speed profile. The above findings should not be used for other projects if not verified carefully.  

Concept design examples

Length/breadth variants: “19 bays 19 rows”, “18 bays 20 rows” and “17 bays 21 rows”.

Block coefficient variants: \(C_B=0.66, 0.68, 0.70\) and \(0.72\).

Perform the loop over the selected main dimensions and block coefficients, estimate the lightship weight and centre of gravity, predict speed-power curves for the operational profile and assess the stability and maximum number of loadable containers for a range of container weights (8t/TEU to 16t/TEU).
THE NEW DNV GL RULES:

THE WELL-KNOWN CLASS STANDARD PREVAILS

Our world-leading class standard for container ships is being brought forward. The know-how and experience of both legacy rules are incorporated into the new DNV GL rules published in October 2015. It has also been enhanced with the latest research and innovation. The technical platform is now state-of-the-art in the industry.
Harvesting from the operational experience
With about 40% of all container ships in service today classed by DNV GL, the experience we gain through supporting their operation constitutes an unrivalled knowledge database. This experience is continuously applied in the development of our rules.

In connection with the development of the new DNV GL rules, we launched a research project were we performed a thorough statistical review of our fleet. The aim of this project was to identifying possible areas where the rules could be further improved. More than 3,000 ships in service were closely monitored, looking for design-related defects. Typical defects and their frequency of occurrence were studied, and the know-how achieved was worked into the new rules.

The extensive operational know-how and understanding enables us to accommodate for container specific issues. Our structural assessment is based on a unique set of standard loading cases that can widely cover realistic loading patterns. Thereby, ship owners and operators can be ensured that their vessels will deliver the necessary flexibility in their day-to-day business. Our customers can benefit from additional class notations covering container ship specific needs, such as RSCS, allowing for Route Specific Container Stowage, and SafeLash, documenting compliance with the CCS code.

Industry involvement
It has been an ambition to develop a unique rule set meeting the needs and expectations in the maritime industry. Stakeholders have been involved throughout the development and implementation phases. Leading ship yards, designers, manufacturers and ship owners world-wide have contributed more than 2,000 comments as well as constructive criticism, enhancing the quality and relevance of the rules.

A new and improved technical foundation
The introduction of Equivalent Design Waves (EDW) marks a significant change in the way dynamic loads are calculated in the DNV GL rules. The new advanced load concept is a major step towards a more realistic and accurate representation of the environmental loads.

Along with our state-of-the-art capacity models, this concept will increase the consistency in the safety level applied for the complete hull structure. In addition, this approach will also accommodate challenges related to the development of innovative designs.

This provides a foundation for an ideal distribution of structural strength, ensuring every ton of steel is used efficiently.

A total review and update
The development of the DNV GL Rules gave us an opportunity to perform a total review of the complete rule book, and to look at how the rules are structured. We have grouped the rules in a logical sequence, complementing a typical design process. This makes it easier to navigate and find what you are looking for. To give shipyards and designers starting out on a new project an easy entry point, all container ship specific requirements can be found in one place. (Part 5, Chapter 2). This chapter covers important aspects of container ship design, with special focus on hull structures and container stowage/securing.

New IACS Unified Requirements for Container Ships
The International Association of Classification Societies (IACS) has revised the longitudinal strength standard for container ships (UR S11a), and added unified requirements to load cases for strength assessment for container ships (UR S34). These requirements are incorporated in the DNV GL rules for container ships from January 2016, and may be applied on voluntary basis until entry into force July 2016.

For Post-Panamax container ships (Breadth>32.26 m), UR S11a requires the effect of whipping to be considered in the strength evaluation in accordance with individual classification societies’ procedures. DNV GL has established a simplified and efficient procedure for this, which is incorporated in our rules. Optionally, more advanced methods are supported by our voluntary WIV (Wave Induced Vibration) notation and class guideline. These methods and procedures provide a more accurate prediction of the whipping effect, thereby giving increased accuracy and consistency in the applied safety factors.

For more information and access to our new rules, please visit our website https://www.dnvgl.com/dnvglrules
Container ship designs that comply with DNV GL class rules have been assessed against wave-induced vibration criteria for a number of years. However, there is a need to make the outcome of these assessments more accessible to all interested parties in the industry. This is achieved through the class notation WIV, which is assigned to ships that have been designed to include the effect of Wave Induced Vibrations (whipping and springing) for both fatigue and ultimate loading.

The methods and procedures are stated in the DNV GL Class Guideline CG-0153 Fatigue and ultimate strength assessments of container ships including whipping and springing for DNV GL classed ships, and in Classification Note 30.12 for DNV or GL classed ships.

The voluntary WIV notation is part of the Class Rules and refers to the above-mentioned class guideline and classification note.

The procedure for obtaining the WIV notation contains a two-level approach:

- Level 1 offers assessments based on empirical factors which represent an increase in the wave-bending moment for ultimate and fatigue loading.
- Level 2 is based on further numerical analyses or model tests, which are regarded as necessary if any parameter such as the ship speed, length, beam or bow flare exceeds certain limits.

Level 1 provides a quick-and-easy estimate based on the data gained from hull monitoring systems installed on DNV GL container vessels.

Level 1 provides a quick-and-easy estimate based on the data gained from hull monitoring systems installed on DNV GL container vessels.

A direct Level 2 analysis gives a refined picture of the hydrodynamic loads, including wave-induced vibration effects computed using validated and tested numerical tools. Unlike the empirical estimate, the computational approach takes into account the individual vessel’s hull shape, loading patterns and available propulsion power.

While essential aspects of wave-induced vibrations are captured in the DNV GL rules for container ships anyhow, the WIV notation offers a ship-specific approach to document that dedicated calculations for wave-induced vibrations have been carried out.

Following the accidents involving the MSC Napoli (2007) and MOL Comfort (2013), there has been concern in the industry as to the effect of whipping on the global strength of container ships. The official reports on both accidents indicate that the buckling failure of the structure was the main reason, but that the acting bending moments were influenced by whipping effects. The size of the ships in these accidents differ quite a lot as does the area of structure collapse.
WHIPPING - SIMULATION

Wave-induced hull vibration for the assessment of hull girder collapse characteristics. DNV GL has developed a computational approach that takes into account the individual hull shape and propulsion power and is seamlessly embedded in the structural design process.

Background
It is well known that hull girder vibration induced by bow slamming impacts, so called whipping, may considerably increase the still-water and wave-bending moments acting on the hull girder. This is most critical for hogging hull deflection patterns when the double bottom is exposed to high compressive stresses. If these exceed the buckling capacity of some shell or double bottom plating, this may trigger the progressive collapse of larger structures and, ultimately, of the whole hull.

Conventionally, the amplification of structural stresses due to whipping is covered by implicit safety margins in the design rules. However, this has become questionable in view of the rapid development of new container ship designs. Many ship owners are concerned about whether their ships are strong enough to withstand loads associated with severe and violent sea conditions. Large and ultra-large container carriers are the focus of these concerns because of their exposure to very high slamming loads.

