

SPECIAL EDITION

DNV Container Ship Update

Information from DNV to the Container Ship industry

No. 1

April 2010

QUANTUM

a container ship
concept for the future

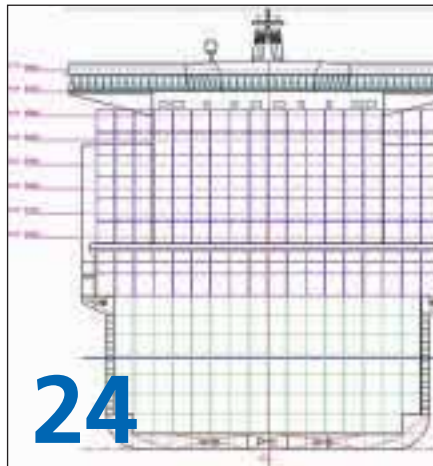
Also inside:

- Industry questionnaire
- LNG in focus
- Increased container capacity





Quantum – a container ship concept for the future »



General arrangement and LNG tank arrangement »



Machinery and ship systems – a flexible solution for an uncertain future »

Illustrations: front cover ©Octaga, MAN, p3 ©Octaga, MAN, p5–6 ©Octaga, MAN, p8 ©DNV/Eirik Byklum, p9 ©DNV/Magne A. Røe, p12 ©DNV/Knut A. Døhlie, p16–17 ©Octaga, MAN, p31 ©Octaga, MAN, p32–33 ©DNV/Magne A. Røe, p35 ©Octaga, MAN, p40 ©Octaga, MAN, p43 ©ABB, p48–49 ©DNV/Magne A. Røe, p59 ©DNV/Knut A. Døhlie, p61–63 ©DNV/Magne A. Røe, back cover ©Octaga, MAN

QUANTUM, THE CONCEPT 4

CHAPTER 1: MARKET NEEDS 10

CHAPTER 2: HULL DESIGN 20

CHAPTER 3: MACHINERY AND SHIP SYSTEMS . 40

CHAPTER 4: OPERATION 50

CHAPTER 5: INDUSTRY FEEDBACK 58



Front cover: An artist's impression of the Quantum concept.



DNV Container Ship Update

WE WELCOME YOUR THOUGHTS!

DNV Container Ship Update is a newsletter published by Det Norske Veritas, DNV Maritime. It is distributed to DNV customers and stations worldwide.

© Det Norske Veritas AS

Please direct any enquiries to your nearest DNV station or Container Ship Update e-mail: Cecilie.Johansen@dnv.com

Editorial committee:
Business Director Container Ships: Vebjørn J. Guttormsen
Editor: Magne A. Røe
Associate Editor: Knut A. Døhlie
Production: Cecilie Johansen
Design: Coor Graphic Services 1001-011
Printing: 07 Oslo AS, 6,000/3-2010

Online edition of *DNV Container Ship Update*:
<http://www.dnv.com/containerupdate>

DNV (Det Norske Veritas AS)
 NO-1322 Høvik, Norway
 Tel: +47 67 57 99 00
 Fax: +47 67 57 99 11

An updated list of all regional offices can be seen on DNV's website: www.dnv.com



Vebjørn J. Guttormsen

Vebjørn J. Guttormsen
Business Director
Container Ships

NEXT GENERATION CONTAINER SHIPS

We are proud to introduce Quantum. An innovative container ship concept developed by DNV with a view to the future of container shipping. In this magazine you can read about the project and the design rationale behind the concept study. We hope this will be a source of inspiration that can give you ideas to better 'future-proof' your fleet investments.

The change in the global economy and increased global environmental con-

cerns mean that shipping is facing a new reality. Vessels ordered today will be in operation for the next 25–30 years and decisions made today will determine your market position in the years to come.

So what are the challenges in this new reality? What will the design speed be? In the long term, the oil price is expected to remain high and to keep on increasing. A tax on carbon emission will probably be introduced. Should we design for the current

super-slow steaming speed, or will the speed return to normal when the market recovers?

DNV put together a team of its own experts from various disciplines to look at the technology and solutions that are expected to be available in a three to five year perspective. Market studies were carried out by AXS Alphaliner and Dynamar B.V. to examine the outlook for and future developments in the container trades. A loop from Europe to East Coast

South America was chosen as a basis for this project.

The result is Quantum, a concept container ship developed by DNV to test new ideas and future-oriented solutions. Flexibility has been the answer in a world of uncertainty. We believe this is a prudent strategy for a future in which we will have to adapt to market changes and environmental legislation that are not yet known to the industry.



»» Artist's impression of the 6,210 TEU *Quantum*.

Quantum

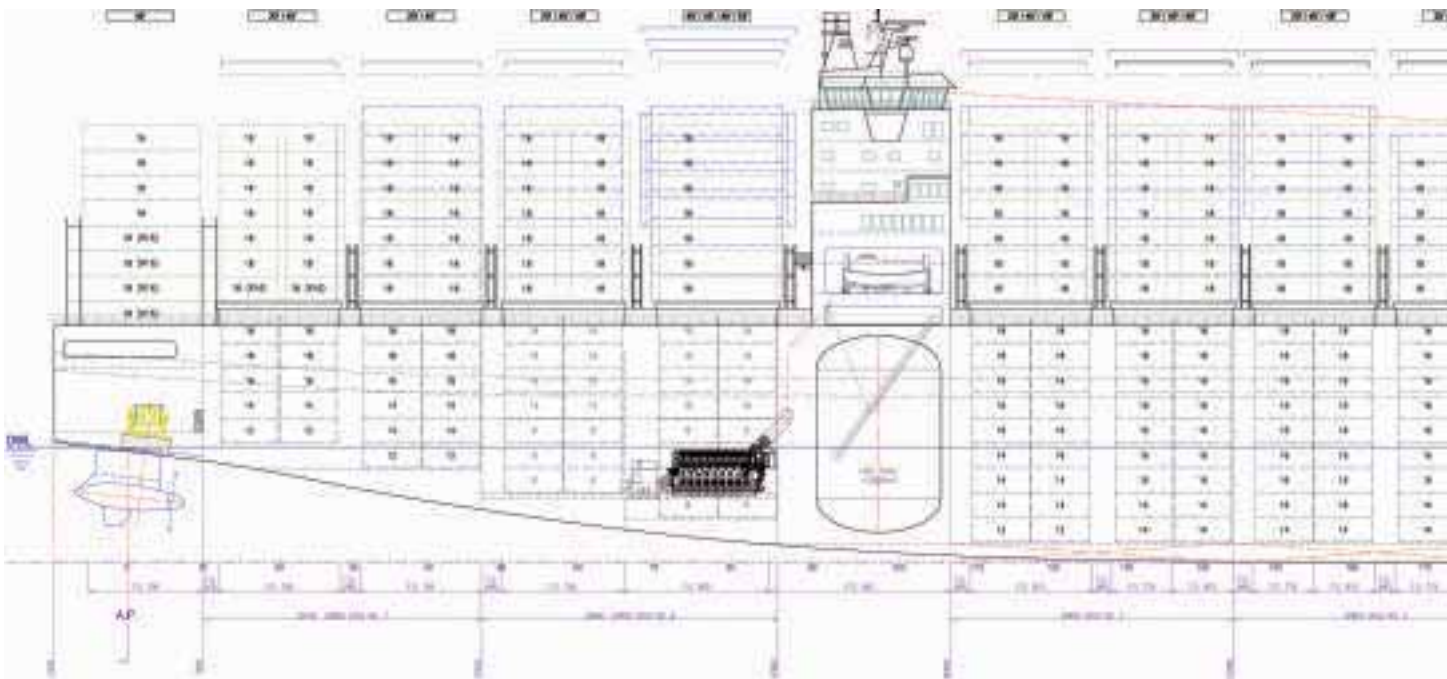
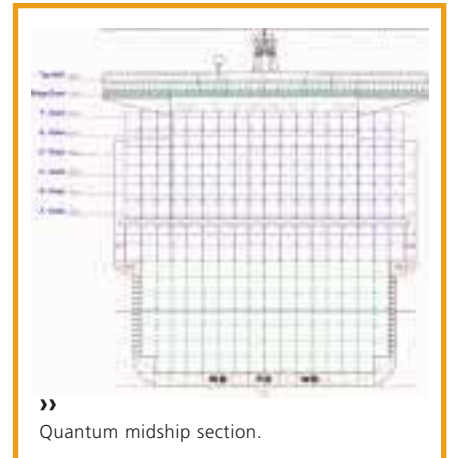
– a container ship concept for the future

Quantum has been designed to transport more cargo while using less fuel and with reduced environmental impact. The focus has been on flexibility in a future of uncertainty, while also ensuring efficient and reliable operations.

TEXT: EIRIK BYKLUM AND KNUT A. DØHLIE

MARKET NEEDS

- Choice of ship and features based on market studies by AXS Alphaliner and Dynamar
- ‘Baby post-Panmax’ of 6,200 TEU with a high reefer capacity of 1,200 plugs designed for flexible operations
- The design is suitable for future trade between Europe and the East Coast of South America
- A ship size with features likely to be among the first to be built in the next ordering wave, with technology that is available today
- Design speed of 21 knots with the ability to boost speed by several knots and slow steam down to less than 10 knots
- A design with a commercial life for the coming decades. Legislation to come, but not yet known, may be better catered for due to the built-in flexibility. Power converters may be exchanged for newer technology (e.g. fuel cells) without redesigning the plant
- The increased capital expenditure will be offset by improved operating costs and trading flexibility





HULL DESIGN

- Increased beam (42.5m), giving improved stability and minimising the need for ballast water
- Increased deck container capacity due to a novel Widedeck™ design (B = 49.0m)
- A novel, robust, narrow wing tank design (b = 1.0m), minimising the steel weight while providing sufficient damage stability
- Optimised hull form and bulb with a low block coefficient ($C_b = 0.57$)
- Significantly reduced lightweight using sandwich composite materials
- A novel wave breaker with aerodynamic design reduces the wind resistance

QUANTUM

Main dimensions

Length overall (m):	L = 272.3
Beam (at waterline) (m):	Bwl = 42.5
Beam (at deck level) (m):	Bd = 49.0
Design draught (m):	T = 12.0
Depth moulded (m):	D = 26.4

Capacity

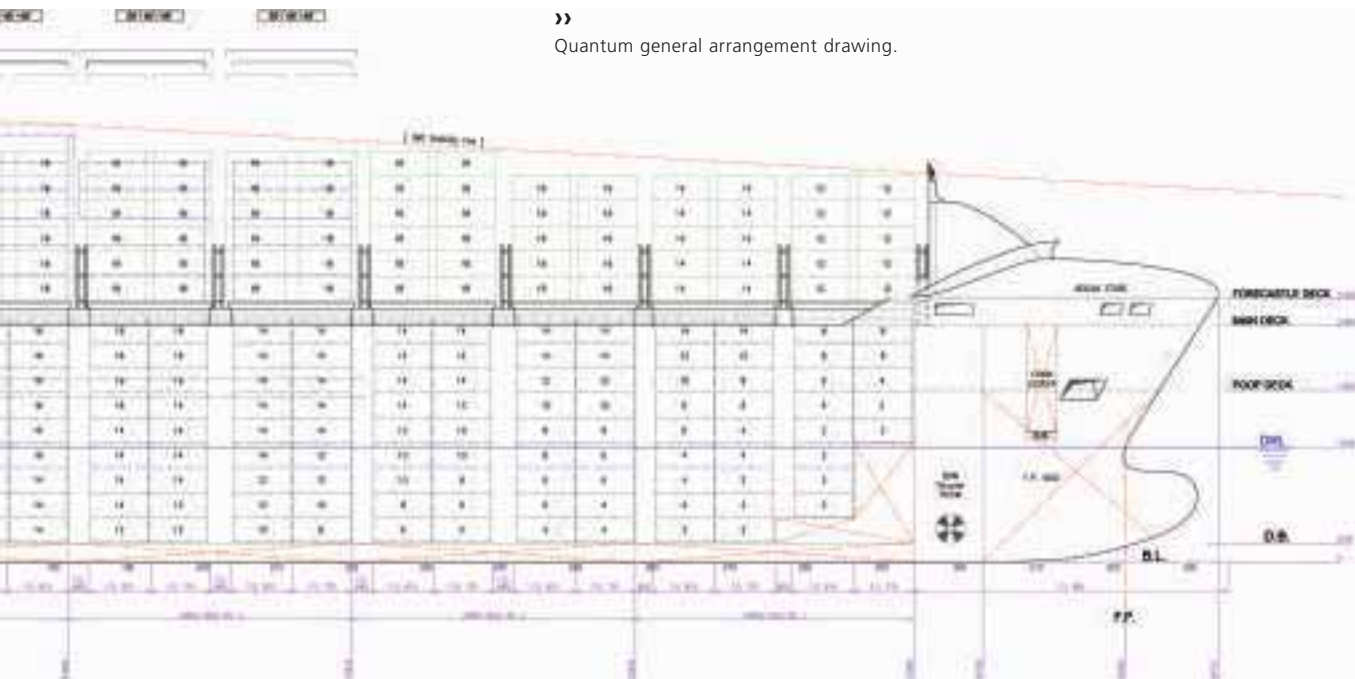
Total container capacity (TEU):	6,210
Container capacity on deck:	3,336
Container capacity in hold:	2,874
Reefer capacity (plugs):	1,200

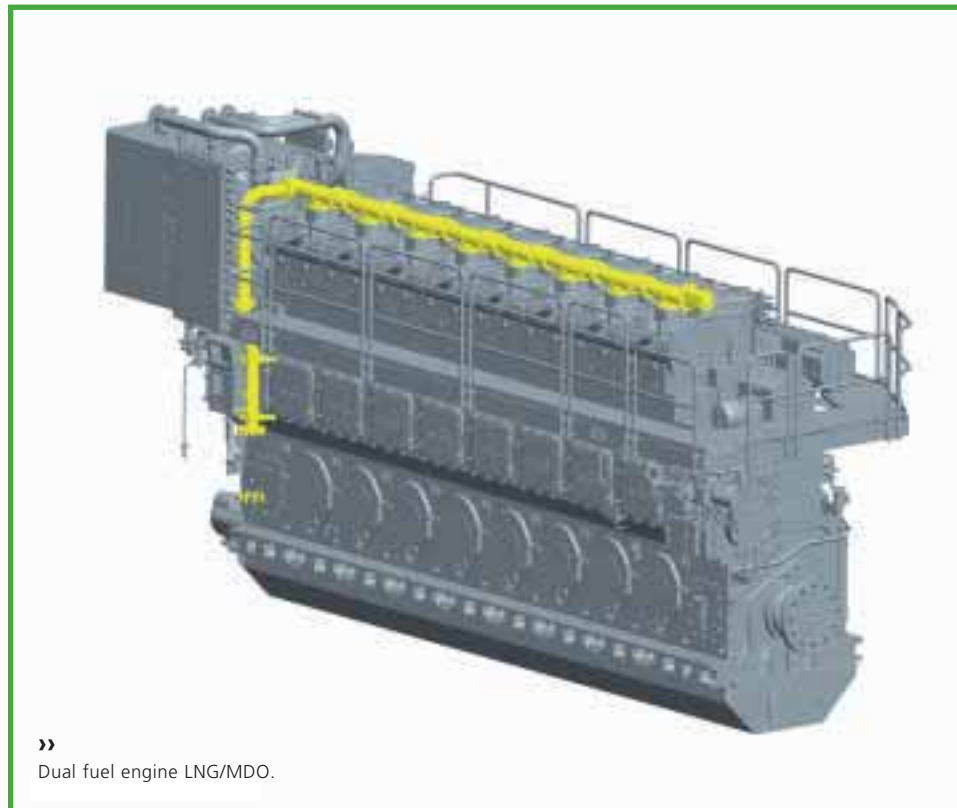
Engine

Dual fuel engines:	L6 + 3xL9
Installed power (MW):	33
Propulsion power (MW):	23

Fuel capacity

LNG (m³):	5,000
MDO (m³):	3,000

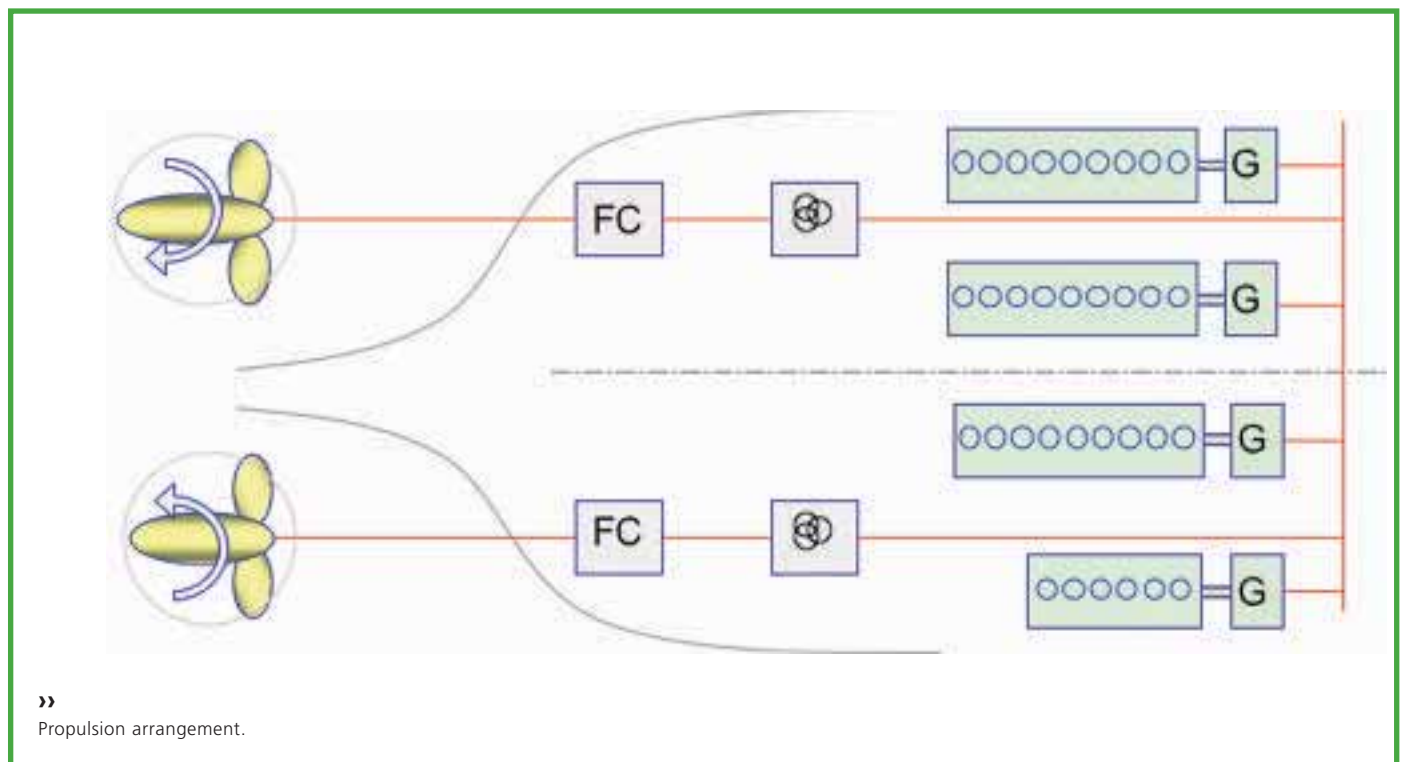




» Dual fuel engine LNG/MDO.

MACHINERY AND SYSTEMS

- A re-designed power production plant facilitating the use of low carbon fuels such as LNG yet based on proven technology
- Propulsion provided by two electrical driven Azimuth Pods
- Improved manoeuvrability and reduced thruster capacity forward due to two manoeuvrable pods aft, eliminating the need for aft thrusters and a rudder
- Redundant propulsion and machinery
- Designed for high efficiency under variable loading conditions
- Improved performance in shallow draught conditions
- Space saving arrangement, providing room for large LNG tanks

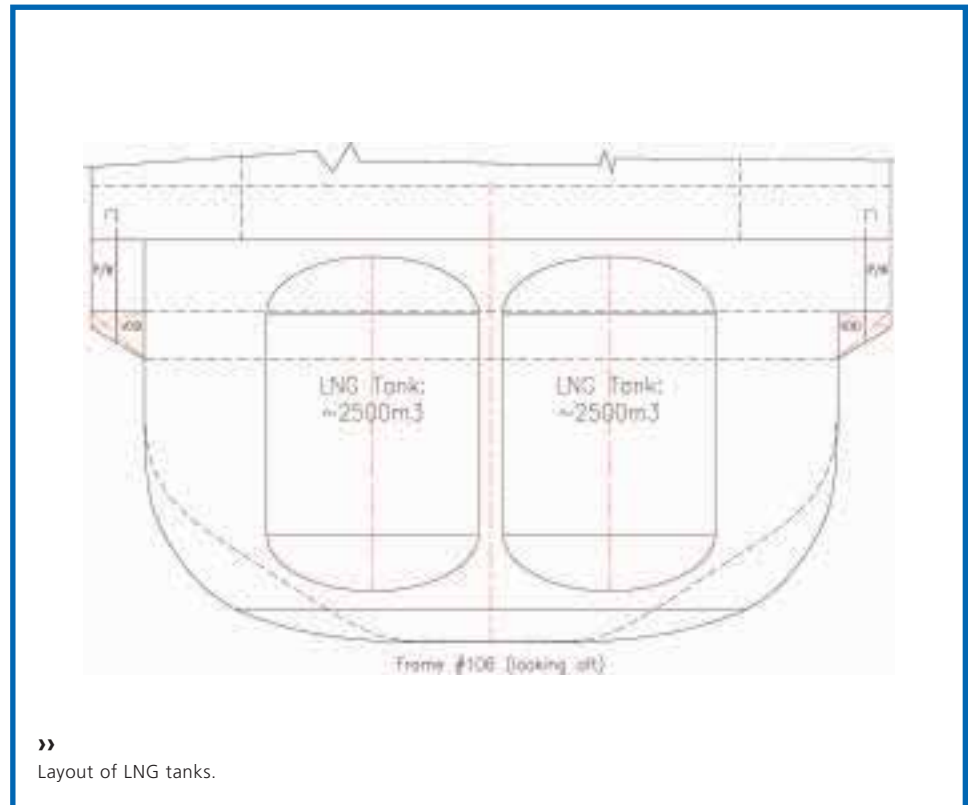


» Propulsion arrangement.

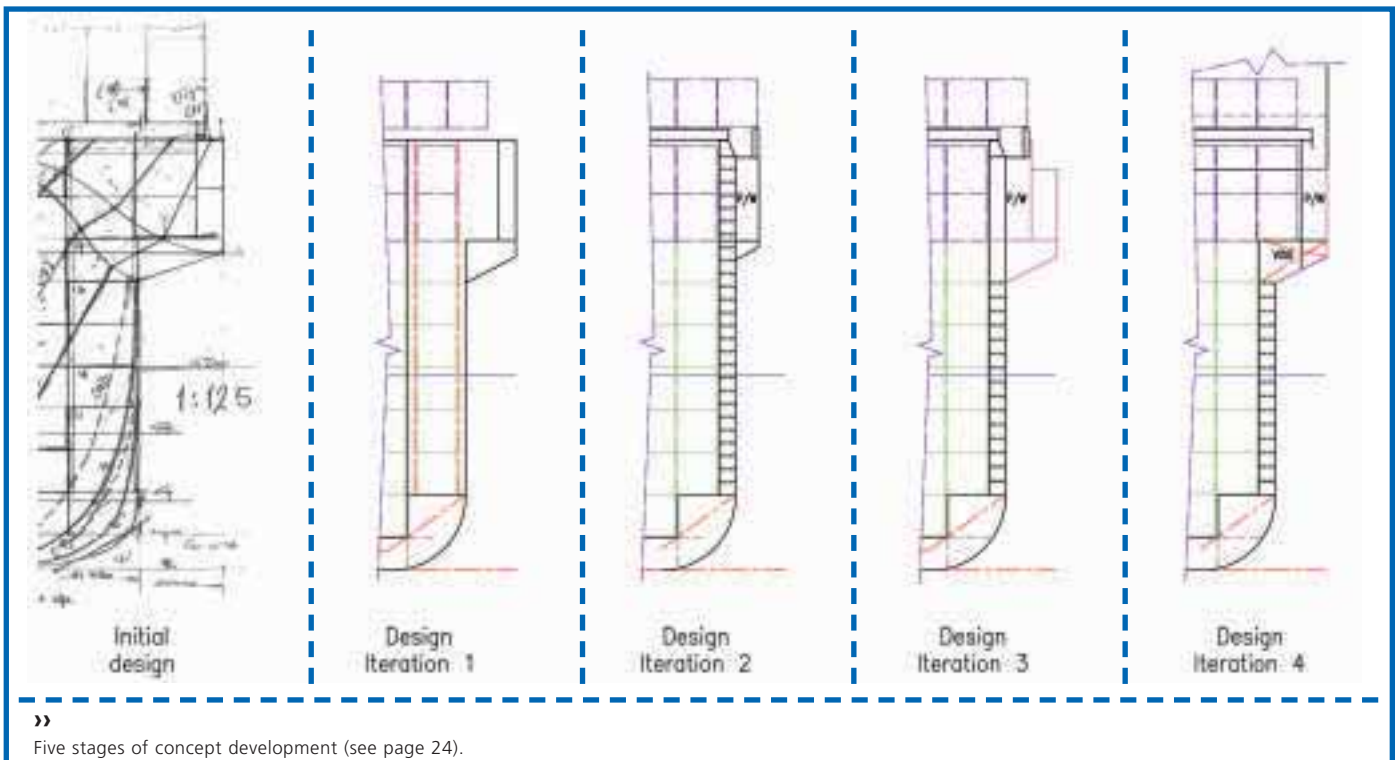
OPERATION

- Flexible engine arrangement – four-stroke engines, either dual fuel (LNG/diesel) or a selection of dedicated energy converters
- LNG fuel for auxiliary power in ECA areas and partly for propulsion. LNG storage tanks provided above the engine room area, allowing maximum container capacity
- Environmentally friendly and prepared for future regulations
- LNG is proven in service on four-stroke engines, while two-stroke engines for LNG do not yet have a track record
- A novel ‘block loading’ device with eight empty or lightweight containers has been introduced, increasing loading efficiency and cargo safety by connecting stacks at the top tier

Eirik.Byklum@dnv.com
Knut.Dohlie@dnv.com



»»
Layout of LNG tanks.



»»
Five stages of concept development (see page 24).

The Quantum project

– thinking outside the box

What is the future of container shipping? Can we develop an innovative container ship concept within a short period of time and design a ship with improved operational and environmental performance? The answer to these questions was the Quantum concept.

TEXT: EIRIK BYKLUM



» Eirik Byklum, Quantum Project Manager.

DEFINING THE FUTURE

In order to take on this challenge, a systematic work process was needed. It is important to decide on a business case and identify the critical needs before jumping to technical solutions. We found it useful to divide the project into three phases:

- Phase 1 – Business case:
Market and transport system analysis
- Phase 2 – Industry needs:
Identify critical industry needs and alternative solutions
- Phase 3 – Development:
Concept and design development, verification analyses

How we define the ‘future’ is an important consideration. Many alternative concepts have been proposed, but they often look 20–30 years into the future. We found it more useful to look at what we can do in the next few years using the best available technology. We are in a period with difficult market conditions and little ordering of newbuildings but steadily increasing environmental awareness. This is the right time to develop new designs. With that in mind, we decided on a time perspective of 3–5 years. This ruled out more long-term solutions such as fuel cells, while introducing LNG into the fuel mix was found to be feasible.

REDUCED DESIGN SPEED, INCREASED FLEXIBILITY

The project’s first step was to consider the container ship market with respect to trends in ship size, speed and trade in order to identify an adequate business case. The 5,000–7,500 TEU segment was chosen as

there are a number of growing economies and emerging trade lanes that will require relatively smaller, more compact ships with features such as shallow draft and high reefer capacity. The Europe – East Coast of South America trade was chosen as an example of a trade which is assumed to have a strong future growth potential.

A transport system analysis was carried out in order to identify critical design requirements for the size segment and trade under consideration. From the operational profile, it was found that large variations must be expected during operation and that flexible solutions should be sought. A sensitivity analysis with respect to design speed was also carried out. Not surprisingly, it was found that lowering the design speed is a very effective way of reducing the operational costs and environmental impact. Some fear that ships with lower design speed may be less attractive when the market conditions improve. However, as a return to cheap oil seems unlikely and consumers’ environmental concerns are continuously increasing, we believe that a shift to lower design speeds is the right way to go in the future.

NEEDS FIRST, THEN SOLUTIONS

Workshops and brainstorming sessions were used to define the critical Needs and identify relevant Solutions to meet the Needs. The focus was on solutions that can improve the performance with respect to operational efficiency, fuel consumption, cost and environmental performance. Innovative solutions were considered within areas such as hull design, machinery systems, propulsion systems, materials, cargo handling and operational efficiency, and the solutions were investigated with respect to market adaptability, fabrication adaptability and fitness for pur-

**THINK
OUTSIDE
THE BOX**

TO GET THE
INSIDE OF
YOUR BUSINESS
RIGHT

www.dnv.com



»

More than 30 people contributed to the project. Here represented by (front row, from left) Arne Færevaa, Gaute Storhaug, Gabriele Mazza, Eirik Byklum, Yang Zhang, Harald Bergsbak, Ivar Håberg, (back row, from left) Nenad Dacic, He Jiang, Kristoffer Brinchmann, Terje Theien, Christian Andersson, Krzysztof Jankowski, Erik Brodin, Knut A. Døhlie, Atle Ellefsen, Morten Kristmoen, Vebjørn Guttormsen.



»

Work in progress. From left: Knut A. Døhlie, Eirik Byklum, Atle Ellefsen, He Jiang, Yang Zhang, Christian Andersson.

pose. A customer survey was used to evaluate the needs and alternative solutions.

Some selected solutions were then chosen for further investigation with respect to technical and economic feasibility. The solutions were not only to look innovative but should also demonstrate real improved performance. During this process, many 'innovative' concepts such as catamaran and trimaran hulls were discarded. In the end, the most promising concept was selected for initial concept development, which was followed by detailed technical development as well as verification analyses.

Finally, although this project mostly focused on design, the operational side should not be forgotten. This is an area where great savings are achievable, and work was also carried out to evaluate various solutions for increasing the operational performance.

We have called our concept Quantum. You can read a lot more about it in the following articles. ●

Eirik.Byklum@dnv.com

Market potential for a new container ship design

A 'baby post-Panmax' may be one of the first ships ordered when the newbuilding market recovers. The 5,000–7,500 TEU range may be the new workhorse of the industry according to a market analysis by Alphaliner prepared for DNV. The Quantum concept design is intended for the Europe to East Coast South America trade.

TEXT: MORTEN KRISTMOEN

The market analysis is based on various items of information, the majority provided by Alphaliner and Dynamar, both of which are recognised and respected providers of shipping market intelligence.

THE CONTAINER SHIP NEWBUILDING PROGRAMME IS UNEVENLY SPREAD OVER THE SIZES

During the couple of years prior to the financial crisis starting in the 2nd half 2008, the shipping industry experienced ever increasing ordering activity. However, the order book is not evenly spread over the segments but rather more dominated by the larger sizes. A massive wave of orders for 10,000+ TEU ships accounts for a large portion of the expected increase in capacity. The trend towards employing bigger and bigger ships on trades servicing growing economies and emerging trade lanes faces one major challenge.

MARKET DEMAND, PORT INFRASTRUCTURE AND RESULTING SHIP REQUIREMENTS

As ship sizes increase, so do the requirements as to port facilities and capabilities. This is particularly the case with regard to draft restrictions, length restrictions and the crane outreach and lifting capacity.

Even though there are many ports in the emerging markets and growing economies too that are well capable of servicing even the biggest of ships, there are still a number of ports that will have challenges and limita-

UNITED STATES IMPORT

US has suffered the most from the present crisis, but is also expected to recover the quickest. Import from South America is expected to increase.

SOUTH AMERICAN EXPORT & IMPORT

Large economies expected to grow fast, leading to increased imports of consumer goods. Also high export volumes from this area, particularly perishable goods in reefer containers.

EXISTING AND EMERGING MARKETS OFFER OPPORTUNITIES FOR NEW DESIGNS



“Ships in the 5,500 TEU region may become the new ‘workhorse’ of the industry,” says Alphaliner



MIDDLE EASTERN IMPORT

High activity within oil and gas, and prosperity in society in general implies increased demand for consumer goods – and through that increased demand for container freight and intra-regional feeding.

INDIAN EXPORT

On the back of a recovered world economy, export from India to Europe and US is expected to increase significantly. Ships of up to VLCS size can be utilised.

tions for a considerable time to come.

We thus foresee a market potential in the 5,000–7,500 TEU segment, as there are a number of growing economies and emerging trade lanes that will require relatively smaller, more compact ships with features such as shallow draft and high reefer capacity. One example of this is the trade to and from the east coast of South America. This trade is assumed to have a strong future growth potential and is likely to require shallow draft ships in many of the ports along the coast. Furthermore, this trade is expected to require ships with a high intake of reefer containers, as there are substantial exports of fruit, meat and other perishable goods.

The list of ships ordered in the 5,000–7,500 TEU segment is also substantial, but it is dominated by ships at the upper end of this segment and often with relatively standard designs. The number of newbuildings at the lower end, i.e. around 5,500 TEU with a high reefer intake and a shallow draft, is limited. These ships have several deployment options on both the established and emerging trade lanes (including through the new Panama Canal) and could become the industry’s new ‘workhorse ships’ over the next few years. They will be highly relevant for both intercontinental trades, especially trades to and from Africa and South America, and large feeder routes such as the ‘Intra Persian Gulf’ trade. ●

Morten.Kristmoen@dnv.com

An innovator or only an inventor?

When companies try to innovate, many of them end up inventing instead. What's the difference between innovation and invention, and what does it mean for my company? This is one of several questions we face as innovators. 'What shall I do to succeed with innovation in my project' or simply 'How do I start', are other commonly asked questions. I'll give you some answers a little bit further down the page.

TEXT: SJUR DAGESTAD



» Sjur Dagestad, Professor in Innovation at the Norwegian University of Science and Technology (NTNU). Partner in the innovation company Innoco AS.

DNV is focusing on containership innovation in order to create new and improved solutions. The team tries to avoid all the traps that can make the project end up with nothing (except for wasted time and money). Typically, companies and project teams tend to go for solutions way too early. Through the years, we've seen companies that have started making solutions before they even know what to solve.

This is the Inventor's dilemma; making solutions, gadgets or things that nobody needs. The difference between an inventor and an innovator is that the Innovator manages to create value for the customer. Inventors typically create solutions for themselves.

Another major mistake developers make is to identify themselves as the customer. Many developers have given birth to new solutions according to the philosophy that: 'I want to have this, thus everybody else also wants to have it'.

CUSTOMER NEEDS

When we consult companies, we typically experience that they lack a deep insight into their customers' needs (N). However, some of the same companies have strong, almost religious, opinions on what the solution (S) should be. This is what we call a small N and large red S focus.

Winners in the marketplace tend to have a large N and medium-sized S focus. A medium S can be modified, a

large red S is not easy to change. Just think about it in your own setting. How many times have you met a supplier who wants to sell you a big red S which does not really meet your need?

Wish: **N S**

Reality: **N S**

So what should you do? First of all, the customer has the solution. Normally the customer doesn't know what the future will look like but yet still knows it.

Good developments start with good needs. Bad developments start with a brilliant idea.

This might sound provocative, but let's take a look at a small investigation carried out by three gentlemen (Goldenberg, Lehmann and Mazursky) at The Marketing Science Institute in 1999. They looked at 197 solutions of which 111 were successes and 86 were failures. Those who based their solution on a brilliant idea, ended up with a success in 28% of the cases. On the other hand, those who based their solution on a market need and created a solution to meet this need, ended up with a success in 69% of the cases.



»

Noia T1000 – a mobile phone with a razor, Swiss army knife, laser beam, radio, Geiger counter and torch. You can do anything except for dialling and making telephone calls. A big red S. Do you think Noia cared? No, they didn't until iPhone from Pear came along.

INNOVATION MODEL

In the US, a company called Doblin has studied a vast number of innovations. It looked into the innovation projects, studying what and where innovation took place. Based on these studies, it has created ten categories for innovation in companies. That means that typically, when we innovate, we work within one or several of these categories or boxes. When your company works on product development, you only work within two of the ten boxes. Why limit yourself to two when you can have ten?

One of the first things we did in the

containership project was to make sure that all the team members got themselves out of the inventor trap and started thinking as innovators. The whole project worked with all ten categories of innovation instead of only the two categories of product development. Small Ns, Big Ns, Red Ss and shapable Ss became a part of the project's competence. We also looked at where money is being spent and where money is earned in innovation projects. The reason for that is of course to put the effort where the money is.

If you're still reading, you might be

wondering what the ten categories of innovation are. These are: business model, network and alliances, enabling process, core process, product performance, product system, service, sales channel, brand and, last but not least, customer experience.

And remember: if you always do what you always did, you'll always get what you always got. This is almost true. The real truth is that you'll get less. That means others get more. Good luck with your innovation. ●

sjur@innoco.no

Industry questionnaire: Exploring industry needs

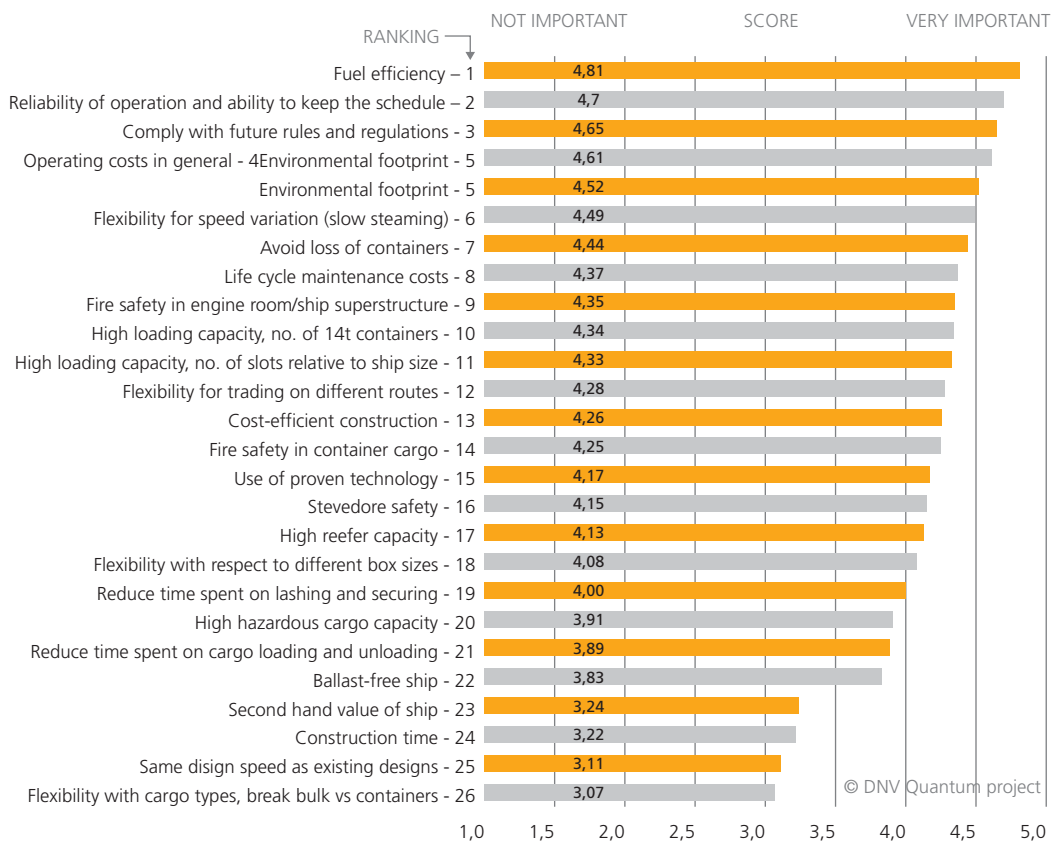
‘Environmental footprint’ in fifth place

The environmental footprint (5) ranking was only preceded by the predictable winners like fuel efficiency (1), schedule integrity (2), regulation compliance (3) and operating costs (4). That is the verdict of a ‘jury’ of 54 industry respondents worldwide when asked by DNV in a recent questionnaire survey “How would you rank the following items when considering building a new container ship?”

TEXT: **KNUT A. DØHLIE**

IMPORTANT ITEMS

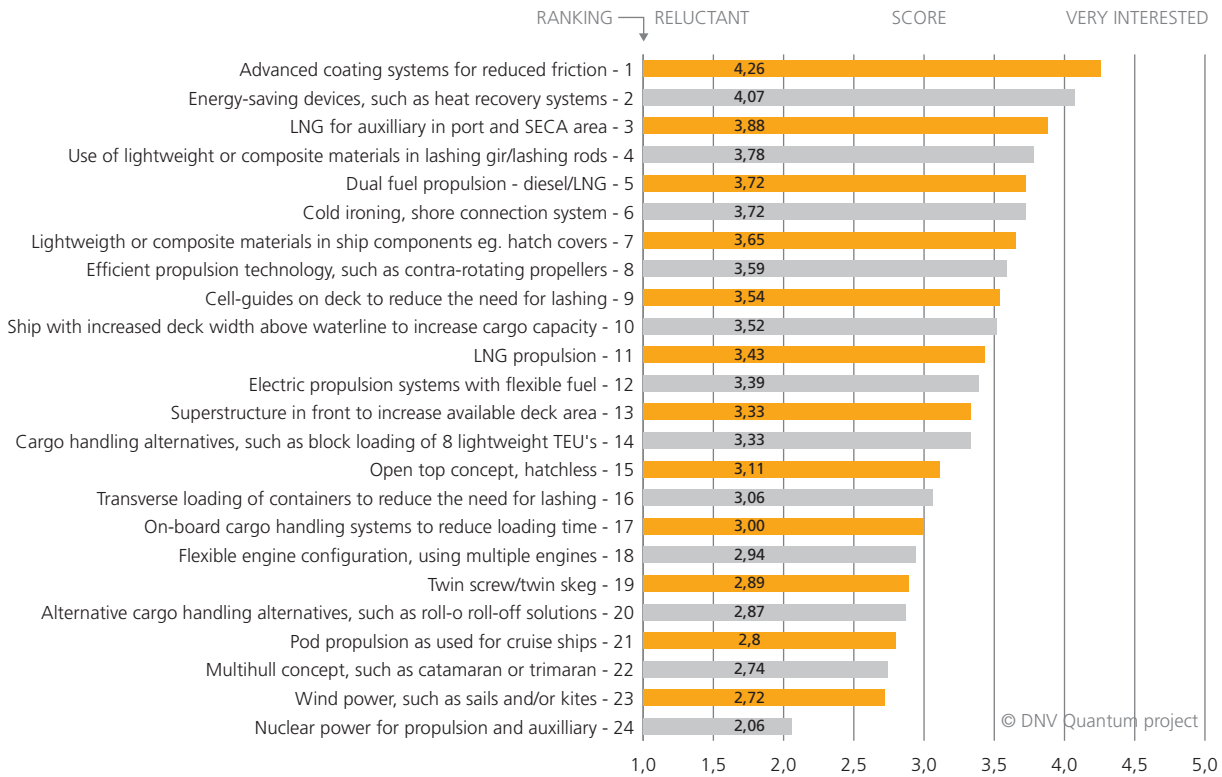
HOW WOULD YOU RANK THE FOLLOWING ITEMS WHEN CONSIDERING BUILDING A NEW CONTAINER SHIP?



»
Fig.1: Important items: how would you rank the following items when considering building a new container ship?

ALTERNATIVE SOLUTIONS

HOW WILLING WOULD YOU BE TO CONSIDER THE FOLLOWING "ALTERNATIVE" SOLUTION FOR A NEW CONTAINER SHIP DESIGN?