Analysis concept
DNV GL developed the computational approach under the premise that the deadlines for the submission of the final key structural drawings for plan approval and steel ordering must not be delayed by the extensive required computational times. This was accomplished by computing the extreme whipping loads and ultimate hull girder capacity in parallel to conducting the strength analyses typical for large container vessels.

Whipping involves highly nonlinear effects and thus requires the application of high-fidelity numerical methods. DNV GL uses CFD, based on the numerical solution of the Reynolds-Averaged Navier-Stokes (RANS) equations, combined with the simultaneous...
calculation of ship motions and deflections. This is the most accurate numerical method available today, and allows the explicit definition of hydrodynamic loads without the need for ad-hoc models or additional safety margins.

Loads due to slamming and consecutive whipping strongly depend on the forward speed of a ship. Assuming a constant speed is unrealistic, particularly for whipping loads: it is excessively conservative in severe sea conditions (where the ship cannot maintain such a speed) but too non-conservative in moderate conditions (when the ship may sail at a higher speed). DNV GL’s approach accounts for involuntary speed reduction due to added resistance in waves, based on the vessel’s individual hull shape and propulsion system and defined individually for each sea state.

**Predicting slamming is not a trivial task**

The use of CFD is already widely accepted for hull resistance predictions, and there is growing interest in its application for seakeeping and load analysis. The inherent supremacy of CFD for wave impact load analysis is due to the implicit account taken of strongly nonlinear effects: wave breaking, splash and green water effects are directly computed and do not need ad-hoc models or empirical calibrations.

DNV GL has pioneered developments in this field and has routinely used CFD for wave load predictions for more than a decade. This has required significant work to couple CFD solvers with ship motions and flexible deformations so that the interaction of fluids and structures is part of the computed solution. Many years of experience in using coupled solvers in whipping analyses and extensive validation work result in strong confidence in our results.
What differentiates the DNV GL approach?

Thanks to substantial research and practical experience, DNV GL is able to offer a unique hydrodynamic assessment procedure, combining the ship- and sea-state-specific maximum achievable ship speed, high-fidelity CFD methods and a comprehensive nonlinear statistical analysis concept.

Unlike widely used simpler approaches to estimate extreme loads, the DNV GL method accounts for all sea state conditions the vessel might encounter. This includes not only extreme sea states at slow sailing speeds but also moderate seas, when strong slamming impacts can be induced due to high ship speeds. This allows the whole wave scatter table to be covered so that the effect of wave-induced vibration on load amplification can be accurately predicted.

Assumptions and simplifications, unavoidable in any theoretical analysis, are made on the safe side. The wave climate of the North Atlantic is used according to IACS Rec. 34, without including weather routing effects. The 100% still-water bending moment and 100% wave-induced bending moment are summed up without any reduction factors, although such a combination is extremely unlikely to occur. Moreover, the maximum achievable speed in the seaway is used in the analysis, i.e. voluntary speed reduction is ignored. Further assumptions concerning the wave heading distribution and the dependency of whipping loads on the wave heading are on the conservative side.

Although the procedure is on the safe side, several commercial projects have proven that the results agree with design experience and are not overly conservative. This is important to note as any unexpected results may lead to additional design loops.

The way ahead

By statistically evaluating AIS data in combination with weather hind-cast data, DNV GL confirmed that severe storms are typically avoided by ship masters through routing. Such statistical observations combined with the enhanced use of hull monitoring systems will enable more realistic assumptions about the environmental and operational conditions a vessel will experience during its service life. This represents the basis for the continuous adaptation of DNV GL’s design rules and methods to take account of technological developments.

Sea states in which a large container vessel is at high risk of severe whipping

CFD simulation of slamming event; free surface (left) and bow pressure distribution (right)
Although the statistics available to the public do not seem to be complete, there are signs of an increasing number of cases where container vessels are involved in serious fire incidents. The size of container ships has more than doubled during the last decade but very little improvement has been seen in the onboard fire-detection and firefighting systems. Additional requirements are now being introduced for new ships, but more could be done.

FIRE SAFETY OF CONTAINER SHIPS
- AN AREA OF CONCERN?
Container vessels have increased in size dramatically during the last couple of years - the average ship size has doubled from about 1,700 TEU in 2000 to about 3,600 TEU in 2015 and the size of the largest container ship in the market has increased from 9,500 TEU in 2000 to almost 20,000 TEU in 2015.

During the same period, container vessels experienced a total of 143 casualties involving fires on board.

About half of the fires, a total of 56 cases, occurred in the cargo area, ref. figure 2.

Another data source is CINS – Cargo Incident Notification System (www.cinsnet.com), a shipping line initiative launched in September 2011 to increase safety in the supply chain, reduce the number of cargo incidents on board ships and highlight the risks caused by certain cargoes and/or packing failures.

Unfortunately, no detailed statistics are available to the public from CINS but Lloyds List stated the following in an article about a fire on board the MV Eugen Maersk in 2013: “New information from the Cargo Incident Notification System group, which compiles data covering cargo-related incidents, shows that its 14 members reported 29 on-board fires or explosions last year [2012].”

Considering that CINS members represented roughly 50% of the world’s liner capacity in 2012, it can be assumed that the total number of fire accidents could have been twice as high (almost 60) if all cases had been reported.

If we compare this number with data from IHS Fairplay, according to which only seven cargo-related fires on container ships were reported for 2012, we see a substantial gap - it can be concluded that roughly only 10% of the total number of fire & explosion incidents become known to the public!

In general, it can be seen that the number of fire accidents on board container ships is increasing.

This can partly be explained by the growing number of container ships (2000: 2,600 ships, 2015: 5,000 ships) as well as by the strong growth in the number of containers transported. However, there is also concern that there are other factors to be considered, e.g.

- The high rate of wrong declaration of DG cargo, leading to wrong handling on board. According to CINS, misdeclared cargo played a role in about 24% of the cases involving “fire and explosion”
- The present rules and regulations which set the standard for fire safety on board may not have been developed at the same speed as the vessel size

The relevant mandatory rules which address fire safety on board container ships are:

- SOLAS Ch. II-2, Fire protection, detection and extinction during ship design and construction
- FSS (Fire Safety Systems) Code, requirements for the design and approval of fire safety systems

![Figure 1: Number of fire accidents on container ships per year](source)

![Figure 2: Number of fire accidents in the cargo area of container ships per year](source)
SOLAS II-2, Reg. 19, Provisions for the carriage of dangerous goods in packaged form in the hold and deck of container vessels
IMDG Code, Packing of DG in packaged form and stowage/separation of containers on board

In addition, class may provide additional class notations, providing support to owners and yards that build vessels to higher fire safety standards, e.g. DNV GL’s F-AMC notation.