» Fig.2: Alternative solutions: how willing would you be to consider the following 'alternative' solutions for a new container ship design?

'Schedule integrity' remains a top priority in the container industry as it always has been, only preceded by fuel efficiency, perhaps not unexpectedly at times with super slow steaming and increasing fuel prices. The high ranking of the 'environmental footprint' came as a bit of a surprise to us. The response to other typical 'green' questions supports this impression, indicating that the industry may be warming to the future challenges.

The survey was conducted in November 2009. The respondents were asked the question "How would you rank the following items when considering building a new container ship?" They were given a list of items covering important features of container ships, with scoring options 1 = not important to 5 = very

important. They were also asked about novel 'alternative solutions', such as the use of LNG for auxiliary engines and propulsion.

A list of 24 alternative solutions was evaluated, ranging from 1 = reluctant to 5 = very interested. Technical and management staff, selected among ship owners, liner operators, ship yards and others (universities etc.) distributed worldwide, were invited to participate in the survey by dedicated e-mail. We received a response from 54 people as follows:

Type of company	Invited	Response
Ship yard	15.4%	13.0%
Ship owner	41.4%	70.3%
Liner operator	41.4%	5.6%
Others	1.9%	11.1%

Some people in the liner operator companies may have put down their response as a ship owner, as such companies also own ships. A more accurate description of the categories could have given a distribution better reflecting the companies from which the respondents were chosen.

A full list of the items covered and the score given in the survey is shown in Fig.1.

"How willing would you be to consider the following 'alternative' solutions for a new container ship design?"

The answers are in line with the attitudes revealed in the first question. 'Energy saving devices, such as heat recovery systems' came second to 'Friction reducing coatings'. The use of 'LNG for auxiliary power in port in (S)ECA areas' was ranked third, and



‘dual fuel propulsion diesel/LNG’ came fifth.

A full list of the items covered and the score given in the survey is shown in Fig.2.

MEASURE OF AGREEMENT

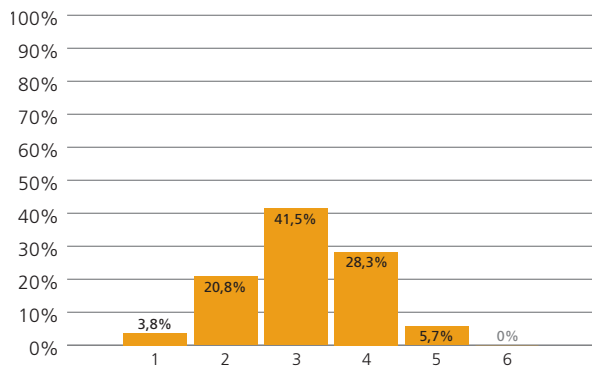
The standard deviation indicates the degree of agreement in the response. Answers close to the average give a small standard deviation, indicating good agreement, whereas a larger standard deviation indicates more disagreement among the respondents. When reviewing

the standard deviations we find that the top ‘important items’ have a good measure of agreement, whereas the lower ranked items show a lower degree of agreement.

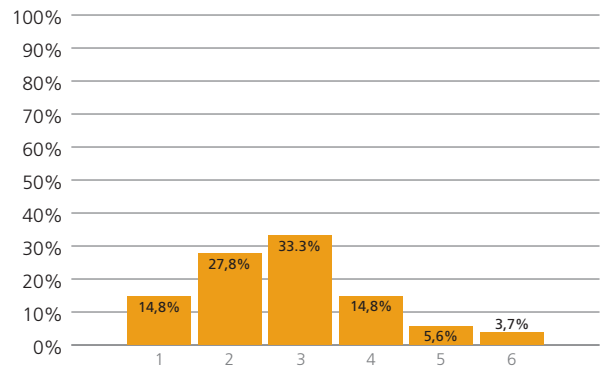
The standard deviation for the alternative solutions show the same picture as the top important items, with a good measure of agreement, whereas the lower ranked items show a lower degree of agreement. However, this trend is not so pronounced as it is for ‘important items’.

Some of the questions with a high standard deviation are interesting and are studied in more detail below.

‘Same design speed as existing design’ (rank 25, score = 3.11, std dev 0.92) produces a fairly even distribution around the middle. Does this mean that the respondents are uncertain and tend to go for the intermediate or neutral response? The same pattern is also observed for some of the other alternative solution questions, particularly those that represent novel ideas for container ship use.



»»
Fig.3: Same design speed as existing design.



»»
Fig.4: Pod propulsion as used for cruise ships.



‘Pod propulsion as used for cruise ships’ (rank 21, score = 2.80, std dev 1.24) gets a low score and a high standard deviation. In this case, too, there is a peak in the middle, with a fairly even distribution on each side but with a bias towards ‘reluctant’. Still, more than 20% (4 and 5) consider this interesting.

The same pattern is repeated when considering ‘flexible engine configuration, using multiple engines’ (rank 18, score = 2.94, std dev 1.10), and ‘electric propulsion systems with flexible fuel’

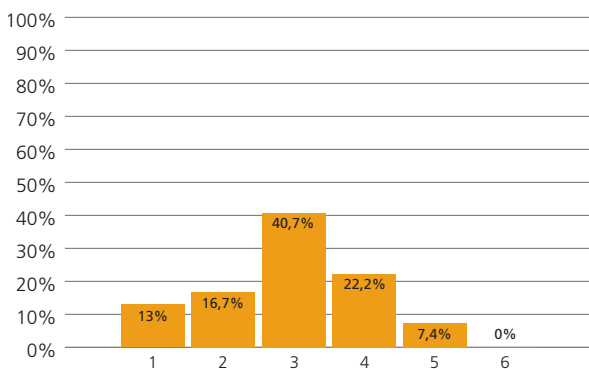
(rank 12, score = 3.39, std dev 1.08). The peak score is close to the middle, with almost even distribution on each side but with more than 20% (4 and 5) interested in both questions.

We have highlighted these questions as they are solutions which have been chosen for the design we have put forward in our project as a viable future container ship design.

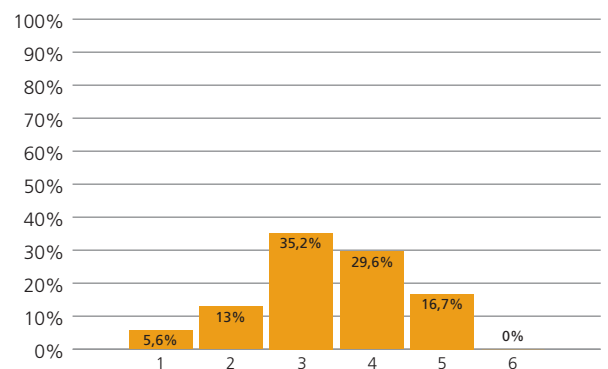
Questions like high fuel efficiency, flexibility for speed variation and schedule integrity are difficult to combine in one

design using proven and well established technology. We have therefore recommended alternative solutions to better achieve this goal. The cost issue has not been studied in detail in this project, but it is recognised that some of the solutions put forward require capital expenditure which is not fully covered in our project. However data is available as all the solutions are commercially viable today and the technology is in use. ●

Knut.Dohlie@dnv.com



»» Fig.5: Flexible engine configuration using multiple engines.



»» Fig.6: Electrical propulsion system with flexible fuel.

Seeing the ship in a transport system context

When considering investments in new container ships, it is vital to understand how the design will perform in the trade it shall operate. By better understanding the different operational demands that a trade might entail, a company is more likely to acquire ships that will operate efficiently and yield greater profit. DNV has developed methods and tools to evaluate different designs against various market and operating conditions. For the selected loop between East Coast South America (ECSA) and Europe three different ship designs optimised for different service speed has been evaluated.

TEXT: INGAR BERGH

TRANSPORT SYSTEM MODEL

DNV has developed a model to evaluate how a ship will perform in any given liner service to ensure that new designs/solutions are adapted to best serve a given trade. The model considers a range of data related to trade and operational issues like sailing speed, cargo volumes, weight/container ratio, reefer capacity, trade imbalances, cargo handling speed, etc. When a new design is tested using the model, a set of performance measures are found, including payload scenarios, power curves, fuel consumption and carbon footprints.

CASE DESCRIPTION

Based on the input from a market review, a case has been constructed to highlight some of the critical issues. The case is based on a typical ECSA–Europe liner service and is depicted in Fig.1. The trade is characterised by a high reefer share and a significant trade imbalance between eastbound and west-



» Fig.1: Typical ECSA–Europe liner service.

bound cargo. The model service is served by six ships and has weekly departures and a total of ten port calls.

OPERATION PROFILE

The operations profile in a trade is compiled by the time spent in several different states. For a typical container trade, the states may be ‘Loading/ unloading’,

‘Waiting in port’, ‘Sailing loaded’, ‘Sailing ballast’, ‘Port manoeuvring’ and ‘Off-hire’. In the Quantum case, about 60% of the time is spent in the condition ‘Sailing loaded’, with an average Mean Continuous Rating (MCR) of slightly less than 80%. The remaining 40% of the time is spent in connection with port calls (including buffer-time to keep to schedule) at an MCR of between 10 and 25%. See Fig.2.

The time spent in the different states is distributed across the ten legs, with each leg having its individual operational pattern. In Fig.3, the time and average engine load on the different legs can be seen (each leg contains all the states seen in Fig.2). Some factors are particularly worth mentioning. Firstly, the shorter legs will naturally have a low average MCR as a smaller percentage of the leg is spent in the ‘Sailing loaded’ state and a larger percentage is spent in port-related activities. Secondly, Leg 4, being a transatlantic voyage from Europe to South America, has a fairly low MCR due to the low average capacity utilisation (few loaded containers), low average weight of loaded containers and low share of reefer containers. On the return transatlantic voyage (Leg 9), the average MCR is more than 60% higher than leg 4 because of the high utilisation, weight and reefer share.

		Baseline	Change	
Speed	knots	25	-4	-8
Number of ships required		6	+1	+2
CO ₂ emitted	Tons	852,000	-175,000	-297,000
Bunkers cost (at USD 500 per ton)	MUSD	134	-27.6	-47
Total annual operating costs	MUSD	100%	-9%	-14%

Table 1: Changes in crucial output parameters when operating a selected service with different ship designs optimised for different service speeds.

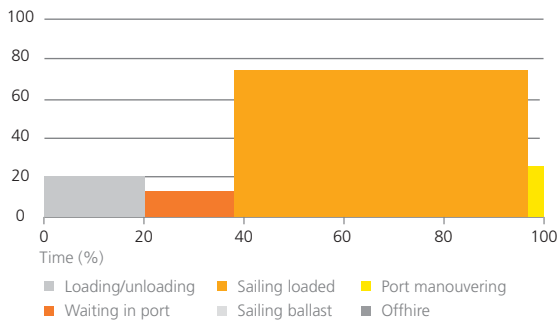


Fig.2: Time and average % of engine power used in the different states for an ECSA-Europe roundtrip with the 25 kn scenario.

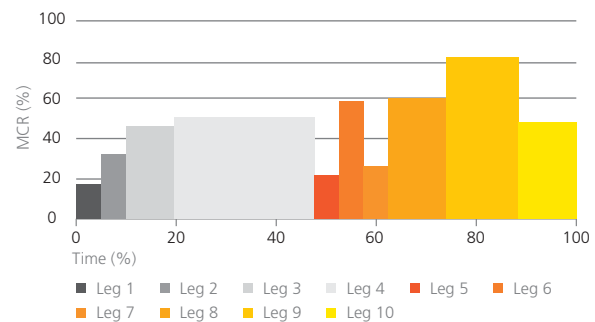


Fig.3: Different average MCR and average time spent on legs during an ECSA-Europe roundtrip.

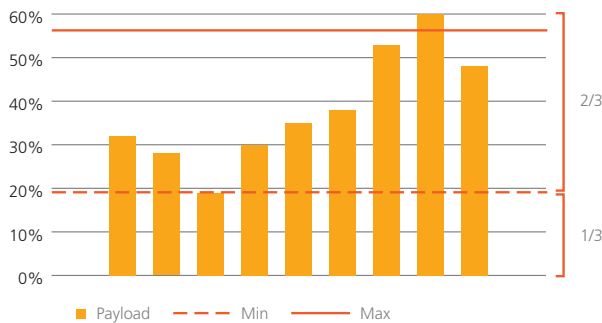


Fig.4: The variation in utilisation of payload capacity during an ECSA-Europe roundtrip.

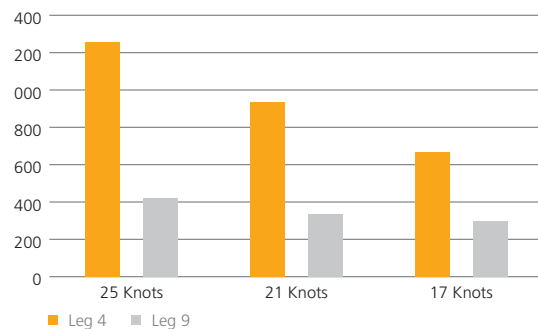


Fig.5: Carbon footprint for a container on Leg 4 and Leg 9 according to the different design scenarios.

Clearly, these kinds of imbalances will influence what is the best design compared to a case where there are few short legs and little variation in payload between the legs.

Fig.4 illustrates the variation in payload capacity utilisation. From the figure we can see that the payload utilisation on the leg with the highest utilisation is triple that of the leg with the lowest utilisation.

SCENARIO OUTPUT

Figures 2, 3 and 4 all represent the 25 knot scenario and illustrate how the engine and designs have to cope with a wide range of loads due to different factors, all related to the ships’ expected modus operandi.

When implementing the different design speed scenarios, the crucial issue is to evaluate not only the effect on the individual ship operations but also how the design speed affects the entire service in areas such as cost, fuel consumption,

CO₂ emissions or required number of operation days.

In Fig.5, the carbon footprint from delivering one TEU between the last port in Europe and the first port in ECSA is reduced from 1.3 tons to 0.7 tons by using a ship designed for (and sailed at) 17 kn compared to the 25 kn ship. However, by reducing the speed, two more ships are needed to uphold the service level (one weekly port call) and the number of annual service days required increases from 2,200 to 2,900.

Further calculations show that the total cost of the system including capital expenditure, operating expenditure and fuel cost will decrease by 14% and the total CO₂ emissions will be reduced by 35%. Calculations of the EEOI (Energy Efficiency Operational Indicator) as suggested by IMO, gives a similar decreases from an average of 510 to 330 grams of CO₂ per TEU-nm.

Based on these assumptions, it can be

seen that the 17 knot scenario will be the best solution for the selected service.

However, when also considering inventory costs and delivery time requirements, the 21 knot design speed will be the best alternative. This speed will also give good flexibility for variation of speed in both directions.

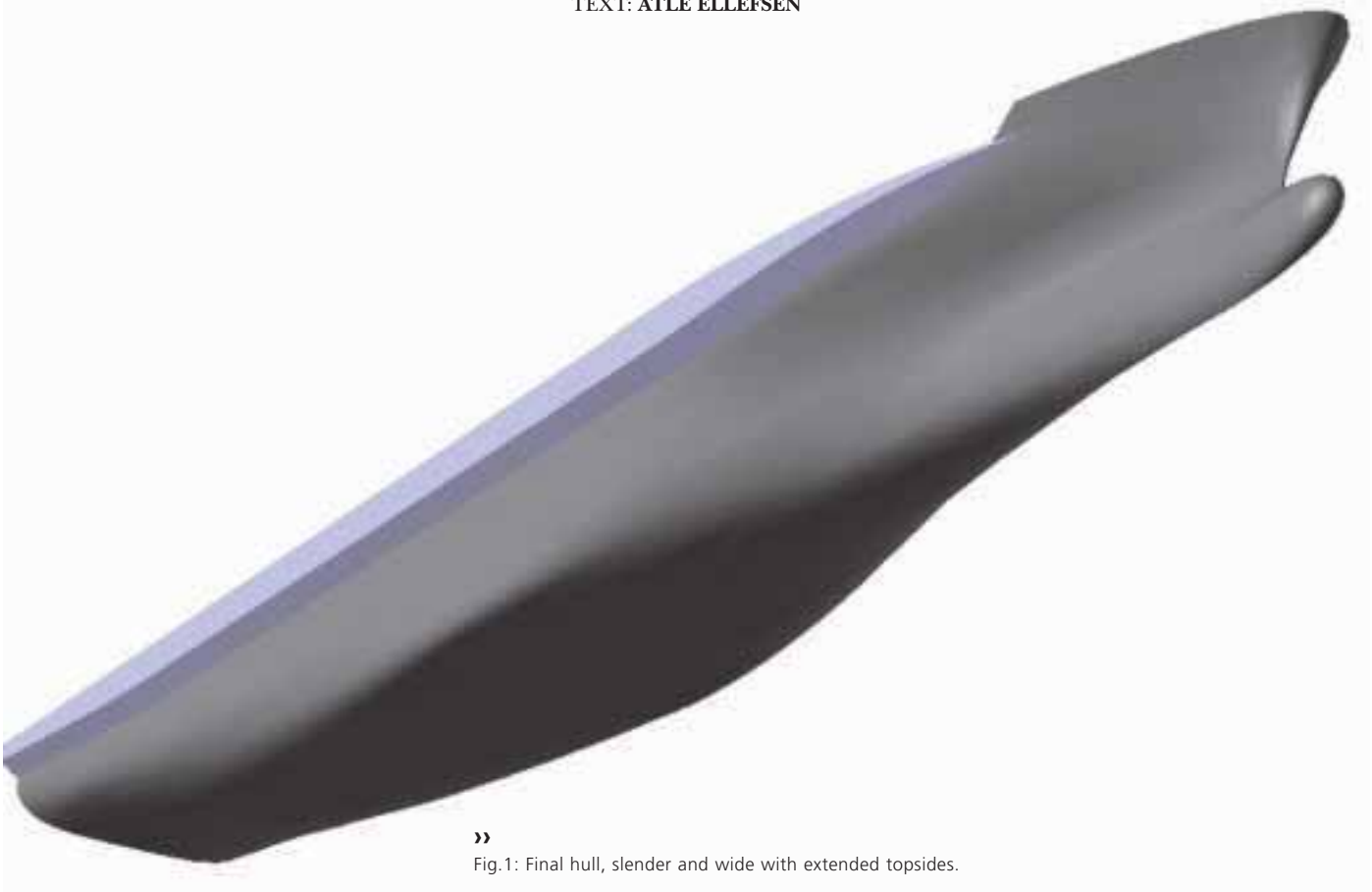
As has been demonstrated, the operational cost and environmental footprint will change significantly if even relatively small changes are made in the trading speed. The requirement that a ship must be flexible, which is to say that it should be energy efficient over a larger range of speeds than before, must therefore be reflected in the way that the power production and consumption are configured as well as in the hull design itself. ●

Ingar.Bergh@dnv.com

The conceptual hull design

The Quantum concept design consists of a ‘baby post-Panmax’ of 6,200 TEU with a slender monohull, low block coefficient and 10% increased container capacity. Alternative hull forms were studied and discarded. The design speed was set at 21 knots based on studies of the logistics and technical aspects, but the ship can sail at higher or lower speeds. The ship may be suitable for the Europe to East Coast South America service.

TEXT: ATLE ELLEFSEN



»

Fig.1: Final hull, slender and wide with extended topsides.

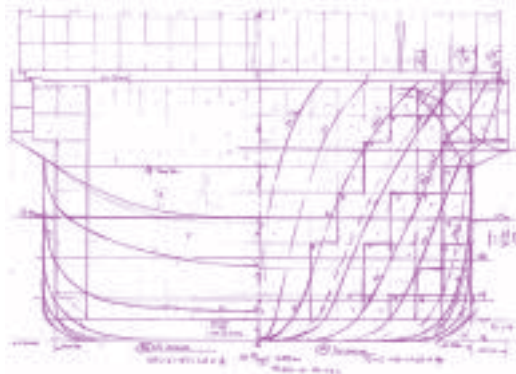
“Design a baby post-Panmax container ship for the Europe to South-East America trade, carrying about 5,500 TEU” was the task we were given. To benchmark our efforts, an existing container ship of recent design and similar capacity was chosen as a reference ship.

Our initial brainstorming sessions suggested that flexibility regarding speed, draught and cargo composition would

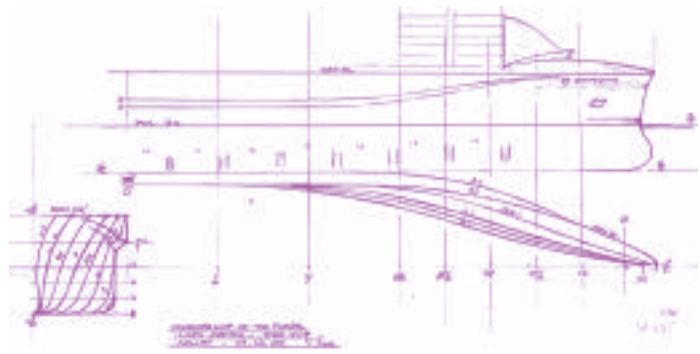
be important in the future. Although almost all current ships of this size are designed for a speed of 24–26 knots, the average roundtrip speeds may be less. The high speed is necessary in order to maintain the schedule and catch up possible delays. However, in the present market, the ability to slow steam at 21 or even 18 knots is an important feature. Lower speeds may also become a perma-

nent feature given future emission legislation and fuel prices. We therefore made the bold decision to reduce the design speed to 21 knots. The design speed determines the hull’s fullness, shape and main dimensions. With a lower speed, we needed to find the best combination of these parameters.

Naval architects typically turn to multi-hulls when thinking of ground-



» Fig.3: Midship section alternatives and lines materialising.



» Fig.4: Early bow lines sketch.

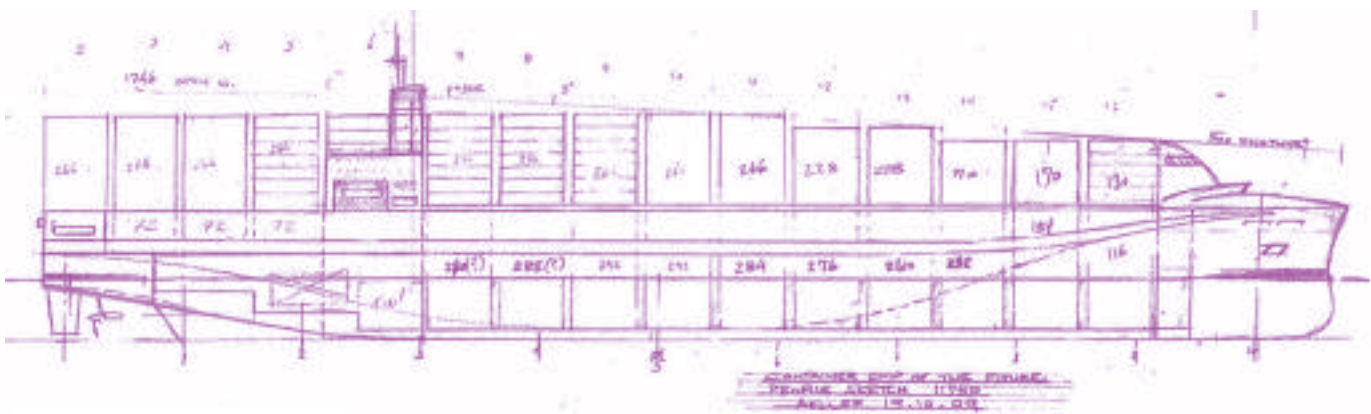
breaking ship designs. DNV's Ro-Ro concept design 'Momentum' successfully ended up as a trimaran, so could the same concept work for the Quantum project? Ro-Ro ships carry a volume cargo and have a moderate displacement compared to the huge volume needed. Their cargo decks are consequently stacked high, requiring a significant amount of ballast. With the trimaran

side hulls taking care of stability, the need for ballast was reduced by about 8,000 tonnes.

However, container ships are different, carrying much more weight-driven cargo. Our container ship displaces 75,000 tonnes, which if applied to the Momentum would indicate a 350-metre-long hull, about a full one hundred metres longer than the reference

container ship. So that alternative was excluded.

The catamaran concept was also dismissed. The Froude number is too low to benefit from the high length to beam ratio. The wetted surface is larger than on a monohull, increasing resistance. Two slender, separated cargo holds with narrow ends cannot match the efficiency of a single box hull. A catamaran may



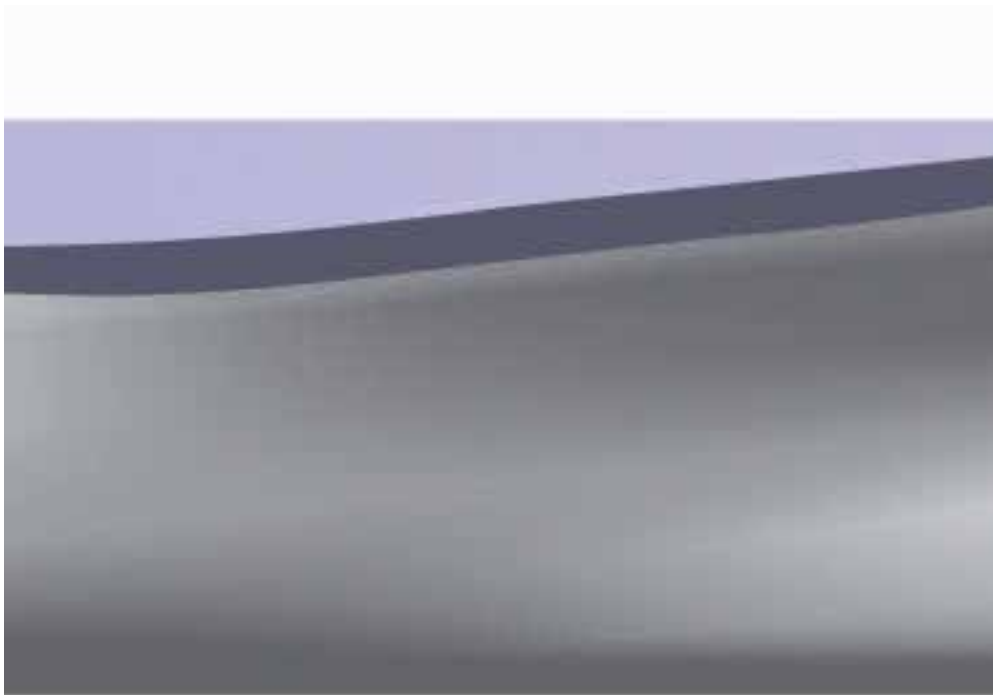
» Fig.2: An early profile sketch.

work for smaller feeder ships carrying deck cargo only, but for deep sea operation we ultimately concluded that a mono-hull was the way ahead.

Of various midship sections, the trapezoid shape has been a popular albeit seldom realised idea. The inclined sides diminish the beam at low draught, thus reducing the wetted surface and resistance. Propeller immersion is maintained, allowing a high propeller diameter. Such a 'two ships in one' concept is feasible for ships trading on an out-bound-homebound type of route with a deep draught on the outbound leg and a lighter draught on the homeward one. The market review told us, however, that the draught is near constant on our container run. Thus a straight-sided midship was decided upon.

Even today, rough sketches, scribbles and quick hand calculations are typical of the early design process. A number of sketches were made of midship sections, lengths, container counts, profiles and details. A 5,500 TEU ship with an NPX beam of 49 metres would, not surprisingly, be short and full, with a large wetted surface, a blunt bow, a very shallow draught, a small propeller, unfavourable course-keeping and a high risk of harmonic pitch. Since none of these attributes form part of a naval architect's dream of a liner, we came up with the 'aircraft carrier' solution.

The idea of this concept is that more containers can be carried above the waterline without increasing the resistance and fuel consumption, since the under-water part of the hull is unchanged. After juggling with structures, container rows, power curves and stability, the breadth at the waterline was ultimately optimised at 42.5 metres for maximum fuel efficiency and we decided on 16 containers across at amidships and a novel narrow side tank. Retaining the NPX beam (<49m) topside, the ship's length ended up at 272,3 metres. Leaving our hydrodynamic experts with free hands to shape the best



possible lines within these constraints, the final block coefficient is a very low 0.57, with very low resistance and thus high fuel efficiency. With the wider deck, the design could still carry 6,200 TEU, 700 more than the reference ship, thus offering added economy of scale.

An important project goal was to reduce or even eliminate the need for ballast. This is probably the most beneficial measure for future ship designs – due not only to the significant amount of energy required to transport this sea water across the oceans but also to the costs of treating ballast. Partly achieved by the wide beam but challenged due to the high cargo stowage topside, the freedom from ballast is dependent on sophisticated loading procedures. The need for ballast water for stability is eliminated for most loading conditions. However, the ship cannot be loaded with full flexibility in the longitudinal direction since the trim needs to be kept within limits.

A number of features were added to the core design, such as an elongated,

raked bow with less flare in order to reduce speed loss in waves and slamming. A straight bow in order to maximise the waterline length was considered but found to be too wet. A large wave breaker is integrated in the foc'sle cap in order to deflect the corresponding increase in spray and a huge wind deflector is located in front of the foremost deck container stack in order to reduce wind resistance. Alternative lightweight material may be considered for these parts of the structure.

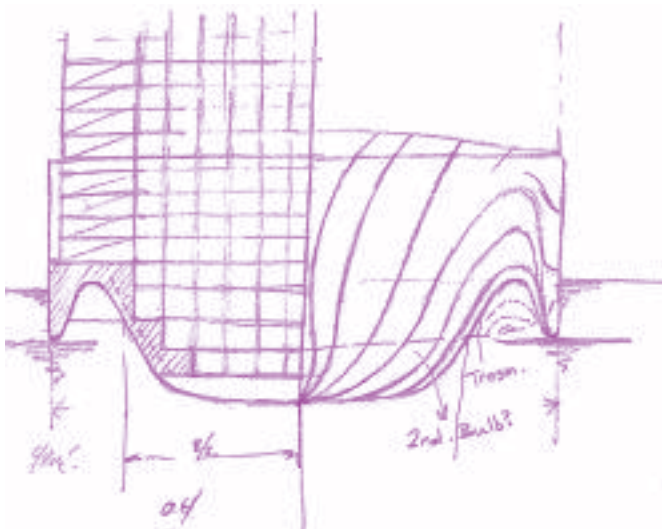
The final concept's innovative factors are: the wider beam, which increases stability and practically eliminates the need for ballast; the wide deck enabling the carriage of more containers without increasing the fuel consumption; a slender hull with high fuel efficiency; a better bow for sea-keeping; the strength-efficient narrow double side box construction which saves space; the use of lightweight materials where possible; and the reduced wind resistance. ●

Atle.Ellefsen@dnv.com



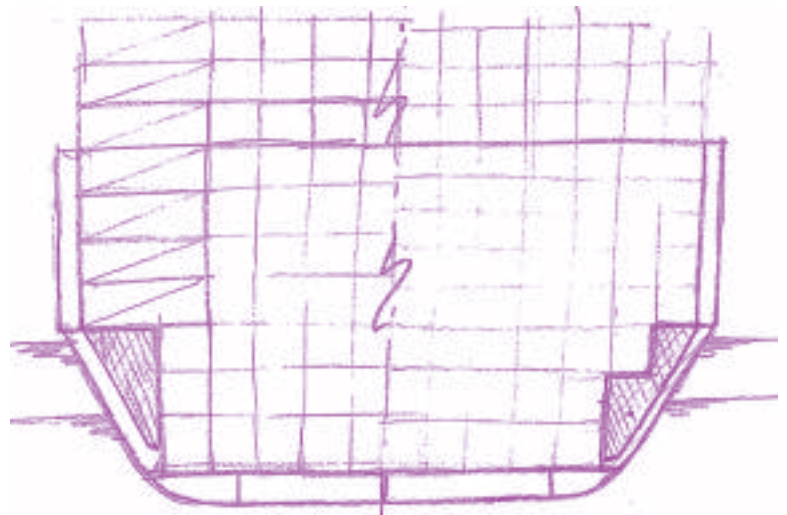
»

Fig.7: Final bow profile is slender and raked, to soften head seas.



»

Fig.5: Trimaran suggestion with transverse stowage of outboard containers was considered, but not used.



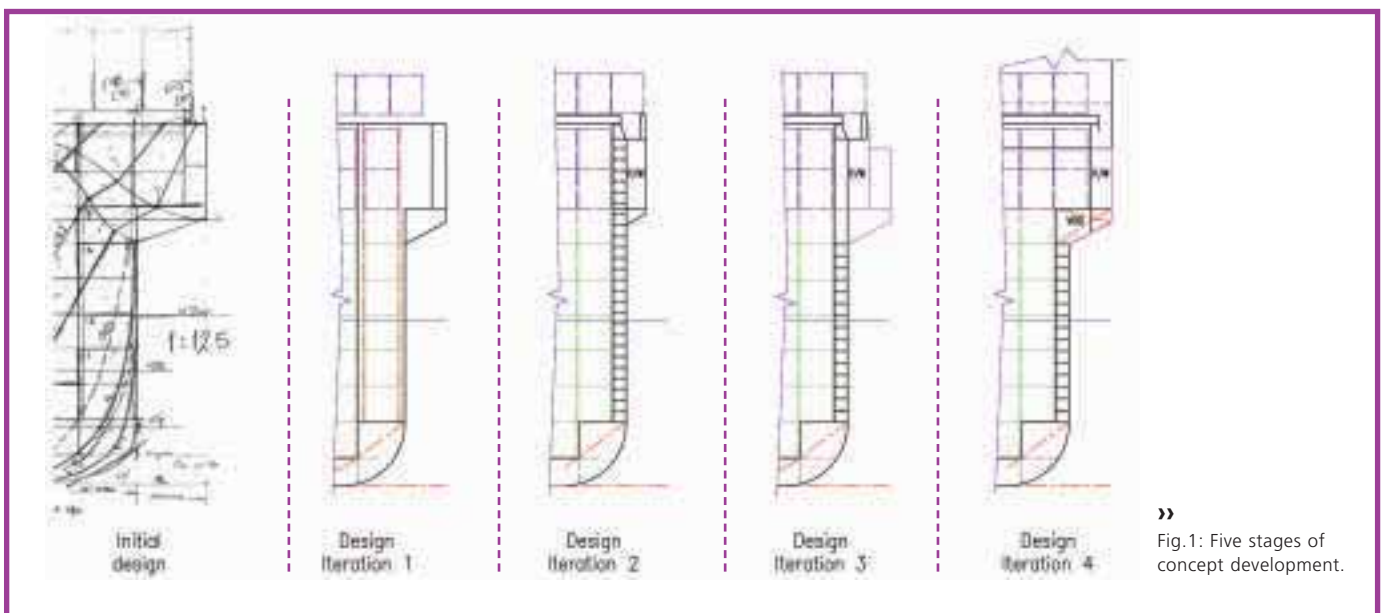
»

Fig.6: Trapezoid midship was abandoned due to small draught variations. Note suggested stowage of outboard containers.

General arrangement and LNG tank arrangement

Developing the General Arrangement drawings is a task that requires close interaction with most of the other disciplines in a concept study. It is also important to have good knowledge about existing and future rules and regulations which may effect the general arrangement. For Quantum, the LNG tank arrangement was a particular challenge.

TEXT: HARALD BERGSBAK



To produce drawings in a pulsating innovating team is a challenging task, involving parallel processes like making drawings, while container arrangement and hull structure continuously changes as a result of design iterations. Frequent project meetings with experts from relevant disciplines like stability, strength, noise & vibration, propulsion, machinery, hydrodynamics and CFD, yard/production, cargo handling and operation are all parts of the process to arrive at the optimal design. In such a process you also need to be pragmatic and not lose sight of the overall goal.

DESIGN ITERATIONS OF SIDE HULL

For illustration, some of the design iterations carried out for the side hull is shown in Fig.1.

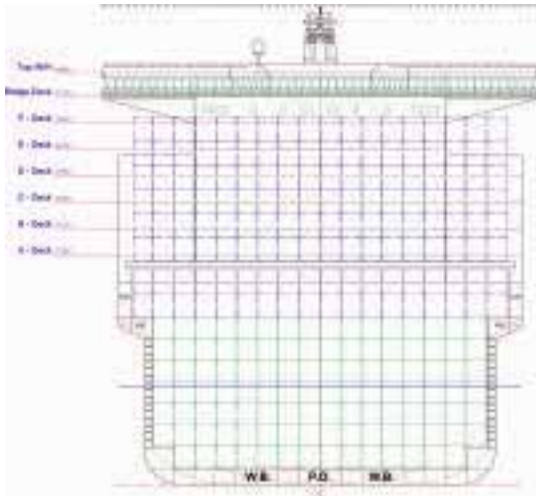
- 1. Initial design:** This design was developed in a small group with core competence on ship design and innovation. The initial idea was to design a wide double side, to be used for container stacking.
- 2. Design Iteration 1:** The initial design was further developed in workshops and meetings. Challenges and obsta-

cles from the initial design was identified with regards to strength of side hull and container stacking.

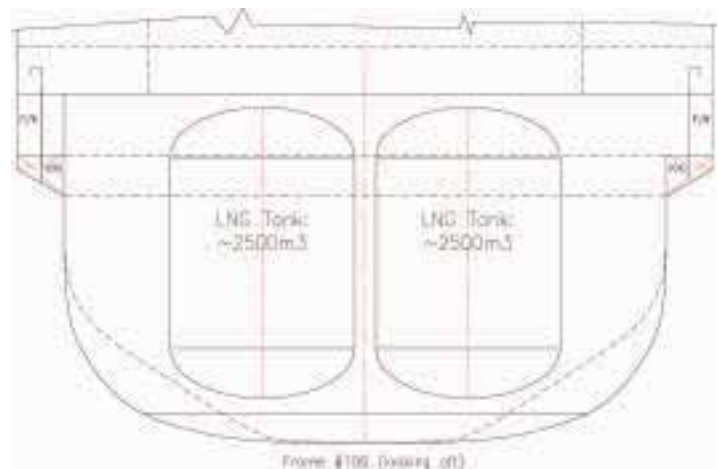
- 3. Design Iteration 2:** A new slender side hull with passageway outside the main hull was proposed, with the aim to maximise the container capacity while achieving enough space for longitudinal piping etc.
- 4. Design Iteration 3:** This iteration was mostly a back and forth discussion on many design issues, such as strength, operation, and maintenance.



»» Fig. 2: Quantum general arrangement drawing.



»» Fig. 3: Quantum midship section.



»» Fig. 4: LNG tank section frame.

5. Design Iteration 4: The final design was based on a holistic approach to all previous iterations, trying to achieve the optimal balance between container capacity, strength, maintenance, operation, and simplicity of construction.

CONTAINER CAPACITY

An Excel file that represents the GA/ Container stacking was developed quite early in the project. This file is flexible and available for all project members; easy to test out different configurations, plan reefer capacity and useful for identifying possible challenges. See Fig. 5.

GENERAL ARRANGEMENT

The general arrangement drawing for Quantum is shown in Fig. 2. In Fig. 3 a typical midship section with the new WidedecK™ concept is illustrated. With the WidedecK™ solution the deck capacity increases with two additional rows. This gives a total container capacity of 6,210 containers of which 3,336 is on deck and 2,874 is in hold.

LNG TANK ARRANGEMENT

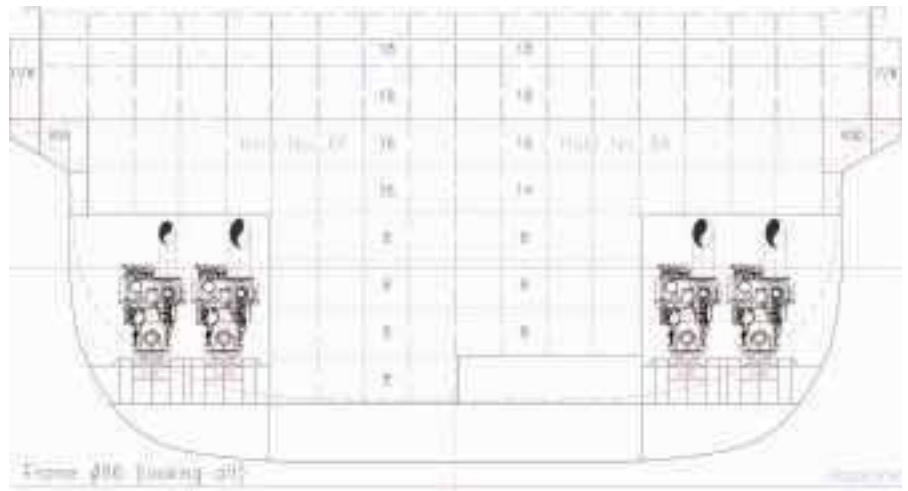
The main challenge was to locate and arrange the targeted LNG storage capacity of approximately 5,000 m³ LNG, divided

on two tanks, each of ~2,500 m³. Cylindrical, pressurized tanks (IGC tank type C) were chosen, due to their proven technology. All LNG fuelled ships operating today use fuel tanks of this type. They could also be made in a double cylindrical shape (Bi-Lobe type) to save space. Prismatic LNG fuel tanks (IGC tank type A, non-pressurized) are under development, and may in the future be used to reduce the space needed for LNG storage.

Cylindrical vertical & horizontal versions of different diameters were investigated, and we decided on two vertical tanks with a diameter of 13m for our

concept, based on an overall 50/50 split on MDO and LNG. See Fig.2 and Fig.4.

The LNG tanks will occupy most of the traditional engine room space below the accommodation, but the dual-fuel electrical arrangement gives us the flexibility to utilise some of the space not suitable for containers. Some container slots have to be sacrificed, but this is the case also for pure fuel oil based ships due to new requirements (MARPOL, regulation I/12A). See Fig. 6 and Fig. 7. ●



»
Fig.7: Machinery arrangement.

Tier No.	Total TEU	8	7A	7F	6A	6F	ACCOMODATION	5A	5F	HATCH C	
		58	54	50	46	42		38	34		
		59 57	55 53	51 49	47 45	43 41		39 37	35 33	31	
96	268	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
94	432	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
92	516	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
90	516	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
88	516	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
86	516	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
82	516	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
80	36	18 18	18 18	18 18	18 18	18 18		18 18	18 18	18	
MAINDECK		HATCH C MAIN									
18	444		18 18	18 18	18 18	18 18	ENGINE ROOM	18 18	18 18	18 18	
16	440		18 18	18 18	18 18	18 18		18 18	18 18	18 18	
14	396		16 16	16 16	16 16	16 16		16 16	16 16	16 16	
12	366		14 14	14 14	14 14	16 16		16 16	16 16	16 16	
10	320		12 12	14 14	14 14	8 8		16 16	16 16	16 16	
08	280			12 12		8 8		14 16	16 16	16 16	
06	244					8 8		14 14	16 16	16 16	
04	212							14 14	14 14	16 16	
02	172							12 12	14 14	14 14	
Σ TEU Ship 6210											
Σ on deck/Bay		144 144	126 126	126 126	126 126	126 126		126 126	126 126	126 126	
Σ in cargo/Bay			78 78	92 92	90 90	100 100		138 140	144 144	144 144	
Σ Total/Bay		144 144	204 204	216 218	216 216	226 226		264 266	270 270	270 270	
40' Reefers on deck - 2 Tiers 516		36	36	36	36	36		36	36		
40' Reefers on deck - 3 Tiers 774		54	54	54	54	54		54	54		

»
Fig.5: Container counting – Excel.

Resistance evaluation and hull parametric study

The design speed for the Quantum has been set at 21 knots, quite a lot lower than the common speed for modern container ships. The hull needed to be redesigned and CFD software has been used to support the study using various hull parameters. The resulting ship has a block coefficient which is lower than conventional designs but is wider.

TEXT: GABRIELE MAZZA

DESIGNED FOR A RANGE OF SPEEDS Slow steaming has become a hot topic in the shipping business these days and container ships are right in the middle of this discussion. It is not unusual to see ships designed for 24–26 knots operating at below 20 knots.

The market study presented earlier in this magazine recommended a design speed of 21 knots for the Quantum. However, the ship is expected to operate over a wide range of speeds in the future.