DNV GL has carried out a number of studies and initiatives over the last couple of years, identifying possible improvement areas and trying to enhance both international rules and standards and its own rules.

- 2009 – GL study “Review of fire protection requirements for on deck cargo areas, FSA - Container fire on deck”, work carried out for the German flag authorities which led to a German submission to IMO FP 54/INF.2 on 11 December 2009

Within this formal safety assessment, fire incident data have been analysed and 25 Risk Control Options (RCOs) have been identified and evaluated by a team of experts. Of these, the following eight measures were found to be the most promising:

- Water screens between container bays
- Water monitors between container bays (with height accessibility)
- Water film for hatch cover
- Mobile water monitors
- Water mist lance
- Detection plus water connection in each container containing dangerous goods
- Container containing dangerous goods with autarkic detection and fire-fighting
- Fire insulation for deck house

A cost-benefit analysis was conducted on these prioritised RCOs - for either individual measures or selected combinations.

In conclusion, a recommendation was proposed to require mobile water monitors and water mist lances for new container vessels in the future.

After lengthy discussions, IMO finally introduced new SOLAS requirements for container vessels that were keel-laid after 01.01.2016, requiring the carriage of two or four (depending on the ship’s size) mobile water monitors as well as a water mist lance, which may be used to penetrate the wall of a burning container in order to flood it with water, both in connection with an upgraded capacity of the fire main line.

It is believed that these measures will have a positive impact on firefighting capabilities on new container ships. However, there are a lot of other issues & new developments which need to be looked into in order to further improve fire safety on board container ships, such as:

- Fire prevention and emergency preparedness
  - Improve the quality of the declaration of (Dangerous Goods) containers
  - Efficient checking of the availability and effectiveness of the fire detection and extinguishing systems on board
  - Realistic onboard fire drills
  - Subscribing ships to an ERS (Emergency Response Service)
  - Conduct regular ERS exercises
- Fire detection
  - Smart Box technology could be used for monitoring the temperature and O$_2$/ CO$_2$ content inside the container during a sea or total voyage
  - Electronic temperature sensors/fixed installation at every container position in the hold
  - 360-degree thermoscanner
- Fire extinguishing
  - New mobile and fixed fire monitors and pumps, not only for new ships
- Managing a fire accident
  - Interaction with salvage companies
  - Area of refuge
  - Fire-incident cleaning procedures and experts

DNV GL will take these matters up with the industry and any input/suggestions would be appreciated.
DATE is an online service for customers and surveyors, providing expert knowledge where and when it is needed. He has with him in Houston three other specialists covering six disciplines. “We handle most of the questions in our group and, if we can’t, we know who to contact. We often call the specialist in question directly, thus reducing the response period for time-critical questions.

EXPERTS ON LINE 24/7

“We work 24/7 around the globe and can answer time-critical questions within four hours,” says an enthusiastic Jan Solum in Houston. He was instrumental in setting up the DATE support hub in Houston early this year. “This has a huge potential for our customers. We’ve increased the number of cases handled monthly so far in 2015 from 1,000 to more than 2,500,” continues Jan, who used to be a master mariner.

“We work in a network of five support hubs - in Hamburg, Høvik (Oslo), Houston, Singapore and our latest addition Piraeus, which opened in September this year. We cover all time zones and all the cases we work on are available to all case handlers in the DATE system, so that a case can start in one hub and be completed and conveyed to customers in another.”
DATE – DIRECT ACCESS TO TECHNICAL EXPERTS

Certificate issues - Postponements - Survey requirements - Evaluation of repair proposals - Class and statutory rule interpretations - Minor alterations

DNV GL now provides a new service where our customers are invited to contact our technical experts directly. All owners and operators of DNV GL classed vessels may use DATE. You may ask any relevant technical question regarding your vessel!

Better Response Faster
DNV GL has established a new technical support setup with the pool of experts located in Hamburg, Oslo, Singapore, Piraeus and Houston. All offices are working together as a single point of contact and you will experience seamless cooperation between our experts. Requests are normally answered within one working day (24 hrs).

Contact
- Send your questions on email to date@dnvgl.com
- Register a case through My.DNVGL.com

Your dedicated DNV GL contact remains in the loop. You are welcome to contact them, they will still be available to you. They are the right persons to contact for issues other than those listed above.

DATE (Direct Access to Technical Experts) is the gateway to more than 400 technical experts in DNV GL Maritime. Our customers get direct access to the same technical experts that assist our own surveyors in the field. The Key Account Manager is still the dedicated contact person in the DNV GL organization, so DATE is a supplement to enhance the service to our customers. Now you can contact the technical expert directly.

The questions supported by DATE are certificate issues, postponements, survey requirements, repair proposals, class and statutory rule interpretations and minor alterations. It may be accessed via your local DNV GL contact who can put your question into the DATE system, or you can ask yourself directly via the ‘My DNV GL’ customer portal for all DNV GL customers.
SUCCESSFUL SURGERY

In an unprecedented endeavour, the ship manager Reederei NSB is widening its Panamax-class container vessels. DNV GL, the class in charge, is on board.

Too young for scrapping, too old to compete: Roughly 500 Panamax-class container ships are currently less than ten years old, barely half their useful life. But facing overcapacities, low charter rates and fierce competition, the Panamax class is under intense pressure. Compared with state-of-the-art and much more capacious newbuildings, its prospects are dim.

This is mainly due to the way these vessels were designed. To pass the old locks of the Panama Canal, they were built with unusual dimensions - long and thin and with a large amount of ballast water to compensate the poor stability. “In addition, Panamax ships are equipped with stronger engines that achieve their highest efficiency when operating at higher speeds, rather than slow steaming, which is more common today,” says Marcus Ihms, Ship Type Expert for Container Ships at DNV GL – Maritime.

So shipowners try to make their fleets more competitive by undertaking minor and major ship conversions (see below). Reederei NSB of Buxtehude, Germany, is causing quite a stir with the idea of widening three of its Panamax container vessels: MSC Geneva went back into service in July of this year after undergoing the procedure, her sister ship MSC Lausanne was delivered in late October, and MSC Carouge should be completed by the end of January 2016. “No one has ever cut a container ship lengthwise from the superstructure to the bow to widen it,” says Tim Ponath, Chief Operative Officer of Reederei NSB. “We are very proud of our team who demonstrated the viability of our concept.”

Innovative and technically sophisticated, this concept was developed jointly by NSB and the Hamburg-based Technolog GmbH. After separating the fore and aft body from the cargo hold in dry dock, the cargo hold is cut in half lengthwise and pulled apart. The new centre sections are inserted and connected to the existing part. “The main idea behind this innovative method is cutting the hull in the least stressed areas and significantly increasing both the container intake and stability by widening it,” says Lutz Müller, Senior Technical Consultant at NSB and one of the key initiators of the project.