Modern engines and propulsion systems are designed to be very flexible and are capable of running at various power settings. However, the ship as a system will operate at a high efficiency

level only if the hull is also designed to operate at off-design conditions. A hull design that is flexible with respect to the operating speed and displacements will translate into a reduction in fuel costs and emissions to air, thus making the ship more profitable and greener.

WILL SLENDER HULLS BE THE OPTIMUM APPROACH FOR NEW CONTAINER SHIP DESIGNS?

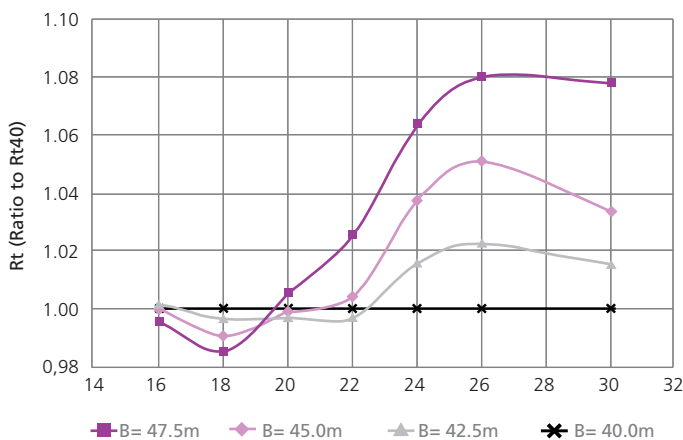
The new Panama Canal dimension gives designers more freedom when determining the hull length and breadth; the maximum draft is still restricted by port limitations.

Several hull parameters need to be screened in order to optimise the hull

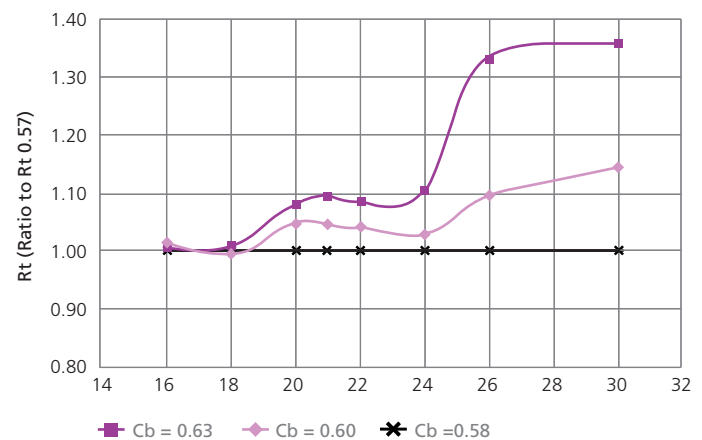
efficiency: length, breadth, block coefficient, longitudinal centre of floatation and bulb shape, among others.

Computational Fluid Dynamic (CFD) tools can be used at an early design phase to optimise the main hull dimensions as potential flow computations allow rapid calculations. The wave patterns (see for example Fig.1) and the pressure distributions on the hull can be estimated and used to compare different possible design alternatives as well as to evaluate the relative importance of each resistance component (wave making and viscous resistance).

Once the Quantum's target displacement and design draft had been selected, a study was carried out to determine



»»
Fig.2: Hull resistance for different ship breadths shown as a ratio to the 40m hull.



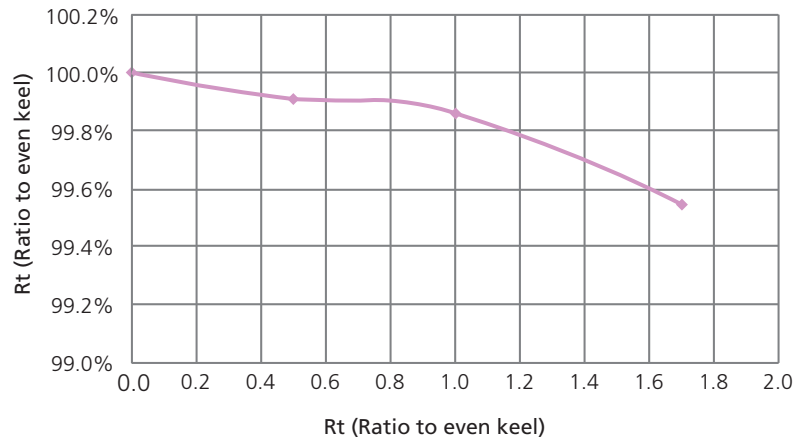
»»
Fig.3: Hull resistance for different block coefficients shown as ratio to the 0.57 hull.

the optimum hull block coefficient. The optimum block coefficient is closely related to the ship length Froude number. It was found, for a range of speeds around the design speed, that the best block coefficient is 0.57.

A new study was then carried out to find the optimum combination of breadth and length. The breadth of a container ship can only be varied in steps driven by the container width. Starting with a beam of 40m, the breadth was increased to 47.5m in 2.5m increments. The next step would be over the maximum breadth of 49m allowed by the new Panama Canal.

The effect of the change of breadth and block coefficient on the hull resistance is illustrated in Fig.2 and 3. The figure covers a speed range from 16 to 30 knots. The resistance is shown as a ratio between the hull with the new breadth and the one with a breadth of 40m.

The most efficient hull at the design speed of 21 knots is the one with a breadth of 42.5m; the waterline length would consequently be about 260m. This hull is also the one least penalised for off-design conditions over the entire speed range.



»

Fig.4: Trim effect on the hull resistance of the design draft at the design speed.

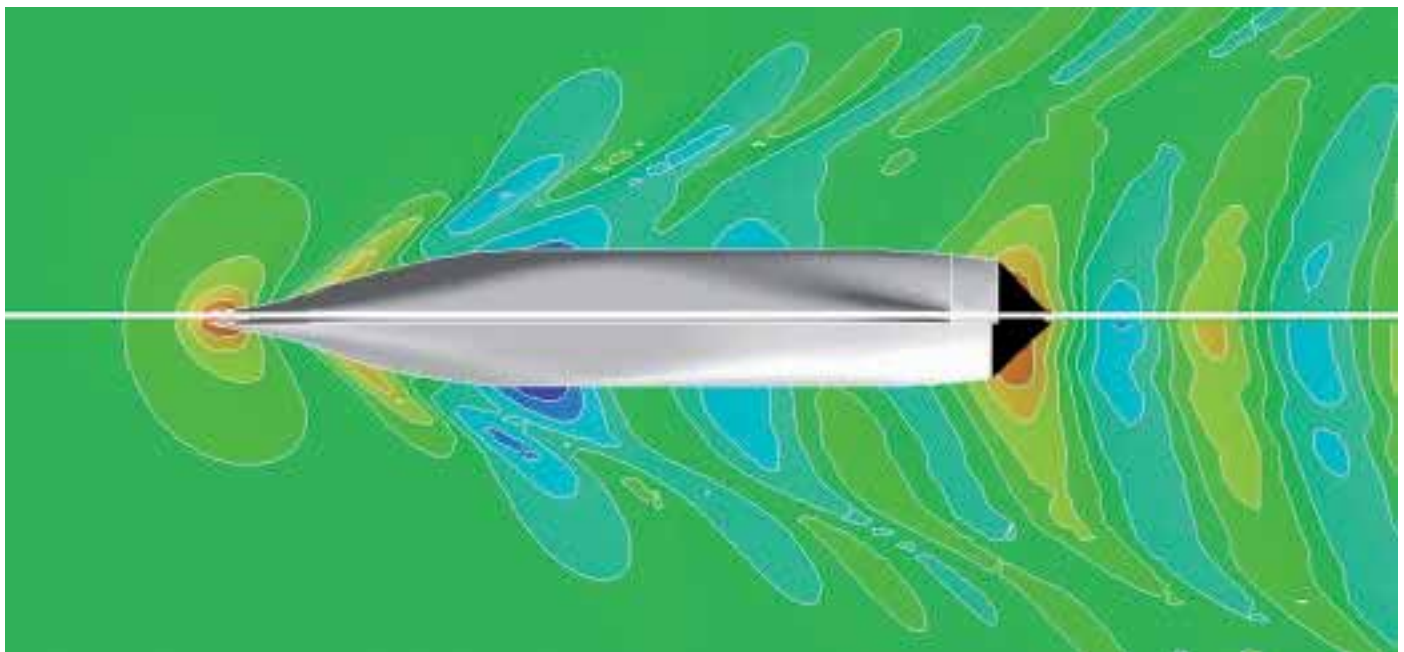
POWER ESTIMATION AND TRIM CHECK

A preliminary estimate of the power required for the engine and propulsion selected was carried out using CFD simulations based on the final hull parameters. For the final power estimation, towing tank model tests should be carried out to complement the numerical simulations.

Container ships operate at multiple trim and draft conditions because of the

type of cargo they carry. It is possible that a large trim by the stern (transom immersion) or by the bow (loss of effectiveness of the bulb) may influence the hull efficiency. Fig.3 shows that for this specific hull at the design draft of 12m and design speed, the influence of trim is marginal. ●

Gabriele.Mazza@dnv.com



»

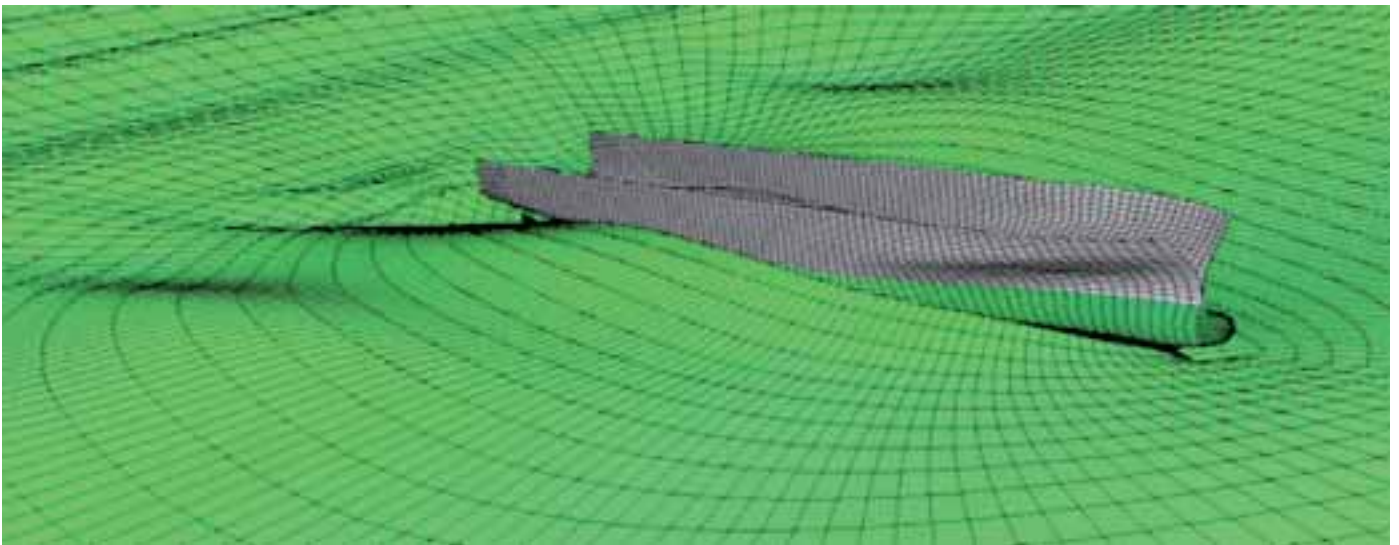
Fig.1: Wave patterns for two different hull designs.

Added resistance in seaways

– optimising the hull for seagoing conditions

Due to a lack of adequate computational tools, ship hulls have traditionally been designed for optimal performance in calm waters. In seaways, ships will be exposed to additional forces resulting in motions and added resistance. The seakeeping computer program DNV-Wasim has been extended to calculate the added resistance when taking such effects into account. By using this tool in the design phase, the hull can be optimised for more realistic conditions.

TEXT: JENS BLOCH HELMERS



»

The Wasim simulation carried out for Quantum at resonant ship motions reveals the hull's added resistance in waves.

DNV-Wasim was applied in order to investigate the effect of trim on added resistance for the Quantum design. The level of added resistance depends on the hull shape, loading condition and how the ship is operated in the actual sea state. When added resistance is at its maximum, a dominant contribution is related to the concurrent distribution of relative wave elevation along the hull. The change of wetted area has implications for several physical effects that should be taken into consideration.

It is quite common for an optimal design with respect to calm water resist-

ance to have a detrimental effect on added resistance and vice-versa. For instance, some optimised bulbous bows may increase the added resistance in certain wave conditions. Another example is the effects of a slender hull, which may have excellent calm water resistance but potential increased pitch motion – hence increased added resistance.

A good design should take both calm water and seaway operations into account. DNV-Wasim is now an important tool in that respect, in addition to other advanced seakeeping assessments. As well as assessing the ship's added

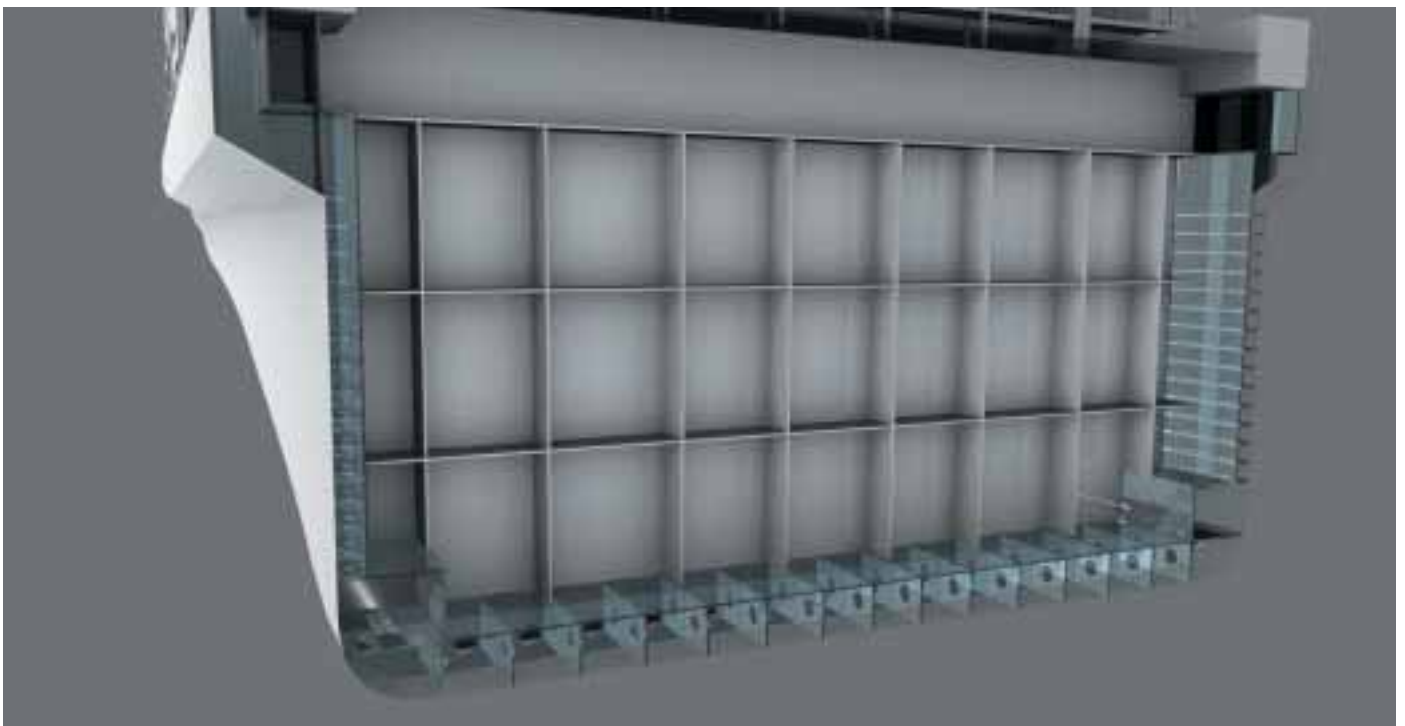
resistance characteristics, the new post-processor WaqumExplorer can assist in investigations into optimal routing and course keeping.

It is well known that draft and trim may have a significant influence on the calm water resistance of ships, and various calculation programs and empirical data exist for such assessments. However the corresponding effects in seaways have been a difficult research topic for years and no commercial tools are available. ●

Jens.Bloch.Helmerts@dnv.com



» Boxes in boxes lifting arrangement.



» Midship section.



Container ship
A DNV Innovation Project



» The model of the Quantum concept is on display at the DNV headquarter reception.



Lightweight structures

Steel is a strong and durable material. However, lightweight structures offer a range of opportunities to build a green, efficient, profitable and reliable container ship at a competitive price. For Quantum, weight savings of 1,100 tonnes have been achieved by using composite structures.

TEXT: PHILIPPE NOURY AND KRISTOFFER BRINCHMANN

Lightweight composite structures have a wide and compelling track record in weight-critical marine applications, such as high speed light crafts. They offer opportunities for not only major weight reduction but also reduced maintenance costs due to better corrosion and fatigue properties. The results of R&D projects have demonstrated that weight savings of 30–70% can be achieved with lightweight composites compared to traditional steel structures.

Until recently, the SOLAS regulations required load-bearing structures to be

made of non-combustible materials. However, a recent amendment to these regulations now allows the use of composite materials provided that adequate safety is demonstrated by a risk assessment and a fire engineering analysis.

WEIGHT SAVING IN QUANTUM

For Quantum, a study was first carried out to screen the potential application areas in order to estimate the weight reduction potential and acquisition cost and identify the most promising solutions. The focus was then put on the

superstructure, piping and hatch covers based on feasibility and potential. The results of the study showed that, by using a glass fibre reinforced plastic (GFRP) composite sandwich construction, a significant weight reduction in the range of tonnes 1,100 can be achieved by only focusing on these items.

The use of 1,200 FEU reefers is another area with opportunities, where increased volume capacity, weight saving and a reduction in the power used by cooling units can be achieved. Foam core sandwich structures offer the addi-

SANDWICH STRUCTURE

A structural sandwich is a special form of a laminated composite comprising of a combination of different materials that are bonded to each other so as to utilise the properties of each separate component to the structural advantage of the whole assembly.

COMPOSITE SANDWICH STRUCTURE



TYPICAL MATERIALS

Face Materials:

- Fibre-reinforced plastics laminates, e.g. glass fibre and epoxy resin
- Metal sheet

Core Materials:

- Foam
- Balsa wood
- Elastomer
- Honeycomb

KEY PROPERTIES

- High stiffness to weight ratio
- High strength to weight ratio
- Good fatigue and corrosion properties

DESIGNER FLEXIBILITY

- Properties can be tailored
- High margin against catastrophic failure
- Dampening of noise and vibration
- Improved thermal insulation

tional benefits of an integrated insulating function in addition to stiffness and an improved strength to weight ratio. The weight saving potential is estimated to be about 2,000 tonnes compared to a traditional steel design for 1,200 TEU reefers.

Weight reduction could be directly turned into financial benefits in two different ways: to reduce fuel consumption and CO₂ emissions and/or to increase the service speed and operation range. The reduction in fuel consumption was estimated to be in the order of 1–3.5% based on weight savings of 2,000–5,000 tonnes.

OTHER BENEFITS FRP materials are subject to little or no corrosion if used properly. Such materials are virtually maintenance-free, producing low running costs. Stress concentrations are less critical than with metals, hence fatigue cracking is less of a problem. For

instance, it is estimated that the fatigue life of composite piping in seawater is 20 years compared to seven for steel piping.

Two of Quantum's special features are the large wind deflector and wave breaker located in the fore. Both components are to be built in GFRP because of this material's low weight and superior corrosion resistance and the ease with which it can be formed into complex shapes.

COSTS

The cost of materials for a lightweight structure is higher than for an equivalent steel structure. However, building large quantities for large structures produces lower prices. Studies of FRP marine structures show that the total cost (materials, fabrication, finishing and installation) varies from about 0.6 to 2 times the cost of an equivalent steel structure. The operating cost is

assumed to be lower than that of a traditional steel structure. Hence, a small initial investment of a few per cent of the construction costs may yield significant lifecycle savings. Whether or not a lightweight construction is commercially attractive depends largely on the intended trade and how those new benefits are capitalised on.