Providing guidance

The conversion is carried out by Huarun Dadong Dockyard (HRDD), China. DNV GL, the classification society in charge of the ships, was involved from the early stages. “This is a major conversion project,” emphasizes Ihms. This means that all classification and flag state rules in effect at the time of conversion have to be observed. It is important to discuss with the flag state and the class, what rules must be adhered to under all circumstances, and what parts of the ship can be handled according to existing standards rather than new requirements.

“Our Class Note for Conversion of Ships provides the necessary guidance to owners as well as engineering companies during the design phase,” Ihms points out. For example, in the case of MSC Geneva and her two sister ships, the anchor equipment had to be adapted, as a widened ship is heavier and offers more resistance.

<table>
<thead>
<tr>
<th>Original ship</th>
<th>MSC GENEVA</th>
<th>After conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length overall in m</td>
<td>275.0</td>
<td>283.0</td>
</tr>
<tr>
<td>Breadth in m</td>
<td>32.2</td>
<td>39.76</td>
</tr>
<tr>
<td>Nom. container intake TEU</td>
<td>4,872</td>
<td>6,296</td>
</tr>
<tr>
<td>Energy Efficiency Transport Index (EETI) at 19 kn/(14 t TEU homogen. x 1,000 nm)</td>
<td>59.4</td>
<td>44.9</td>
</tr>
<tr>
<td>Fuel oil consumption per container; per day in kg/(day*TEU)</td>
<td>27.1</td>
<td>20.1</td>
</tr>
</tbody>
</table>

1) ISO cond., LCV 40 MJ/kg, m kg/(TEU*nm)
A stately lady, the widened MSC Geneva now boasts a 30% higher TEU capacity at the same operating costs.

to wind. “According to our well proven method, additional chain lengths can provide more holding force. Thereby, the retrofit of the entire winch system can be avoided without jeopardizing the anchoring capability,” Ihms reports. From anchor equipment and ship strength and stability through to statutory compliance and cargo lashing, close collaboration between all project stakeholders was crucial for the success of this world premiere.

Added benefits
A conversion adds up to four container rows to the cargo hold, increasing the container capacity by about 30%. In addition, it improves engine efficiency when combined with an optimized propeller, and bolsters stability. “Stability increases exponentially when you widen a ship,” Ihms explains. As an added benefit, the required ballast water per loaded container could be reduced by half. The IMO Energy Efficiency Design Index (EEDI) achieved will equal that of a newbuilding and meet EEDI regulations as per 2025. The life-extending surgery will pay for itself within four years – so in the end it has all been well worth the effort, Ihms assures.

Options for minor and major conversions
A changed economic environment calls for measures to make existing container tonnage originally designed for different operating conditions more competitive.

A number of options are available:

Increase the draught
Increasing the draught, and thereby the deadweight, will allow the ship to take on more weight per container. Strength and stability considerations, the resulting visibility line and the location of pilot doors must be accounted for.

Heighten the deckhouse
A taller deckhouse will increase deck container capacity and improve the line of sight at the same deadweight. Appropriate lashing bridges and innovative methods to determine the cargo securing help to fully utilize the benefits.

Upgrade the lashing bridges
Installing lashing bridges or heightening existing ones improves stowage performance. This is often combined with a hatch cover upgrade to enlarge the stackweight. Structural re-approval of the substructure is necessary.

Lengthen the ship
Often combined with lengthening, this complex conversion means cutting the ship apart lengthwise to add a new centre line section. The cargo capacity and performance is boosted substantially.

Widen the ship
Often combined with lengthening, this complex conversion means cutting the ship apart lengthwise to add a new centre line section. The cargo capacity and performance is boosted substantially.
NEW VERSION OF ECO INSIGHT

DRAWS ON USER FEEDBACK TO BOOST FLEET PERFORMANCE

DNV GL has published the latest release of its fleet performance solution ECO Insight. Drawing on the feedback from a rapidly growing user community, this update incorporates several new features designed to give the user even more features and analytical decision support than ever before.
“One of the benefits of having such a rapidly growing user community is that we are always getting new ideas and input from our customers,” says Dr Torsten Büssow, DNV GL’s head of fleet performance management. “There has been a very positive response to ECO Insight in the market with more than 400 vessels having signed up since January this year. But what has been even more exciting is the engagement of our customers. They are continually looking to innovate, even within our solution, and we are happy to work with them to meet their needs. This new version is the direct result of their input and feedback.”

The new version of ECO Insight now offers several major new features, including:

- A complete satellite weather feed allowing the user to compare reported with measured weather.
- Automatically generated PDF reports to be send periodically to predefined recipients, e.g. the crew can in this way get a performance comparison against sister vessels to see how and why they are performing differently.
- Additional speed consumption baselines, alongside the existing speed power, engine or market segment baselines, can be inserted to reflect significant benchmarks, for example: the terms of the charter party, post dry dock status, or the sea trial.
- A complete fuel consumption simulation depending on speed, draft and trim of the vessel allows fuel oil consumption predictions for planning purposes.

A host of additional features and analytics, such as displaying hull degradation now also as speed loss, are part of the release. All users will get an automatic update of the solution today without further user effort.

DNV GL’s performance management portal ECO Insight provides a comprehensive and easily accessible way to manage the performance of a fleet, including voyage, hull and propeller, engine and systems and fuel performance. It enriches customers’ own fleet reports with industry data, such as Automatic Identiication System (AIS), satellite weather, or fuel quality, and provides unique benchmarking capabilities. Advanced engineering methods, for example hull fouling prediction and vessel baseline normalizations based on CFD, are also packaged into the portal.

Navigator Insight ensures high quality data collection on board through smart plausibility checks against specific vessel particulars. The solution taps into existing data collection processes on board, so there are no changes required to existing procedures. There is no hardware investment needed and the solution can be implemented in only eight to twelve weeks for a complete fleet. Optionally, it also covers environmental reporting standards such as CCWG, ESI, CSI and the upcoming MRV.
RAISING THE AIS DATA TREASURE

IT experts call it data mining: the art of extracting highly specific and meaningful information from large stores of business data. AIS ship position data harbours enormous potential for decision-makers across the industry.
Around the world, more than 400,000 ships are equipped with Automatic Identification Systems (AIS), which transmit ship identification, position, speed, draught and dimensional data to shore via satellite at regular intervals. These AIS transponders allow accurate tracking of ship movements around the world. Far beyond the original idea of improving navigational safety and security at sea, this information can be used for a multitude of purposes.

Powerful computers and business intelligence software open up a vast array of new uses for AIS information. In many industries, data mining technology, which searches a company’s stored business data for key information to support strategic decisions, has become an indispensable means of understanding the behaviour of customers, supply chains and competitors. Today’s big data processing capabilities make this technology even more attractive.

In fact, AIS data mining has the potential to become a fundamental game changer for the shipping industry.