RECYCLING

The recycling of composite materials is becoming an important topic as the volume of composite used in the world is growing fast. No universal solution for recycling composite materials has yet been found. Nevertheless, there are a number of promising technologies that have been and are being tested with two kinds of valorisation: thermal and material. ●

Philippe.Noury@dnv.com
Kristoffer.Brinchmann@dnv.com

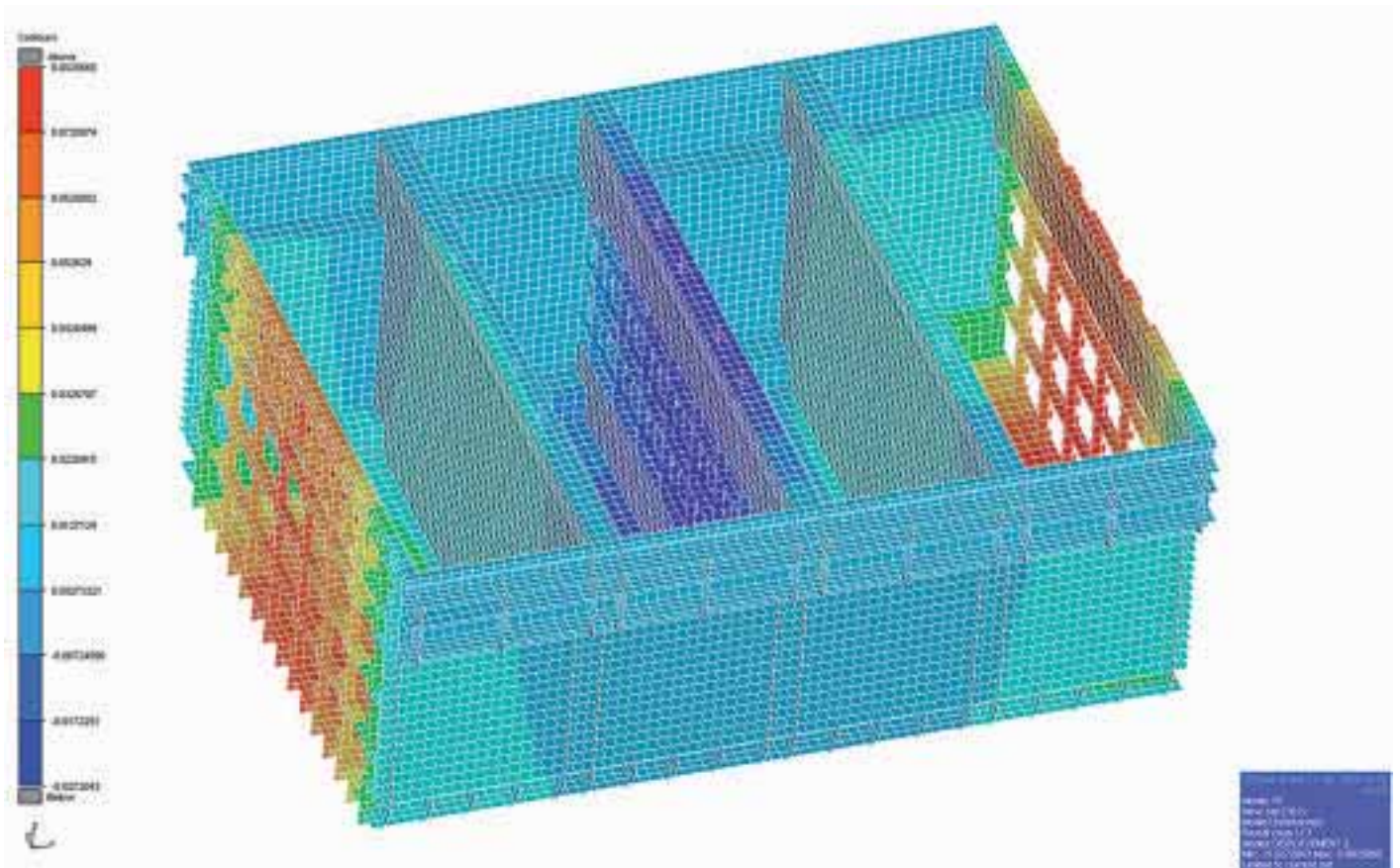


» Wind deflector and wave breaker build in GFRP.

Hull strength – more boxes into the box ship?

The double bottom and double side are normally designed as ballast tanks. Very often, there is more ballast capacity than is necessary. Can some of these spaces be used to stow containers? In the Quantum project, two alternatives were investigated from a strength and scantlings point of view. The final design has a narrow double side, designed as a void space.

TEXT: HE JIANG



»

Fig.3: FEA – cargo hold model.

Two different concepts for the Quantum were evaluated to maximise the container capacity and reduce the ship lightweight as much as possible:

- Decreasing the traditional double side (See Cross Section A – Fig.1)
- Container stowage in the double side (See Cross Section B – Fig.2)

By making the traditional double side narrower, the container capacity can be increased. The double side compartments are very narrow and are designed as void spaces. The double side just below the strength deck and the top wing space further below may be utilised as an access tunnel and pipe duct.

The double side void space is approximately 1m wide with a uni-girder system. This means that all the longitudinals are replaced by longitudinal stringers which are supported by transverse structures instead of transverse bulkheads alone, leading to a span of more than 12m.

The first advantage is that the total area of Cross Section A is less than that of Cross Section B, which means less steel weight. Also, the introduction of the uni-girder system will eliminate all side longitudinals around the draught and consequently eliminate relevant fatigue cracks where side longitudinals connect to the web frames. Therefore, survey and maintenance work will not require a lot of access to the narrow void space.

The access to the double side space will be rather difficult. However the double side space is designed as a void space only, so that the corrosion in the space will be quite limited compared to that in the ballast tanks.

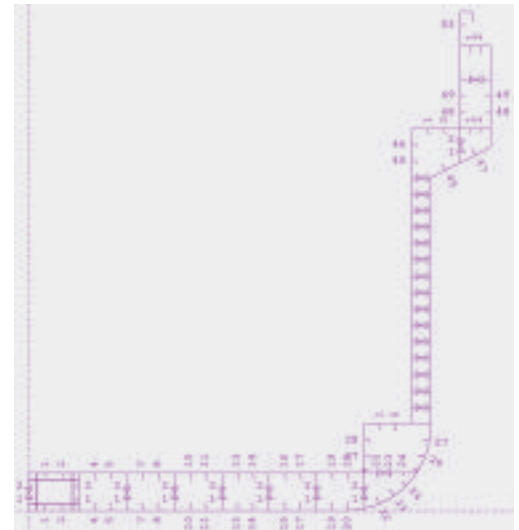
As can be seen in Fig.2 (Cross Section B), it was decided to utilise the double side compartments for container stowage. The arrangement makes the double side wider so that containers can be stowed in it. One row of containers is stowed in the lower part

of the wider compartment. In the upper part, there is enough space to stow two rows of containers. The narrow double side just below the strength deck and the top wing space further below may be utilised as an access tunnel and pipe duct.

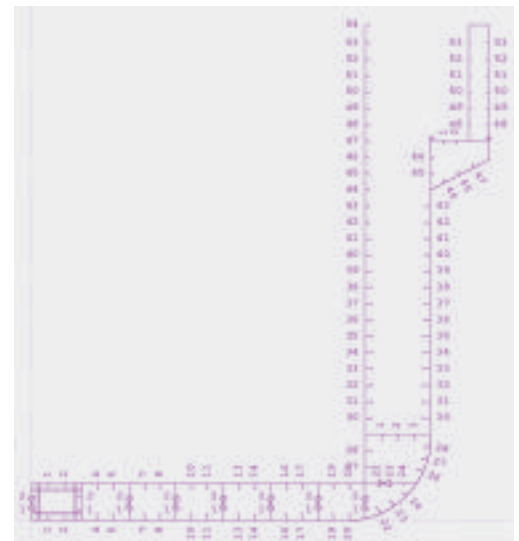
From a strength point of view, the challenge was to design sufficient longitudinals for the outer and inner shell. If a 40-foot container was to be stowed in the wider double side, the span would be more than 12m, resulting in too large sizes for the longitudinals. However, the wider double side could be designed for 20-foot containers only, making it is possible to control the size of longitudinals, cell guides and relevant clearance.

Another challenge was the torsion stiffness of the hull girder. Because the strength deck between the inner side and outer side has been removed in Cross Section B, it will be an open type structure and the hull girder torsion stiffness will be reduced.

Following an evaluation of the advantages and disadvantages of the Cross Section A and B designs, the former was chosen for Quantum. A finite element analysis for a $\frac{1}{2}+1+\frac{1}{2}$ cargo hold model has been conducted for this design (see Fig.3). In general, the analysis shows that the arrangement is sufficient with respect to strength. However, there are some special areas where careful consideration is necessary. The stress level for stringers in the narrow double side void space is in general low. However, because all the stringers are connected to transverse structures instead of transverse bulkheads alone, special attention needs to be paid to the web plates and connections with the transverse bulkheads. Considering that openings on these vertical webs are necessary to enable access to the space, the buckling capacity of vertical web panels should also be carefully considered.



»»
Fig.1: Cross Section A – Narrower Double Side.



»»
Fig.2: Cross Section B – Wider Double Side.

In the end, the concept came out with approximately the same steel weight as a 5,500 TEU comparison ship, even though the container capacity has been increased by approximately 10%. ●

Jiang.He@dnv.com

Minimum ballast design – intact stability and damage stability

The handling of ballast water creates a lot of extra operational challenges which are expected to increase in the future due to the introduction of a requirement of a Ballast Water Treatment System. In addition, by removing the ballast water, more cargo could be carried with the same displacement. As a result, while designing Quantum, how to achieve a ballast-free green ship and at the same time fully comply with all the stability rules has been a major concern.

TEXT: YANG ZHANG

DAMAGE STABILITY Generally speaking, the damage stability requirements are more critical than the intact stability requirements. Also, as a result of new harmonised probabilistic damage stability rules which took effect on 1 January 2009, discussions about what effects the new rules will have on ship designs have been held throughout the shipping industry. Therefore, while designing Quantum, the focus has been on certain design factors which will influence container ships' damage stability results.

The new probabilistic damage stability rules can be summarised in the very short formula $A \geq R$ where A is the attained index and R is the required index.

For Quantum, the maximum damage extent taken into consideration is up to

three compartments, and over 600 damage cases have been defined and calculated. A typical damage case is illustrated in Fig.1.

As a major design factor, the size of the double shell (a typical cross-section can be seen in Fig.2) will have a certain influence on the cargo hold capacity, and it may also be of great interest to investigate the probabilistic damage stability results for different widths of the wing tank.

Two different sizes of double shell (Design A and Design B) in cargo holds No.5 and No.4 have been studied. As No.5 and No.4 are located in the middle part of the ship, this will give a clear indication of the damage stability results. Some design factors are summarised in Table 1.

When calculating the attained index A, each partial index is a summation of the contributions from all the damage cases taken into consideration, using the following formula:

$$A = \sum x_i p_i$$

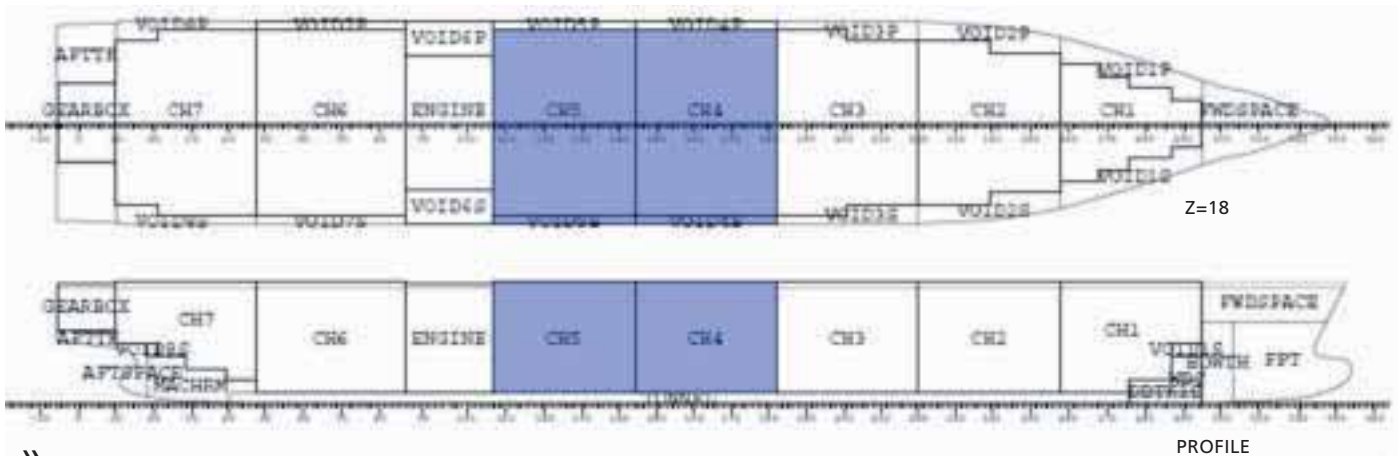
Here comes the probabilistic concept. p_i is the probability that only the compartment or group of compartments under consideration will be flooded; and x_i is the probability of surviving certain damage.

The probability of certain damage happening to a single compartment or a group of compartments, p_i , is highly dependent on the geometric arrangement of the considered ship. For example: for the damage case shown in Fig.2 which penetrates all the way to cargo holds No.4 and No.5, $p_i = 0.04215$ for Design A and $p_i = 0.04468$ for Design B.

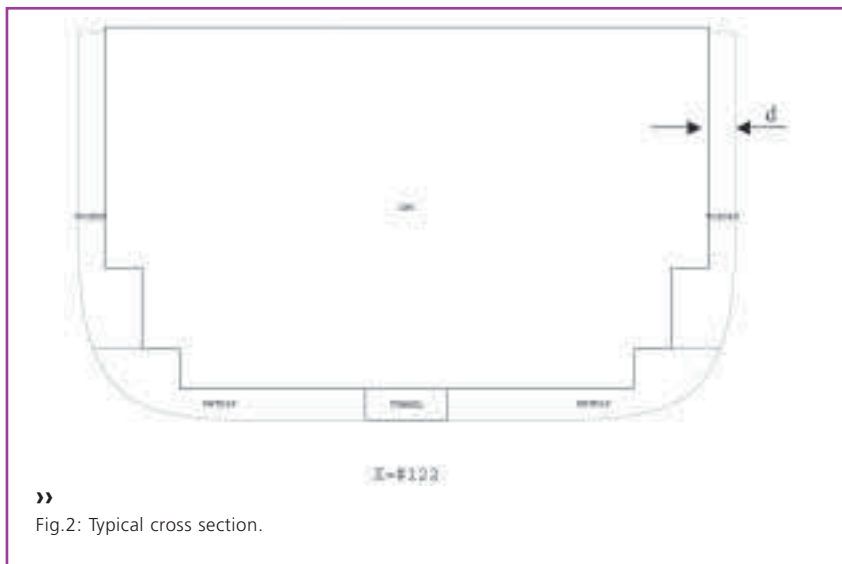
How about x_i then? The overall stability of the ship will be improved even when the possibility of a serious damage case happening is increased (see Table 1 for volume information for the cargo hold and side shell space). For Quantum, both designs achieved $x_i = 1$, which means that, for Design B, although the chance of having the cargo hold damaged is 3% higher than with Design A, this damage case contributes more in the summation $A = \sum x_i p_i$. One conclusion that can be reached is that as long as the ship can survive the

	Volume (m³)	
	Design A: Size of widest part of side shell d =1.73m	Design B: Size of widest part of side shell d =1.25m
Cargo Hold No. 5	25,915.5	26,729.5
Void Space No. 5 (S-side) between double side shell and hull	1,331.1	930.8
Double bottom ballast tank No.5 (S-side)	1,102.1	1,122.7
Cargo Hold No. 4	26,221.8	27,077.9
Void Space No. 4 (S-side) between double side shell and hull	1,172.0	747.6
Double bottom ballast tank No. 4 (S-side)	1,298.4	1,308.3

Table 1 Cargo hold capacity of No. 5 and No. 4



» Fig.1: Two-compartment damage case with damage penetrating into cargo holds No.5 and No.4.



» Fig.2: Typical cross section.

damage (i.e. $\lambda_1 = 1$), the side shell size can be even less in order to achieve a higher cargo capacity.

The above analysis is only based on one damage case shown in Fig.2.

The final results of Designs A and B are shown in Table 2.

LOADABILITY – INTACT STABILITY

As mentioned in the first paragraph, the damage stability is normally more critical. In order to comply with probabilistic damage stability, the GM value has to be kept at least at 1.25m.

Bearing this in mind, some loading conditions have been tested with respect to the intact stability. From the results, it has been found that stability is not a critical issue for most of the realistic con-

ditions, and ballast water is hence not needed for the purpose of stability. However, the trim is an issue for some of the conditions, depending on the weight distribution of the containers.

Thus, there are two design and operation options when it comes to ballast water:

- Using an intelligent loading system, the trim and bending moment can be controlled by distributing the weight properly in the longitudinal direction. In this case, ballast water is not needed, which means that fuel can be saved and ballast water treatment can be avoided. This should be the option for the future.
- If flexible loading is a requirement, ballast water can be used to achieve the correct trim regardless of the container weight distribution. The ballast water can then also be used to control the bending moment. This is normal practice in container ships today. ●

Yang.Zhang@dnv.com

	Required Subdivision Index R	Attained Subdivision Index A
Design A GM =1.25m	0.6967	0.70852>R
Design B GM =1.25m	0.6967	0.71720>R

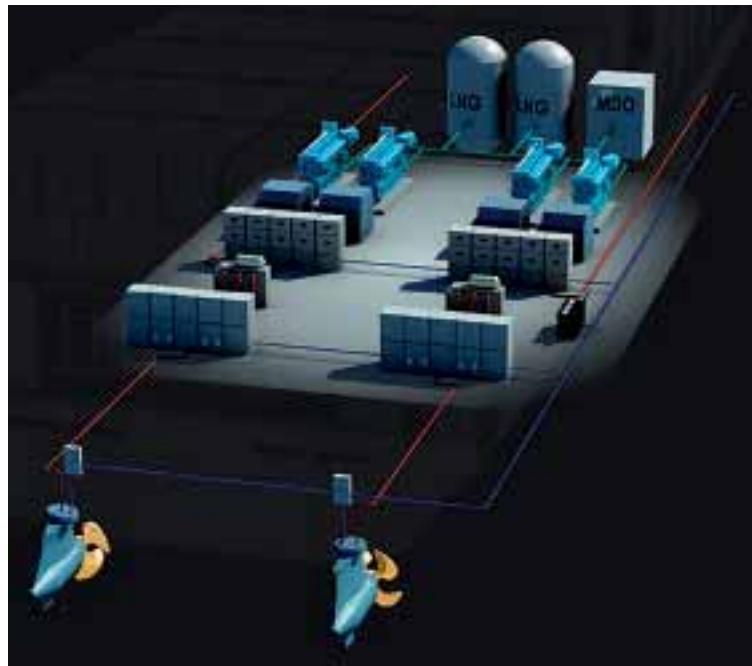
Table 2 Final results

Machinery and ship systems

– a flexible solution for an uncertain future

Recent change in the global economy and increased worldwide environmental concerns have opened up for new machinery concepts as realistic alternatives to traditional designs. For Quantum, an arrangement with electric propulsion powered by four dual-fuel generator sets was chosen. The main advantage with electric propulsion is the flexibility to operate more efficient across a wide range of speeds. By switching to LNG when approaching the coastline, ECA requirements are fulfilled and cold ironing is not needed. Two azimuth pods ensure excellent manoeuvrability and increased harbour efficiency.

TEXT: ERIK BRODIN



»
Fig. 1 Quantum machinery arrangement

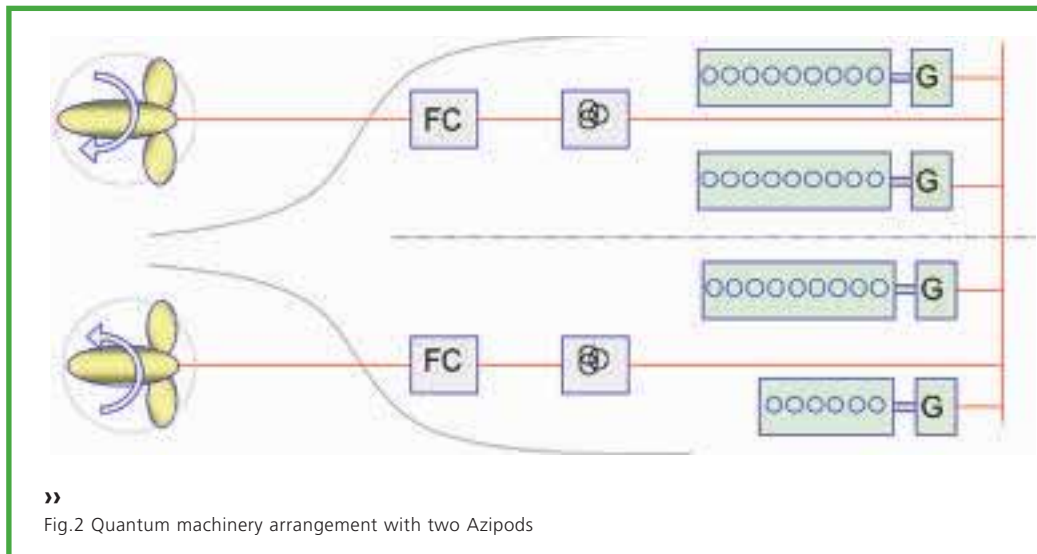
OPERATIONAL FLEXIBILITY

Container ships are known for utilising the largest engines available, justified by one single reason – the need for speed. However, in today's uncertain market, more variations in operational speed are seen. A large portion of the container fleet is now slow steaming, with engine loads down as low as to 10% MCR. Although the ships are reducing their total fuel bill by slow steaming, the specific fuel consump-

tion is increasing. This is because these engines often have their maximum fuel efficiency at around 80-85% MCR, while the amount of fuel needed per kW is larger at lower loads.

With a conventional design, large variations in power consumption can lead to operational challenges. Long periods of low engine load operation will result in problems with soot formation due to a lower compression temperature and reduced exhaust gas

velocity. As a result, a “blow out” with high engine loads at regular intervals may be needed. In addition to being an operational disturbance, this will also result in unnecessary increased fuel consumption compared to continuous RPM sailing. This opens up for diesel electric transmission, where the power management system will ensure a balance between the consumed and available power. Diesel electric systems are much better than traditional



mechanical systems with respect to operational flexibility, engine location and the utilisation of space.

QUANTUM'S MACHINERY SYSTEMS

The chosen concept has electric propulsion powered by four dual-fuel generator sets fuelled by MDO and LNG, providing flexible and environmental friendly operations. See Fig. 1 and Fig. 2. If the ship needs to operate at a lower speed, one engine may be shut down, leading to optimised operation and fuel consumption for the remaining three engines that still are running.

Do tomorrow's container ships need a service speed as high as 25 knots or could it be less? With the strong focus on the carbon footprint, this issue will have to be thoroughly evaluated, since all other environmental initiatives are of less importance than the operating speed. It is estimated that Quantum would need nearly 50 MW of propulsion power for a service speed of 25 knots, while less than 24 MW is enough for 21 knots, including the sea margin. To have some flexibility, a maximum propulsion power of 30 MW has been defined for Quantum, which gives a

maximum service speed of 22.5 knots. This includes an 18% sea margin, 4% air resistance, 5% appendices resistance and 70% propeller efficiency.

Quantum has 1,200 reefer plugs and each reefer container can require up to 12 kW at full load. The need for power to the reefers depends on the operating profile, such as the number and type of reefers loaded in each port. Different kinds of cargoes have differing temperature and ventilation requirements. There may also be large seasonal variations for products like fruit and Christmas trees. Hence the power consumption can be anything between 0 and 14 MW.

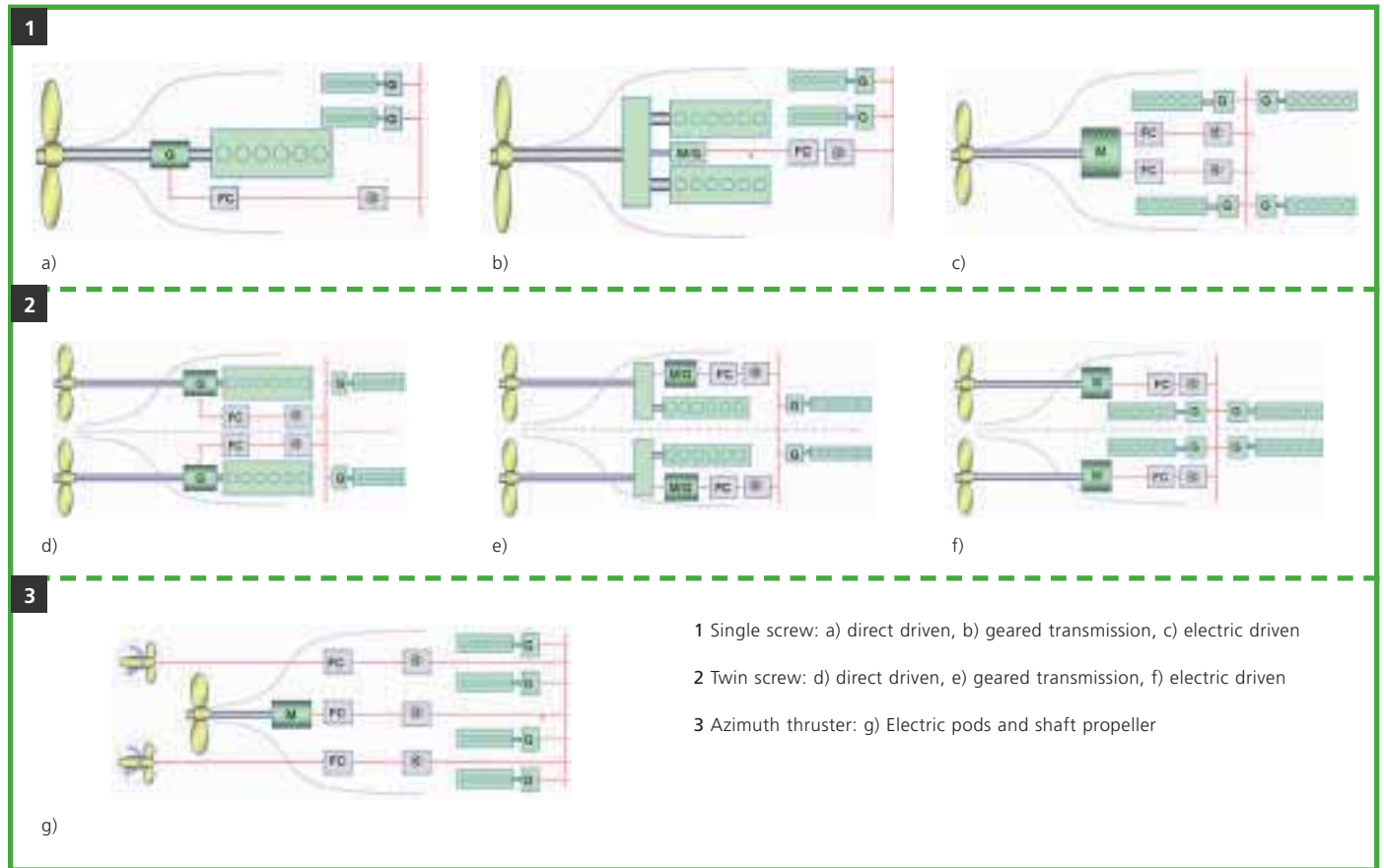
Quantum has 33 MW of installed engine power, allowing it to keep to the 21 knot design speed with all possible service loads.

CHOICE OF FUEL IS A KEY TOPIC

HFO has been more or less the only option for seagoing ships. However, the stricter emission regulations under the IMO Tier II & III and ECA zone implementations and volatile fuel prices mean that ship owners and operators are facing serious challenges. Solutions that allow compli-

ance with new environmental rules while maintaining cost-efficient operations vary, but LNG appears to fulfil all the requirements. LNG is not only an environmentally good solution, it is also economically interesting when the expected increase in the fuel oil price and future costs related to emissions are taken into account. Furthermore, there will be no need for additional and possibly very expensive solutions like scrubbers, cold ironing and humidification.

As a result, a dual-fuel concept was selected for Quantum. Fuel flexibility enables owners and operators to opt for the most suitable fuel, taking account of local environmental restrictions, fuel price variations and fuel bunkering availability. Fuel flexibility also represents a significant safety feature. In the case of an interruption to the gas supply, dual-fuel engines automatically switch to diesel operation without any loss in speed or power output. Single-fuel installations do not have this additional level of operational safety. With a dual-fuel solution, the complex settling and mixing tank arrangement used for the fuel switch between HFO and MGO is also avoided.



1 Single screw: a) direct driven, b) geared transmission, c) electric driven
 2 Twin screw: d) direct driven, e) geared transmission, f) electric driven
 3 Azimuth thruster: g) Electric pods and shaft propeller

»
 Fig.3 Different arrangements suggested.

PROPULSION ARRANGEMENT
 Electric propulsion opens up for many different arrangements. Several concepts have been evaluated as part of this study and some of them are presented in Fig.3.

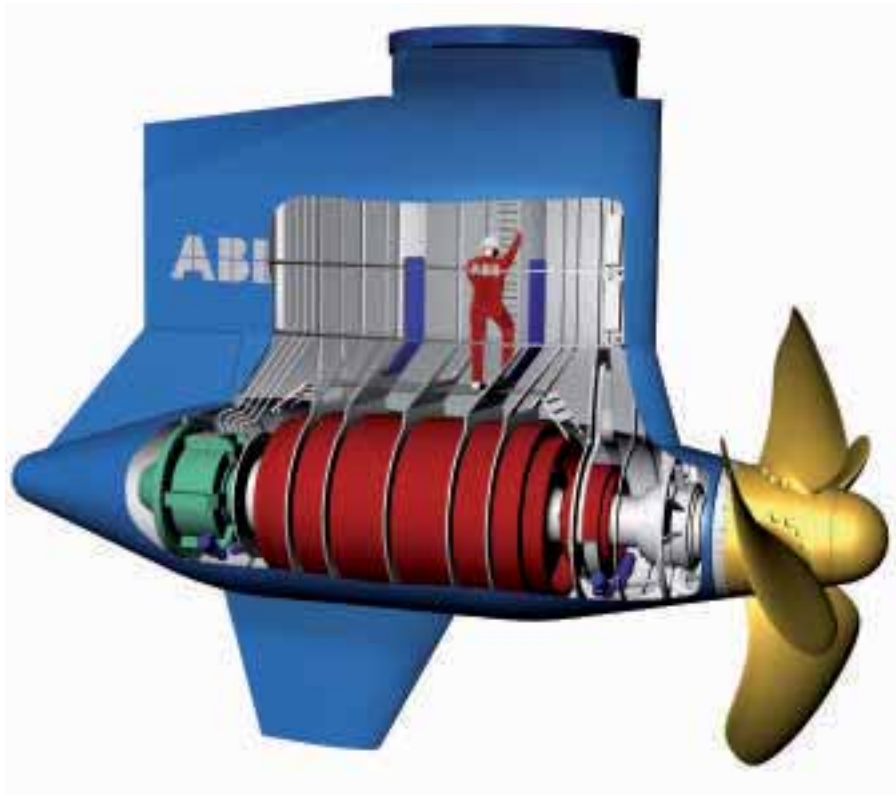
FIXED PITCH SINGLE SCREW SOLUTIONS

A fixed pitch single screw has up to now been the preferred solution due to its simplicity and high efficiency. Fixed pitch implies that power and torque are controlled by the propeller speed, given by a characteristic propeller curve. The traditional concept is to have one direct coupled two-stroke engine, which has no system redundancy. Two engines may provide increased redundancy, but a major part of the increased

availability is lost by introducing a reduction gear without redundancy. With two engines and one propeller, it is possible to operate on one engine during slow steaming, but the fact that the gear is a high-cost component makes the gain questionable.

It is possible to combine single screw and electric propulsion, but a single electric motor of this size is not common and will be both expensive and heavy. Another solution is to use a gear driven by two electric motors (not shown in Fig.3). It is a matter of costs which solution to choose. The power loss between the engine and propeller with electric transmission is 8-9%, mainly in the generator and motor, while a direct coupled two-stroke engine has negligible losses.

A reduction gear will also introduce some losses; approx 1-2%. The flexible electric power production can be utilised by using PTI/PTO for a direct coupled fix pitch system. The generator has large inertia, making it preferable to have it shaft mounted instead of gear mounted when running in rough sea. The generator has to follow the engine speed, which is variable and less than 120 rpm, so a frequency correction is required or a DC-generator can be used. Manoeuvrability was defined as important for this project due to the considered trade and route, so even with large stern thrusters a single screw is not the first choice. A large fixed pitch propeller may also perform worse in shallow waters due to vessel squatting.



»

Fig.4: ABB Azipods are at the moment the most common electrical pod unit. This illustration is of a larger unit than the one used in this concept.

TWIN SCREW SOLUTIONS

With a twin screw arrangement, it is possible to have full redundancy and increased manoeuvrability. The power efficiency is not clear since there are increased losses from the twin-skeg and reduced losses relating to wave resistance and the propeller. The twin screw concept opens up for a hull with a reduced draught since the propeller diameter is smaller. One drawback with a twin-skeg solution is the mounting of aft tunnel thrusters, since it requires a longer tunnel.

ROTATING PODS

See Fig. 4. As a means to increase manoeuvrability and operational flexibility, azimuth thrusters were evaluated. The first to be considered were two rotating pods + one

electrically driven fixed pitch propeller used to boost the power in transit mode. In manoeuvre mode, only the pods are in operation. This was found to be a very costly solution, which is relevant for higher speeds and power only. Different concepts with three pods were also rejected for the same reason.

QUANTUM ARRANGEMENT

The arrangement chosen for Quantum is a concept with two rotating pods as presented in Fig. 2. The main advantage of pods is the excellent manoeuvrability they allow. With pods there is also no need for stern thrusters and rudders. Quantum will call at 10 ports in a round trip voyage, 45% of which will be in coastal waters. Good manoeuvrability increases

the efficiency in harbour and reduces the need for tugs. The estimated savings on tug assistance are in the range of Euro 400 000 per year, taking account of the fact that some ports have mandatory tug assistance. The main disadvantages with a pod solution are the higher investment costs, increased propulsion power transmission losses and the need for qualified electricians on board.

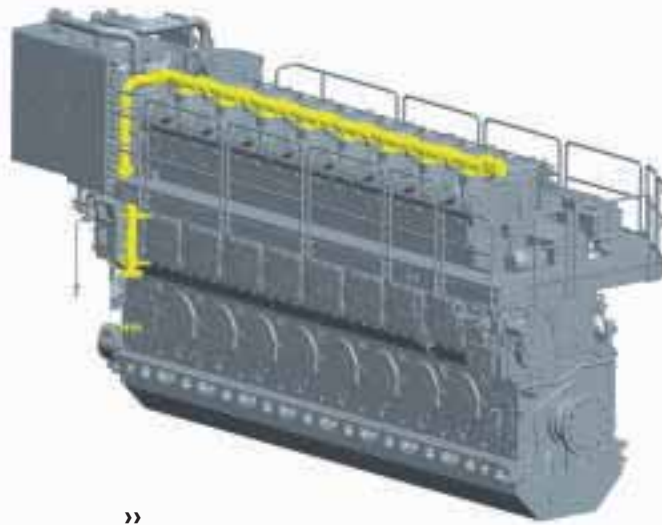
The major manufacturers of large pods (6-25MW) are ABB (Azipod) and Rolls-Royce/Alstom (Mermaid). The required propulsion power of 23MW could be provided, for instance, by two ABB VO1800 or XO2100. There have been uncertainties regarding the hydrodynamic loads acting on the pods, but ABB and DNV have car-

ried out continuous full-scale measurements of a pod in service over a period of two years in order to determine these. Pods are also a relatively new concept compared to direct driven or geared mechanical systems; hence there have been some quality cases which are well known in the maritime business, leading to some scepticism. However, new design generations have now been presented and the initial problems are assumed to be solved.

DUAL-FUEL ENGINES

See Fig.5. Today there are two makers of large four-stroke dual-fuel engines: Wärtsilä (50DF) and MAN (51/60DF). Both engines have a rating of approx 950-1000 kW/cyl, which we expect to increase to 1100-1200 kW/cyl within five years. These are four-stroke medium-speed engines which are well suited for generator application and operate at approx 500 rpm depending on the electrical frequency.

When fuelled with MDO or MGO they run as a diesel engine, following the thermal Diesel-cycle. They also have a gas mode with an independent fuel system that operates using LNG. This process follows the Otto-cycle, and a small pilot injection with, e.g., MGO behaves like a spark plug. It should be noted that MAN has a two-stroke dual-fuel engine (ME-GI), but for this application both rpm and weight are advantages



» Fig.5 MAN 51/60 DF is an example of a dual-fuel engine

held by the four-stroke engines.

In order to achieve full redundancy, the vessel will have two engine rooms – PS and SB. In general, a V-engine will be shorter than an L-engine but the overhaul time is longer and maintainability is reduced due to the cylinder angle. It is preferable to have at least one small engine which can be operated at low load in port when there is no reefer load. Based on this, a setup with L6 + 3xL9 has been chosen.

Even though a pod solution has been selected for the Quantum concept, it is important to remember that the selected dual-fuel engines with LNG can also be used in a conventional propulsion arrangement with a single screw as

shown in Fig.3. The benefits of complying with the emission regulations in ECA areas would still be there, and the need for other additional measures would be eliminated.

ECONOMY

The additional investments in the machinery and propulsion system have to be covered by reductions in fuel cost, manoeuvring time, emission taxes and tug assistance.

ABB has carried out a life cycle cost analysis of

two alternative propulsion systems based on the operational profile defined for the Quantum project. The disadvantage of mechanical transmission is related to unexpected downtime (533 k€/year), failure-related maintenance and lube oil consumption. The main results for the chosen concept compared with a traditional concept are presented in Fig. 6. It can be seen that the cumulative costs of the Quantum design are approx. 11% higher than those of a conventional arrangement. A concept study like this contains many uncertain parameters but it provides an indication of the cost-picture for the machinery and propulsion arrangement. ●

Configuration	Investment M€*	Maintenance k€/year*	Fuel tons/year*	Cumulative cost M€ after 30 years*
2 x 15 MW pods, 40 MW DF gensets	29,2	1.067	25,208	212
Direct mechanical propulsion, one 2-stroke engine, one 12MW genset, Thrusters and rudder	11,9	1.268	23,357	187

* Analysis is based on 30MW propulsion power and HFO as fuel. Engines, electric equipment are included, but not hull investments.

» Fig.6 Output from life cycle cost analysis

Introducing LNG into the fuel mix

For many decades, Heavy Fuel Oil (HFO) has been the predominant alternative for marine fuel. Today, the situation is more open and several options have to be considered. The revised Annex VI of MARPOL 73/78 adopted by the International Maritime Organisation (IMO) in 2008 introduces stricter requirements for NO_x, SO_x and PM emissions and local emission-controlled areas (ECAs) define even stricter emission requirements. Several oil fields are now depleted and a lot of the remaining oil is in areas where there are political conflicts, so the future crude cost is uncertain. LNG could be part of the solution for the future.

TEXT: ERIK BRODIN

QUANTUM FUEL MIX

The choice of a fuel for the Quantum concept was based on some assumptions and choices:

- Electric propulsion
- Increased prices for LSHFO due to lack of LS crude
- New areas with emission restrictions (ECAs) will be established, e.g. 200 nm from all coasts
- The availability of LNG will be established when there is a market

A dual fuel solution was chosen, with MDO for Atlantic crossings and LNG for the coastal legs and LNG refuelling in Europe and South America. A pure LNG solution was not realistic since LNG requires more space for tanks and gas handling, which is lost cargo space.

WHAT ARE THE ALTERNATIVES

More or less all merchant ships today use fossil fuel as their energy source. Up to now, heavy fuel oil (HFO) has been the most common fuel for sea going ships. This fuel consists of heavy products and is what is left of the crude (residuals) after lighter products have been removed during the refinery process. It has a large variety of properties with respect to viscosity, flash point and amount of contaminations, such as sulphur. The use of low sulphur heavy fuel oil (LSHFO), which

means less than 0.1% sulphur in 2015, is one option to reduce this emission, but removing the sulphur increases the fuel price. In the table below, the difference is only 20 \$/ton, probably because both may be based on an LS crude, but the difference will increase when the demand for LS fuel increases. It is not easy to compare fuels since the prices vary so much, e.g. IFO380 was down at 210 \$/ton one year ago. It should be noted that IFO is a blend of HFO and a small amount of MGO. The density of HFO is approximately 1,0 kg/m³, so water separation can be a challenge.

Fuel	\$/ton
HFO (IFO380)	430
LSHFO (LS380)	450
MGO	605
MDO	570
LNG	450

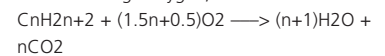
Fuel cost in Europe (approx. Dec 09)

Sources: Bunkerworld, IEA OMR etc.

Marine gas oil (MGO) and marine diesel oil (MDO) are refined from crude and are so called distillates. The main disadvantage of residuals compared with distillates is the need for heating before use or pumping, which normally requires a steam system. Maintenance and operation are also easier when HFO can be avoided.

HYDROCARBON AS FUEL

Available energy is obtained as heat from combustion in which hydrocarbons and oxygen have a chemical reaction. The reaction equation for alkanes, which are the simplest ones, when there is enough oxygen, is:



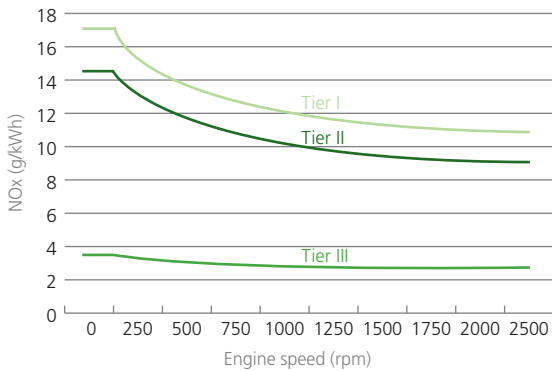
In addition to energy, water (H₂O) and carbon dioxide (CO₂) will always be an end-product. The ratio of energy to CO₂ depends on the hydrocarbon that is reacting. Each carbon atom has four bonds and for methane (CH₄) all bounds are occupied by a hydrogen atom. The high hydrogen to carbon ratio is one reason why methane produces less CO₂ per energy unit. The lack of oxygen (O₂) will lead to the production of carbon monoxide (CO) or carbon (C) as soot particles.

The NO_x products are formed by combustion under high temperature. Nitrogen comes from both air and fuel. In general, high efficiency depends on high temperature, hence a decrease in NO_x will lead to an increase in CO₂. In general, the NO_x emissions depend on the engine design. NO_x can be extremely toxic and is also a greenhouse gas. The SO_x products are created during combustion but are only dependent on the fuel's sulphur content. SO_x is a major cause of acid rain.

BRIEF STATUS OF EMISSION REQUIREMENTS

The revised MARPOL Annex VI Regulations for the prevention of air pollution from ships, which enters into force on 1 July 2010, sets the new limits for permissible NOx, SOx and particulate emissions to air.

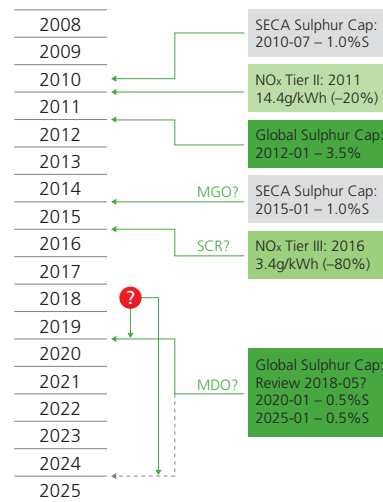
Nitrogen oxide (NOx) emissions have three tiers. Tier I is for ships constructed in 2000 and later, and was ratified by flag states representing more than 50% of the merchant fleet tonnage. Tier II is stricter and is a global requirement as from July 2011. Tier III will be even stricter, but is limited to emission controlled areas (ECAs) like the Baltic Sea, the North Sea and most of the US & Canadian coast. Tier III will come into force in 2016. The NOx limits are for engines above 130 kW and depend on rotational speed.



» Fig.1: MARPOL Annex VI NOx Emission Limits.

The sulphur oxide (SOx) requirements state the maximum sulphur content allowed in the fuel, but it is also possible to remove the sulphur on board using scrubbers or other means. In 2000, the maximum allowed sulphur amount was 4.5% globally and 1.5% in ECAs. New ECA limits are 1.0% (2010) and 0.1% (2015), while the global limits will be 3.5% in 2012 and 0.5% in 2020 or 2025.

Particulate restrictions can be defined within the ECAs.



» Fig.2: MARPOL Annex VI Emission Limits time line.

At the moment, the price of MDO is 26% higher than LSHFO. This has to be balanced by other benefits.

LNG FOR THE FUTURE

LNG is different since it is based on natural gas and not on crude. LNG contains no sulphur and emits 90% less NOx and will almost eliminate particulate emissions.

CO₂ can be reduced by approx. 25% (but with an increase in methane this figure is reduced to approx. 15%).

LNG's properties were presented in the last edition of DNV Container Ship Update in relation to short sea shipping, but a brief description will be given here as well. LNG is a blend of gases which may vary but is dominated by methane.

Formula	Name	content %
N ₂	Nitrogen	0.3–2
CH ₄	Methane	87–98
C ₂ H ₆	Ethane	2–8
C ₃ H ₈	Propane	0.2–3

Blends of nitrogen and alkanes in LNG

The properties are more or less as for methane, which has a boiling point of -161.6°C.