**High visibility**

Equipped with AIS data, an electronic map and a set of GPS coordinates to identify ports, quays, emission control areas, etc., ship operators can track vessel routes and speeds over ground in near real-time or estimate arrival times at the respective next port of call. Cargo owners looking for available ships or status information on chartered vessels can obtain snapshot overviews of ships in port or in certain regions, and visualize cargo flows.

But that is by no means all. Combined with other data sources, such as technical vessel information, consumption models, weather and sea state data, geographical information and sailing
AIS data can deliver tremendous value to shipping companies and other stakeholders, supporting maritime business at an operational, tactical and strategic level.

Typical applications for integrated AIS analytics and post-processing include tracking how partners and competitors run their networks and manage their port operations, or how many direct connections and transhipments are being offered. AIS data can provide insight into port and terminal congestion problems, berth availability, slow steaming practices, speed profiles, and their effects on fuel costs.

One of the key benefits of this technology is the availability of ship and voyage information to any interested party. Ship operators can use this data as reference for benchmarking their own fleet’s schedule integrity, operational costs, time spent in ports schedules.
and at anchorage, bunkering footprints and average speed. A few example scenarios may highlight the potential economic benefits of AIS data analytics.

- **Dry-dock selection:** A chemical tanker owner needs to send two of his chemical tankers to dry dock within the next six months. His superintendent lacks current information on the best places to go. By combining chemical tanker AIS movement data with geospatial object information about yard locations he can generate a quick overview of the yards used most frequently and the time ships typically spend in dry dock.

- **Delay management:** While common, delays in container shipping can be costly as berths become unavailable, speeding up burns more fuel, cargo from skipped ports needs to be repositioned, etc. Managing delays efficiently is crucial, and being able to retrace where services ran out of schedule and what remedial actions were taken (increasing speed, skipping ports, cutting and running, etc.) will enable ship operators to optimize their strategies for keeping ships on schedule and their costs under control.

- **Port selection:** A tanker operator encounters problems at certain ports and pinpoints long vessel turnaround times as the core problem. By using AIS data to calculate average turnaround times for similarly sized crude oil and product tankers at other ports in the same region, the company can identify ways to save time, reduce charter hire and avoid supply chain bottlenecks.

- **Berth selection:** A container carrier contemplating a schedule change needs to determine berthing availability at various ports within a region. Acquiring this information the traditional way can be time-consuming. However, an analysis of AIS data can reveal which terminals are underutilized on specific week days, and at what times ships have arrived at and departed from specific terminals in recent weeks or months. The container carrier can thus see quite clearly what would be the best times to call at a certain port.

- **Voyage management:** AIS data can be used by shipping companies to analyse their own and their competitors’ performance in terms of voyage management. For example, the granularity of speed information provided by AIS data is much better than that of noon reports. A variety of key indicators can be derived from a detailed AIS data analysis, such as speed variability. A vessel sailing too fast at the beginning of a voyage only to slow down to arrive in port at the proper time is indicative of poor voyage planning. An excessive average sea passage speed may be caused by poor pro forma scheduling. Long port stays are often the result of poor port productivity or inadequate coordination with the terminal operator. Similarly, anchorage times due to premature arrival can be avoided by planning voyages more carefully. Other important parameters that can be extracted from AIS data include a ship’s nautical miles sailed per day, and the operating profile standard deviation (head-haul/back-haul).

In a comparative test, irregular speed patterns resulted in an annual fuel bill difference of approximately two million US Dollars for an 8,500 TEU container ship.

**A treasure worth unlocking**

There are many more potential applications for AIS-based business intelligence. The above examples demonstrate the power of this new technology which enables a new level of transparency in the shipping market. Early adopters can expect to reap huge benefits from it.
ENERGY EFFICIENT OPERATIONS – WHAT MATTERS

Defining energy efficiency measures is easy. Implementing them is not. The awareness and capabilities of ship and shore staff as well as performance management are the key “enablers” to actually realize savings, reveals the latest DNV GL energy management study.
What qualitative targets did you define?

| Performance management (equipment and culture) | 53% |
| Awareness, capabilities and behavior | 33% |
| Measure implementation (retrofit) | 13% |
| Measure implementation (voyage performance) | 7% |
| Measure implementation (vessel performance) | 7% |
| Management system | 7% |
| Other environmental targets | 20% |

Take away
- More than half of companies with qualitative targets want to implement or strengthen performance management in 2015.
- One third of companies want to foster awareness and capabilities for behavioral change.

What matters
With increasing regulatory requirements and pressure from charter markets, energy efficiency is now at the top of shipping companies’ agendas - even at currently low fuel prices. Daily practice, however, reveals that shipping companies handle the topic in very different ways. Thus, it has been the objective of the recent study “Energy Efficient Operation – what really matters” to reveal what successful shipping companies do differently. What has worked well? What were the stumbling blocks? What are the success factors? What are the plans? Or in short: what matters?

Industry insight
The Energy Management Study 2015, the second of its kind conducted by DNV GL Shipping Advisory, aimed at understanding how the industry handles the need to increase energy efficiency. The study covers the input of 80 shipping companies, including ship managers, owners and operators, headquartered in 24 countries. All major vessel segments are represented - container, tanker and bulker segments - by more than 30 survey participants.

Energy efficiency determines competitiveness: More than three quarters of the companies call energy saving a main topic on their agenda, with over 80% naming costs as the main driver even at today’s low fuel prices. Improved market positioning and utilization and the positive image effect from a smaller environmental footprint are further reasons. This especially applies in the container segment.

Varying ambitions
Even though energy saving enjoys high priority within most of the companies, when questioned about energy targets, many shipping companies reveal that they have not formulated ambitious savings targets. The share of companies with no defined target decreased from 44% in 2013 to 28% in 2015, but is still high. Only about one third of participants aim for energy savings of 5% or more. The average target is 2.8%. However, one interesting observation is that 53% of respondents want to implement or strengthen performance management and 33% want to improve the awareness, capabilities and behaviour of ship and shore staff.

Common measures
So far the industry has focused on implementing well-known practices that require little investment. Nine measures have been addressed (and partially implemented) by more than half of the shipping companies participating. The shares are even a little higher in the container segment. Most of the measures refer to ship operation or ship management, and just one of them is technical. Particularly interesting is “Awareness and/or incentives”. 28% of shipping companies want to act on this lever. This lifts this “enabler” from 15th place in 2014 to 1st place in 2015. This is a clear
sign that shipping companies are struggling with implementation and intend to address this issue. By far the greatest contributors to energy savings in 2014 were slow steaming, hull and propeller cleaning and voyage planning optimization.

Unclear responsibilities
The organizational anchoring of energy efficiency just plays a minor role so far. Not even a third of all companies have a dedicated energy manager or team. Most companies have assigned the task to “everybody,” which often means “actually nobody”.

Success factor performance management
Performance monitoring is ranked as the strongest contributor of the “enablers”. Efficient performance monitoring and management means continuous energy performance transparency, being able to identify obstacles on the way to realising targets and being able to proactively improve ship performance immediately. "Reliable data collection, monitoring and analysis are the key to benchmarking and achieving the goal in energy management,” claims one participant. Nevertheless, fully or partially manual data gathering is still prevalent and the ways in which the data are used vary widely. Reports are still rather prepared manually than automatically - if at all. Most successful companies have implemented both an IT-based performance management system and a performance management culture.

Implementation is a people business
Besides the lack of financial resources, the lack of time and capabilities and the resistance to change are obviously the main hurdles on the way to implementing energy saving measures. Participants see the need for crews and onshore staff to gain awareness and develop relevant knowledge about energy efficiency. “All those involved in the day-to-day operation of the vessel should be aware of, and willing to implement, energy saving techniques, from the wiper in the ship up to the managing director in the main office,” says one respondent. In 2015, one third of companies want to foster awareness of, and capabilities for, behavioural change.
ECO RETROFIT SERVICE
– MAKING BULBOUS BOW OPTIMIZATIONS FUTURE-PROOF
Many shipowners and operators are turning to bulbous bow retrofits to increase their vessels’ energy efficiency. DNV GL has developed a new tool as part of the ECO Retrofit service to support the industry in tailoring retrofit projects to the future needs of their fleet. The new ECO Retrofit tool quantifies a vessel’s performance for a bandwidth of scenarios from worst-case to best-case scenarios, supporting more informed business decisions.

While the service identifies new bow shapes based on computational fluid dynamics (CFD) calculations, the new tool explores the effect of alternative operational options. Overall, this approach can customers help save 5–10% on their annual fuel bill.

The biggest issue in many retrofit projects is the definition of the individual operational profile. In the past two years the ECO Retrofit service has already helped to upgrade some 200 vessels. Aside from analysing their fleet’s past performance, shipowners and operators frequently have questions concerning the future, such as: What if I operate at other conditions some day? Can we change the operational profile again? “Even though our new ECO Retrofit tool cannot change the volatility of the market, it quantifies performance for a bandwidth of scenarios from worst-case to best-case scenarios, supporting more informed business decisions,” says Carsten Hahn, Senior Project Engineer ECO Lines at DNV GL – Maritime.

DNV GL’s new ECO Retrofit service creates 5,000 to 10,000 vessel-specific bow designs and assesses them for a broad range of operational conditions using CFD. An interactive excel-based tool allows easy and immediate exploration of “what-if” scenarios for changing operational conditions. The input is drawn from the target operational profile and is typically displayed in a matrix of four speeds and three drafts.

Optional constraints, such as reaching design speed at 85% engine power, are also considered before the best bow shape for the operational profile is chosen. The tool can then assess the performance of this bow for alternative operational profiles. It displays estimated savings (in USD per year and amount of power in percent) and payback time of the best bulbous bow option for all specified operational profiles. The payback time calculation takes aspects like fleet size, conversion costs and fuel price into account. Should customers want to change any elements of the analysis the tool simply recalibrates the new input to create more what-if-scenarios and to ensure that the final design is future-proof.

DNV GL’s new ECO Retrofit service creates 5,000 to 10,000 vessel-specific bow designs and assesses them for a broad range of operational conditions using CFD.
POWER WITHOUT PISTONS:

LNG-FUELLED TURBINE-POWERED MEGA BOX SHIP STUDY

GTT, CMA CGM (and its subsidiary CMA Ships) and DNV GL recently released a technical and feasibility study for a new mega box ship - the Piston Engine Room Free Efficient Containership PERFECt. The concept vessel is LNG-fuelled, powered by a combined gas and steam turbine, and is electrically driven.

Exploring this novel configuration resulted in the partners identifying and analyzing a propulsion concept that has the potential to offer a more efficient, more flexible and greener box ship design than current 20,000 TEU two-stroke diesel engine driven ultra large container vessels.

The study shows considerable benefits due to capacity gains at the same efficiency level. It demonstrates that the use of the clean LNG fuel has significant efficiency benefits which cannot be achieved by a conventional-fuelled COGAS system. The potential for an optimized LNG-fuelled COGAS system goes even beyond the efficiency of the oil-fuelled engine systems used today. At the same time, cargo capacity is increased by the use of LNG and not decreased as is the case for LNG-fuelled piston engine systems. In fact, the cargo capacity is higher than the capacity of a conventional oil-fuelled ship of the same size. This is the result of placing the COGAS system at deck level within the area of the deck house and the LNG tanks. Therefore, nearly the complete space normally occupied by the engine room and the funnel structure can be used for cargo.

The electric power generation allows the power plant to be split from the propulsion motors. For this reason, a conventional engine room is not needed any more. In addition, the three electric...
main motors, which are arranged on one common shaft, can run fully independently from each other, providing increased redundancy and reliability.

With gas-turbine-driven power production, utilizing a very clean fuel and with electric propulsion, the ship’s machinery systems are simplified and made much more robust. It is expected that this approach can lead to new maintenance strategies as found in the airline industry, which may make it possible to reduce the ship’s engine crew, leading to further cost savings.

Optimizing the power plant by minimizing the steam turbine size, reducing power capacities, condenser cooling, using a two stage pressure steam turbine and steam generator will increase the system’s efficiency further. The net efficiency is expected to be well above conventional-fuelled piston engine ships.

In a next step, the project partners GTT, CMA CGM and its subsidiary CMA Ships and DNV GL intend to work on the optimization of the power supply system and of the overall ship design.

Background
LNG as a fuel is the ideal fuel for gas turbines. By using this clean fuel, the turbine inlet temperatures and, as a consequence, the turbine efficiency can be increased compared to turbines fuelled with conventional ship fuel. At the same time, the turbine outlet temperature increases as well and allows for the installation of high-efficient steam turbine cycles which use the turbine exhaust gas.

For these reasons, COMbined Gas and Steam turbine (COGAS) power generation today is the most efficient and economical way to convert fuel into mechanical power or electricity. Modern stationary COGAS plants running on natural gas achieve net plant efficiencies of approx. 60%. This value cannot be reached by conventional diesel engines of ships where the engine efficiency is known to be around 52%.

The high power density and the modularity of COGAS plants, together with the electric propulsion concepts, lead to additional container slots. This makes up for the slots which are lost by the higher space requirements for LNG as fuel compared to HFO as fuel.

The trend towards increasing size and relatively high design speeds of container ships leads to a high power demand of these ships. This high power demand allows COGAS plants of high efficiencies which can be expected to be competitive with conventional-fuelled 2-stroke diesel engine systems.

For these reasons, GTT, CMA CGM and its subsidiary CMA Ships and DNV GL decided to have a closer look to the COGAS technology applied to container ships to determine the feasibility of such systems.

The reference ship
As a reference and base for the evaluation, a conventional HFO-fuelled 20,000 TEU container vessel (Figure 1) is used. The main design parameters are similar but not identical to the main design parameters of the “CMA CGM Marco Polo” shown in Figure 1.

The most relevant design parameters used for the study are:

- 80 MW total installed power
- Single screw layout
- 65 MW at 22 knots at scantling draft
- Length overall of 400 m
- Beam of 59 m
- Depth of 33 m
- Container capacity of 20,000 TEU

The analysis of overall ship efficiency and fuel consumption is based on an Asia – Europe return voyage using the real profile and including all port calls (Figure 2).

The operational profile of the ship for the leg is shown in Figure 2. It demonstrates the chronological order of the ship’s electric power demand, including sea, manoeuvre and port operation modes.

The power demand of the ship is also based on real data (Figure 3 and Figure 4).

The electric power demand for the leg varies widely as a result of varying ship speeds between the single ports and the different numbers of reefer containers carried. And, of course, there is a big difference between the power demand at sea, which reaches values of more than 50 MW, and the power demand in port, at less than 5 MW. This also becomes obvious by the histograms in Figure 3 and Figure 4, representing the ranges and the frequency of the required propulsion power and auxiliary power demand of the ship throughout the leg.

In addition to the power demand of the ship, it is important to consider the ambient conditions when designing a propulsion concept. The ambient conditions affect the performance of a powering system, especially that of a gas turbine. For the main sea areas of the leg, the ambient conditions air temperature, relative
humidity and sea water temperature are used for summer and winter seasons.

For the conventional-fuelled reference ship, a scrubber system was assumed. The comparison of both designs is based on the total fuel consumption during the two-way voyage. The different operation modes, power demands, efficiencies in part load, operation of auxiliary engines, etc. were considered.

The final result showed that the overall efficiency of the COGAS system and that of the HFO-fuelled 2-stroke engine system are very close to each other. It has to be considered that the COGAS system chosen for the feasibility study is not finally optimized. There is still efficiency potential, for instance by:

- minimizing the steam turbine size to increase efficiency,
- reducing power capacities to run the system closer to the optimal efficiency,
- optimizing the condenser cooling of the steam turbine to increase steam turbine efficiency, and
- using a two-stage pressure steam turbine and steam generator instead of the single-stage turbines used in the feasibility study.

It is expected that the net efficiency of the COGAS system will be well above the efficiency of the conventional system. Additional gains in efficiency are expected by optimizing the ship design and taking advantage of the flexibility related to the “missing” engine room.

The PERFEC(T) ship

All power consumers are electrically driven. The electrical propulsion concept of the design allows for the decoupling of the power generation by generator sets from the power supply to the propeller by electrical motors. As a consequence, a conventional engine room is not needed and additional container slots are provided. Figure 5 shows the general arrangement of the ship.

The following main design aspects are considered:

- Power distribution
  The aim is to provide a minimum number of power generating sets (or gen-sets), most of them being identical and all of them able to run in parallel in load sharing mode. This allows for the higher load of operation of the gen-sets during operating modes with small power requirements, which effectively increases the system’s efficiency.
  The advantage of having identical gen-sets is mainly related to cost savings for maintenance (consumable, management of spare parts, etc.), the training of crew and adjustment of parameters in the various running modes.

- Number, type and capacity of gen-sets
  The electrical power generation is adapted to the required power demand and considers the operating profile of the ship.

- Dynamics in the power demand of the ship
  The architecture of the power-generating system considers the fast reaction time needed to increase or decrease the power even when such changes occur abruptly.
For the evaluation of the COGAS system, the chosen layout is modelled and simulated in DNV GL COSSMOS simulation software. A detailed model of the system is developed and calibrated using validated data. A simplified representation of the model is shown in Figure 6.

The model consists of 209 components (main and auxiliary) counting for 4,048 non-linear equations. The key system aspects that were considered for the simulation are reflected in Figure 7.

One of the main challenges for the simulation – pointing out the strength of COSSMOS – is the high complexity and dependency among all components. For example, the power generation of the gas turbine and the power generation of the steam turbine depend on each other, which has to be considered for the simulation. For a given power demand, the starting point of iteration has to assume a certain load of the gas turbines, while the rest of the power needs to be provided by the steam turbines. The produced power of the steam turbines, however, depends on the exhaust gas parameters of the gas turbines which are the power source for the steam generator of the steam turbines.

If the steam turbine cannot match the power demand, the gas turbine load must be increased; exhaust gas parameters and mass flow change accordingly until the power of steam and gas systems is balanced and the actual demand of the ship propulsion, hotel load, auxiliary and cargo demand is met.

The balanced operational condition defines the LNG consumption of the gas turbines, thus determining the required heating demand for LNG vaporization. As this is applied for the intake...
air cooling of the gas turbines, this again affects the gas turbine power, hence balance of load sharing. The principle is the same for the changed demand in electricity for cytogenetic pumps for LNG treatment, etc. This line could be further drawn through all components in the complex system.

LNG storage in membrane tanks

Two membrane fuel tanks with a geometrical capacity of 10,960 m³ each (100% volume) are used for LNG storage. The tanks are of GTT’s Mark III Flex design. Figure 8 shows the principle of the insulation system and Figure 9 shows a Mark III tank installed on an LNG carrier. This design ensures safe operation under all weather conditions and at all filling levels, high thermal performance and high volume utilization. The tanks are located near the midship section below the superstructure. The size of the tanks is approximately twice the size of an HFO tank with similar energy content.

The space above the tanks is sufficient for the installation of the COGAS system and the accommodation, hence no engine room is needed at the aft of the vessel (see general arrangement plan in Figure 5). As a result, the ship gains approx. 300 container slots compared to the HFO-fuelled reference ship.

Global strength

Without an aft engine room island, the question of global strength had to be evaluated to decide on the feasibility of the concept.

DNV GL performed the global strength analysis based on a generic standard container ship design of about 20,000 TEU. This design was modified in the aft part by removing the machinery room and decks and adding lower engine room decks for the electric propulsion machinery space. On top of the deck, container spaces were considered within the hold. Additionally, main engine foundations have been replaced by smaller foundations for the electric propulsion engines (Figure 10).

Both designs – the generic standard design and the simplified alternative design – are analysed with finite elements with respect to:

- hatch opening deflections and movements,
- stress evaluation of the whole vessel, and
- hatch corner fatigue.

The modified design will have to be reinforced at several local positions. This is mainly due to the reduced torsional stiffness of the new aft ship without the stiffening engine room construction. Within the scope of the study it was qualitatively judged if the modified aft ship creates major problems regarding the ship’s strength. No fundamental show-stoppers have been identified.

The diagonal hatch opening deflections resulted in higher – but controllable – values.

Maximum hatch cover movements rose and therefore the affected holds require a modified hatch cover design (e.g. five-cover design) or a stiffer hull construction.

At midship areas, the strength limit was partly exceeded; buckling in the inner and outer bottoms is possible. Here the moment of inertia would need to be increased or the plate thickness in the critical regions must be increased.

Some container benches in the aft and the new propulsion engine room need reinforcement.

Finally, the hatch corner fatigue was investigated. DNV GL calculated all corners within the vessel. Results showed that all but

Figure 7: Modelling aspects of the COSSMOS model
one corner could be controlled by maintaining radius and adding plate thicknesses. The most critical corner was on the upper deck where the support of the removed main engine room deck is lacking. Here a keyhole or alternative solution would be required in the design.

In summary, the required modifications are mainly based on the fact that the study was based on dimensioning of the conventional two-island design with less torsional deformation in the aft part. The higher torsional deflection of the hull generates higher stresses in some locations, requiring adjusted scantlings. As an alternative solution to stiffening, for some bays a five-part cover could be considered. The additional steel works on the hull were considered, changing the hull costs only marginally.

**CAPEX and OPEX**

For the cost–benefit assessment, investment costs of the PERFEC(T) LNG-fuelled ship were compared to the conventional-propelled ship. Within the analysis, costs for additional and reduced systems to the base case where considered.

This includes additional costs for, among others,

- membrane tanks,
- gas and steam turbines,
- fuel gas handling, and
- structural reinforcements (no aft engine casing).

Some costs can be compared to the 2-stroke engine system. These are, among others,

- scrubber, which is eliminated,
- cooling system capacity, which is reduced and the system simplified, and
- HFO treatment or tank heating, which is not needed.

At the end, the CAPEX for the COGAS ship are regarded to be 20% to 24% above a conventional-fuelled vessel.

The OPEX costs largely depend on the difference in fuel price, the additional income related to the additional containers which can be transported and the savings related to a possibly higher system efficiency.

Currently, the gas price in Europe on the spot market is nearly the same as the HFO price (as of 19 October 2015; IFO 380: 6.59 $/mmBTU = 253 $/t; Gas TTF: 6.85 $/mmBTU [lİv]). In a developed market, the distribution costs may be around 2 $/mmBTU. A business case using HFO plus scrubber as a reference therefore needs compensation either by a larger difference between gas and LNG price or by additional benefits from efficiency improvement and additional revenue from additional container slots.

The results of the feasibility study, including the CAPEX and OPEX calculations, encourage the partners GTT, CMA CGM and its subsidiary CMA Ships and DNV GL to plan a more detailed evaluation of the overall system in a follow-up project.

**Contact**

GTT: abarret@gtt.fr
CMA CGM: media@cma-cgm.com
DNV GL: gerd.wuersig@dnvgl.com
RECENT DELIVERIES

X-Press Lhotse is one of the selected newbuildings presented on the following pages, which are delivered to DNV GL class within the last year, representing remarkable examples in range from feeder size to ULCS.
<table>
<thead>
<tr>
<th>Vessel name</th>
<th>TEU</th>
<th>Owner/ manager</th>
<th>Yard</th>
<th>DNV GL class notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MSC MAYA</td>
<td>19224</td>
<td>MSC Mediterranean Shipping Co</td>
<td>Daewoo Shipbuilding &amp; Marine</td>
<td>※100 A5 Container Ship RSD(gFE) IW NAV RSD(D2) DG +MC AUT CM-PS EP-D</td>
</tr>
<tr>
<td>2 BARZAN</td>
<td>18691</td>
<td>United Arab Shipping Co</td>
<td>Hyundai Heavy Industries</td>
<td>※1A1 Container carrier BIS BWMT(T) Clean DG(P) E0 NAUTOC(Neewbuilding) Shore power TMON</td>
</tr>
<tr>
<td>3 SAJIR</td>
<td>15000</td>
<td>United Arab Shipping Co</td>
<td>Hyundai Heavy Industries Co</td>
<td>※1A1 Container carrier BIS BWMT(T) Clean DG(P) E0 NAUTOC(Neewbuilding) Shore power TMON</td>
</tr>
<tr>
<td>4 UASC ZAMZAM</td>
<td>9034</td>
<td>Asiatc Lloyd Maritime LLP</td>
<td>Hyundai Samho Heavy Industries</td>
<td>※100 A5 Container Ship BW (D2) DG ERS IW RSD +MC AUT CM-PS EP-D</td>
</tr>
<tr>
<td>5 CCNI ANDES</td>
<td>9030</td>
<td>NSC Holding GmbH &amp; Cie KG/NSC Shipping GmbH &amp; Cie KG</td>
<td>HHIC-Phil Inc</td>
<td>※100 A5 Container Ship HLP RSD(gFE) IW BWMD(D2) DG LC +MC AUT CM-PS</td>
</tr>
<tr>
<td>6 OOCL UTAH</td>
<td>8888</td>
<td>Financial Products Group Co/Orient Overseas Container Line</td>
<td>Hudong-Zhonghua Shipbuilding</td>
<td>※100 A5 Container Ship RSCS BWMD(D2) DG IW LC NAV-OC RSD +MC AUT CM-PS EP</td>
</tr>
<tr>
<td>7 MSC ELODIE</td>
<td>8800</td>
<td>China International Marine/MSC Mediterranean Shipping Co</td>
<td>New Times Shipbuilding Co Ltd</td>
<td>※100 A5 Container Ship RSD BWMD(1)(D2) DG ERS IW LC NAV-OC RSD(F25, gFE) +MC AUT CM-PS</td>
</tr>
<tr>
<td>8 TOMMI RITSCHER</td>
<td>4957</td>
<td>Gerd Ritscher Reederei GmbH/Transeste Schifffahrt GmbH</td>
<td>Taizhou CATIC Shipbuilding HI</td>
<td>※100 A5 Container Ship RSCS BWMD (D2) DG IW LC NAV-O RSD +MC AUT CM-PS EP-D</td>
</tr>
<tr>
<td>9 SIMA GISELLE</td>
<td>4350</td>
<td>Simatech Shipping &amp; Forwarding</td>
<td>Taizhou CATIC Shipbuilding HI</td>
<td>※100 A5 Container Ship BWMD (D2) DG LC RSCS +MC AUT CM-PS EP-D</td>
</tr>
<tr>
<td>10 NILEDUTCH DORDRECHT</td>
<td>3510</td>
<td>Nile Dutch Africa Line BV</td>
<td>Shanghai Shipyard Co Ltd</td>
<td>※100 A5 E Container Ship BWMD DG ERS IW LC NAV-O RSD(F25) MC AUT CM-PS</td>
</tr>
<tr>
<td>11 X-PRESS LHOTSE</td>
<td>1700</td>
<td>Yan Kit Shipping Pte Ltd/X-Press Feeders</td>
<td>Zhejiang Ouhua Shipbuilding Co</td>
<td>※100 A5 Container Ship BWMD(D1) DG ERS IW NAV-O +MC AUT CM-PS EP-D RCP(300/25)</td>
</tr>
</tbody>
</table>