	MDO	LNG	% rel. MDO
Density	880	450	49
Energy MJ/kg	44	50	-14
Energy TJ/m ³	39	22	44

Comparison between LNG and MDO, approx. values. Energy is based on low heating value (LHV).

The values above are not exact since both are blends. LNG needs approximately 40% more volume for the same amount of energy, but it should be noted that there will always be some carryover in the LNG tanks. The tank itself must also be larger due to pressure, insulation and gas handling equipment. Hence, LNG may require up to three times as much space as MDO.

LNG was traditionally used as fuel in LNG tankers due to the boil-off from the cargo tanks. Today, several coastal ships like ferries and offshore ships use LNG as ordinary fuel in dual fuel (MAN and Wärtsilä) or pure lean burn gas engines (Rolls-Royce and Mitsubishi). Dual fuel engines can operate on HFO, but MDO is required as pilot fuel when operating

on LNG. The main challenge for ocean going ships is the increased need for fuel tank volume, but stricter emission requirements may compensate for this. Today's gas code is meant for passenger ships and gas carriers, but in general there are three tank alternatives (A, B and C – ref. the IMO's IGC code). The most realistic alternative today is a C-tank, which is insulated and pressurised up to approx. 10 bar.

QUANTUM FUEL CONSUMPTION AND TANK SIZES

When following the operating profile with a service speed of 21 knots but with 1,200 reefers to Europe and 300 to South America, the total energy consumption will be 92,300 TJ. By using equal energy density (45MJ/kg) and an equal estimated overall efficiency rate of 0.38, the estimated fuel consumption will be 5,700 tons per journey, of which 56% will be required on the northbound leg due to the reefers.

Fuel Case	MDO		LNG	
	ton	m ³	ton	m ³
1	5,397	6,133	0	0
2	108	123	5,289	11,806
3	4,731	5,376	512	1,143
4	2,566	2,916	2,831	6,319

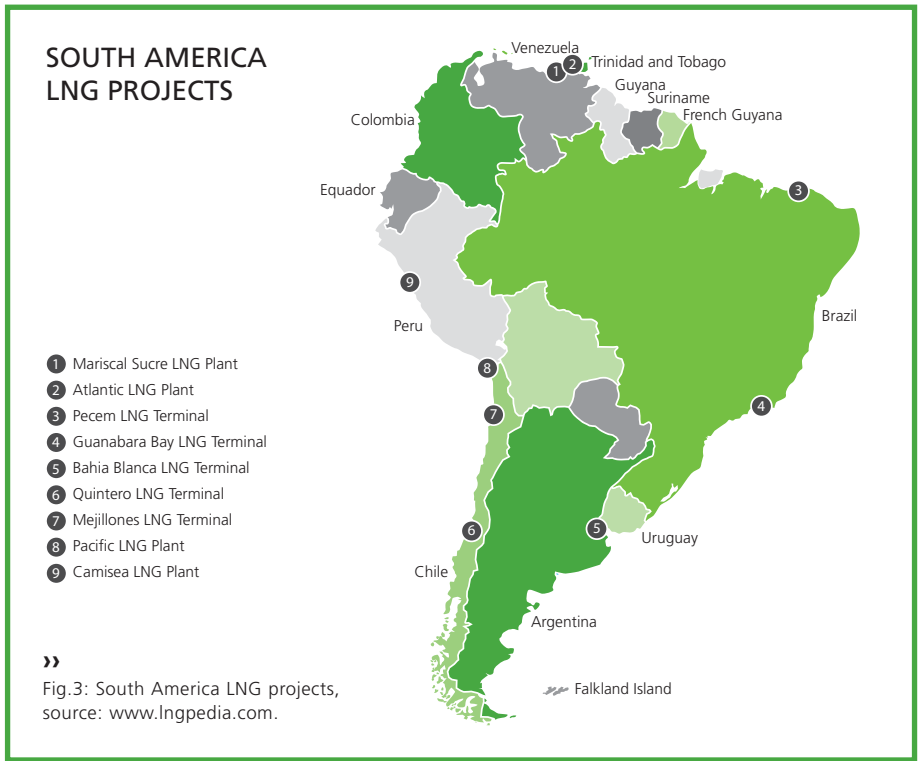
Estimation of fuel consumption during a journey for different combinations of MDO and LNG.

1: Only MDO, 2: Only LNG; 3: LNG in port; 4: MDO on Atlantic crossings.

All combinations are possible, but Quantum's tank arrangement is based on case 4. Preferably, LNG should be refuelled in every port but if this is limited to Rotterdam and Buenos Aires a net LNG tank volume of 5,000 m³ is required. The space required for an LNG tank system is approx. 7,000 m³ compared to 2,300 m³ for MDO which it replaces. The increased need for space is approx. 110 TEU. A refuelling in Santos would reduce the required space by 30%.

AVAILABILITY OF LNG

The production of LNG requires high



cost facilities and power. Today, most consumers of natural gas are connected to a distribution grid with gas pipes. It is considered most realistic to distribute LNG as fuel through the existing bunker sites. MAGALOG partners (EU project) have been in contact with several large LNG terminals in Europe and some may be technically suited for loading small LNG ships with no or small modifications (this has already been done from a terminal in Spain). Many existing bunker sites may include LNG bunkering equipment without extensive investments.

Arrangements for LNG bunkering equipment are today normally made pursuant to an agreement between the operator and customer.

Europe:

- The availability of LNG (large scale) is today good
- Several LNG terminals (large scale) are under development/construction
- A few LNG bunkering sites exist, mainly located in western Norway
- Small LNG terminals for small-scale distribution of LNG are already in place

- Ships propelled by LNG already exist and new ones are under construction

South America:

- LNG is available today, but fewer terminals compared to Europe
- LNG production based on Brazilian gas is under development, increasing the amount of available LNG in the region
- LNG bunkering sites have not been located

Venezuela, Bolivia and Peru have large reserves of natural gas but there are some uncertainties about the political situation. The terminal in Bahia Blanca is 600 km south of Buenos Aires, and Pecem also has a brand new terminal for importing LNG to produce electricity. At the moment there is an overcapacity in the LNG tanker market, so existing LNG tankers may be used as LNG bunkering facilities. In general the increase in the availability of LNG is a worldwide trend, e.g. Nippon Oil is planning to build LNG terminals in Japan. ●

Erik.Brodin@dnv.com



»
Above: one of the two LNG tanks on board.
Below: a fuelling station for the LNG ferry.



»

Bergensfjord, above, is a LNG-propelled coastal ferry in Norway.

Cost-benefit assessment of Quantum

The economic performance of the Quantum design’s main features has been evaluated according to different future scenarios. The improved hull shape has a short payback time of about 2 years, while the investment in switching to LNG requires 10 to 13 years to recuperate. In the long run, LNG is shown to be the best alternative and will in the future become even more viable as stricter requirements regarding NOx and SOx emissions come into force.

TEXT: TORE LONGVA

THREE SOLUTIONS ASSESSED

This assessment covers three alternatives to the conventional design. The baseline design used for comparison is a conventional design with two-stroke diesel-mechanical propulsion. Each alternative adds a new measure to the design, so alternative “switch to LNG” includes an improved hull shape, new machinery system and switch to LNG in coastal areas. Table 1 shows the costs

and benefits of the individual solutions.

The cost of the improved hull shape covers both development and extra production costs. These costs are difficult to estimate but are in this analysis set at €1.8 million. New machinery system benefits include reduced maintenance and reduced tug costs due to improved manoeuvrability, while the cost is related to the additional generators and propulsion system. The hydrodynamic efficiency

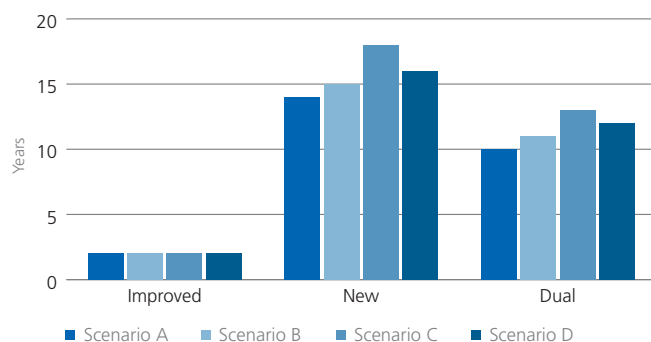
is reduced by 5 per cent, but this is compensated with the engines running at more optimal load. Switching to LNG requires the installation of LNG tanks and piping, while the engine is the same as for the new machinery system.

OPERATIONAL PROFILE

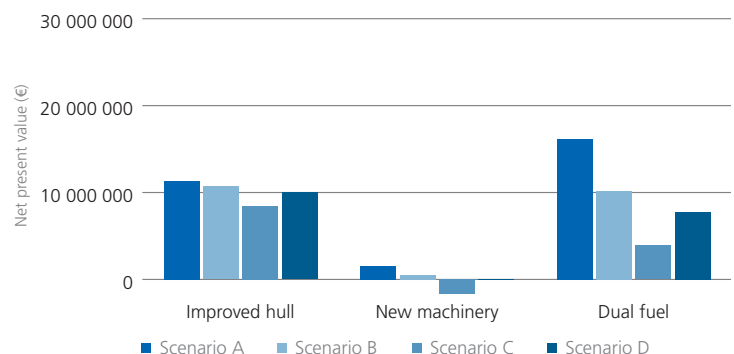
The operational profile will depend on the trade for which the ship is intended. The design requirements were

Solutions	OpEx (€ per year)	CapEx (€)	Fuel reduction	CO ₂ reduction	NOx reduction
Conventional ship	-	-	-	-	-
+Improved hull shape	-	1 800 000 €	10%	10%	10%
+New machinery system	-564 000 €	16 100 000 €	-	-	-
+Switch to LNG	-201 000 €	5 400 000 €	-	11%	80%

»
Table 1: Costs and benefits of solutions.



Payback time, 8% discount rate.



Net present value 15 years, 8% discount rate.

based on the ship trading between Europe and the East Coast of South America. The assumptions regarding the operational profile are as follows:

- 350 days on hire per year
- 107 days deep-sea steaming
- 107 coastal sea steaming (50% in Europe and 50% in South America)
- 136 days in port (50% in Europe and 50% in South America)

ALTERNATIVE FUTURE DEVELOPMENT SCENARIOS

Designing a ship for future demands must take into consideration external factors which influence the cost picture and legislative requirements regarding, for example, emission levels. DNV has developed four scenarios that include some major influencing factors, such as fuel prices, emission taxes and global and regional emission requirements.

RESULTS

The results are shown as both the expected payback time of the investment and the net present value after 15 years, using a discount rate of 8%. No

increased second-hand value of the vessel compared to the conventional design after 15 years has been assumed.

The improved hull shape has a very low investment compared to the reduced fuel consumption and is cost-effective in all the scenarios.

The new machinery system incurs a very high initial investment which takes a long time to recover. However, when combined with switching to LNG in coastal areas, the solution becomes more viable and the payback time is between 10–13 years depending on the scenario. Even in a worst case scenario, with low fuel prices and no further regulations, the switch to LNG in coastal areas will pay off in the long run compared to the other solutions.

The fuel price is the main driver, but NO_x and SO_x requirements play a significant role in the promotion of LNG-based solutions. The advantages of LNG will be more significant, especially for ships built after 2016, when NO_x tier III will be required in ECAs and expensive NO_x reducing measures will have to be installed. ●

SCENARIO DESCRIPTIONS

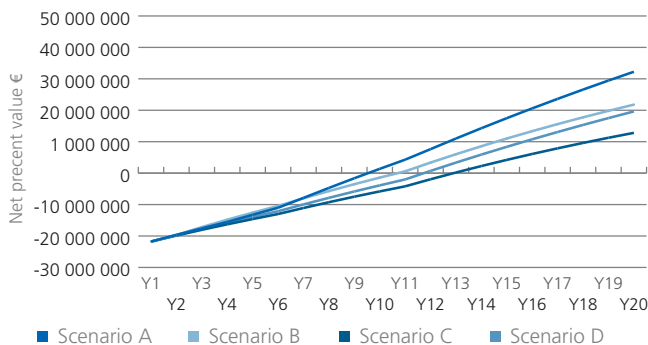
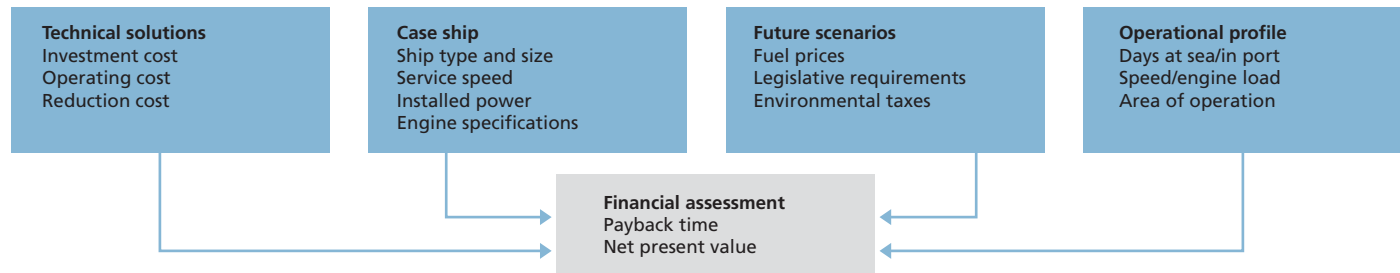
Common: All scenarios consider regulations which are already decided on. These include NO_x tier II for new engines and the 0.1% sulphur limit for ships in EU ports and 0.5% sulphur limit for all ships as from 2020.

Scenario A: The price of fuel, especially conventional fuel, will continue to grow. In 2015, South America will be designated as an ECA, with strict limits on fuel sulphur levels. In addition, an emission trading system will be introduced, putting a cost on CO₂ that starts at €20/tonne in 2012 and increases to €50/tonne by 2020.

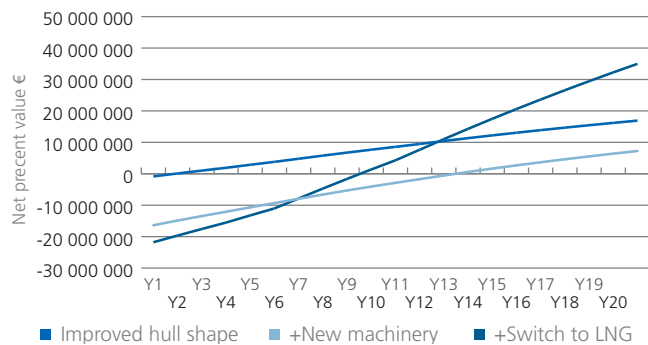
Scenario B: The prices of conventional fuels will grow moderately, while the price of LNG will experience little or no growth after taking inflation into consideration. A 100€ levy on fuel is introduced in 2012. South America will be designated as an ECA but not before 2020.

Scenario C: Fuel prices will not increase much but conventional fuel prices will still increase more than the price of LNG. South America will not be an ECA and there will be no price or other requirements on CO₂ emissions.

Scenario D: All types of fuel prices will continue to rise sharply, including the price of LNG, but there will be no other additional requirements relating to CO₂, NO_x or SO_x emissions.



Aggregated discounted cash flow. All solutions applied, 8% discount rate.



Aggregated discounted cash flow. Scenario A, 8% discount rate.

DNV Triple-E™: Environmental Rating Scheme

Quantum is designed to meet the highest rating – Level 1 – according to DNV's Environmental & Energy Efficiency Rating Scheme for ships – DNV Triple-E™. This means that the ship design enables world leading environmental performance by minimising the resistance to the sea and thereby facilitating energy-efficient ship operations, as well as applying state-of-the-art technology for controlling all emissions to air and discharges to sea.

TEXT: PETTER ANDERSEN



Compliance with the DNV Triple-E™ requirements will make a ship better prepared for emerging environmental regulations and industry trends. It will also encourage and help the operator to achieve more energy efficient ship operations.

The quantum hull form and propulsion system is designed such that compared to a reference ship with standard design and similar size, Quantum will have a better calculated Energy Efficiency

Design Index (EEDI) score according to the IMO's Guideline for EEDI. This is mainly due to its:

- Increased cargo capacity due to innovative hull design
- A ship design with better EEDI score than industry average will give a greater benefit to the society in terms of reduced environmental costs for the transported goods. In addition, for a ship owner this means reduced fuel consumption which again will

reduce the fuel costs and the emissions to air.

BALLAST WATER TREATMENT

Quantum is designed to minimise the need for ballast water, and this can be eliminated completely by using an intelligent loading system. If flexible loading is a requirement, some ballast water is needed in order to control the trim and longitudinal strength. In such a case, an approved Ballast Water Treatment system



»»
Fig. 1: DNV Triple-E™ staircase.

WHAT IS DNV TRIPLE-E™?

DNV Triple-E™ is a rating scheme for a ship's environmental performance and has a rating scale from 4 to 1, where 1 is best. A DNV Triple-E™ rating is accomplished through a client's self-assessment according to DNV Triple-E™ requirements, where DNV will carry out a survey and verification leading to a ship-specific DNV Triple-E™ Rating Declaration. The four levels of environmental performance in Triple-E™ are defined as follows:

- 1 Leading environmental performance
- 2 Sustained environmental performance
- 3 Systemised environmental performance
- 4 Heightened environmental awareness

Each level in DNV Triple-E™ has requirements within the three areas of:

- Environmental performance of design
- Environmental performance of operations
- Environmental competence and leadership

All elements are equally important in order to achieve a given environmental rating.

DNV Triple-E™ has been developed in response to the increasing demand for transparency in the transport value chain. It is intended that having a high DNV Triple-E™ rating in the future can be the preferred way for a ship operator to prove environmental responsibility.



will ensure that no organisms are taken up at one location and dumped into the sea in another part of the world, causing harm to and the contamination of the marine environment.

MATERIALS

The Quantum design facilitates compliance with the latest IMO Convention on Ship Recycling, meaning that no asbestos, PCB or other harmful materials will exist on board the ship. All materials

on board will be documented in an Inventory of Hazardous Materials (IHM). Lightweight materials are used in parts of the construction (such as hatch covers and piping) to reduce the lightship weight.

MINIMUM DISCHARGES TO SEA

Quantum will exceed the most stringent international environmental requirements applicable to discharges of oily bilge water, garbage and sewage to the sea:

- Oily Water Separator reducing the bilge water oil content to less than 5 ppm.
- Garbage storage and handling system ensuring no garbage overboard
- Approved sewage treatment system cleaning all sewage before discharge to sea
- Sufficient tank storage capacity for sludge and other relevant discharge products ●

Petter.Andersen@dnv.com

Boxes in boxes

– improved cargo handling efficiency and reduced lashing

A lightweight, open-top frame structure, capable of carrying up to eight containers, can be loaded on the quay and lifted on board in one go. This will save valuable time in port, something which is of utmost importance to shipping companies as well as shippers and terminals. Additionally, this 'boxes in boxes' concept can reduce the need for container lashing and increase cargo safety.

TEXT: CHRISTIAN ANDERSSON

Since the 58 TEU ship *Ideal X* made its maiden voyage in 1956, loading and lashing methods have principally remained the same while the carrying capacity of the largest container ships has surpassed 14,000 TEU. This staggering increase in cargo volume has led to longer port stays and more labour-intensive loading and lashing. This is a serious matter for a business which is characterised by tight time schedules and complex logistics chains, where delays often have a direct impact – not only on financial results and reputations but also on the entire transportation network which brings goods from the point of production to the point of sale. Hence, more efficient cargo handling is indeed worth striving for.

The concept proposed here, which reduces the number of crane lifts and the need for lashing, could be a significant step towards this goal. While waiting for the ship to arrive in port, the containers are loaded into an open-frame structure which is equipped with built-in stacking cones and cell guides. The loaded frame is then lifted on board onto two adjacent container stacks, to which it is secured by means of twistlocks. In addition to reducing the number of crane lifts, this has the benefit of locking two stacks together so that the deck reaction loads – and consequently the lashing requirements – are significantly reduced.

A frame dimensioned for empty containers would only weigh approximately three tons. The decision to design it for empty containers was based on several considerations. Firstly, lifting up to eight loaded containers would be beyond the capacity of today's cranes. Secondly, reinforcing the frame for the carriage of loaded containers would lead to increases in size and weight. Lastly, on many trades a large number of the carried containers are empty on parts of the loop. These empty containers are typically stowed in the top tiers, which cor-

responds well with the proposed use of the frame.

Because the frame has an open top, once it is on board single containers can be unloaded just as easily as from an ordinary stack. Similarly, single containers can be loaded from the quay into a partially filled frame. This means that the improved efficiency can be obtained without sacrificing cargo handling flexibility. The only additional planning involved to allow for the use of frames is the planning of the pairs of stacks on top of which the frames are to be



»

Fig.1: Frame structure for empty boxes capable of carrying eight 20-foot containers, four 40-foot containers or combinations thereof.



»

Fig.2: Hinged sides allow folding for convenient storage when not in use.

stowed. The stacks in each pair have to be of equal height, meaning that care must be taken to ensure an equal number of high cubes in those particular stacks. However, should unforeseen circumstances make this impossible, the containers that were planned to be stowed in a frame can be lifted on board individually. The empty frame left on the quay can be folded for convenient storage.

Another advantage of the concept is that it does not require any modifications to terminal facilities, lashing equipment or the existing fleet; it can be lifted by existing cranes, secured by means of ordinary twistlocks and carried on any container ship. This is an important feature of any innovative measure aimed at improving container handling efficiency. Container transportation was introduced more than

half a century ago, and the highly standardised infrastructure which supports it is truly enormous and thus very costly to replace.

Apart from the boxes in boxes concept, a number of other measures were evaluated in terms of efficiency and safety gains as well as cost, reliability and technical feasibility. Some of these were aimed at reducing the amount of lashing. One such method was transverse container stowage; however, it was found that the amount of transverse lashing would not be dramatically reduced and some additional longitudinal lashing might be necessary. Other possible methods included constant-tension wire lashing, electromagnetic container securing and cell guides on deck. These were abandoned mainly because they involve the introduction of new components which would require maintenance

and which could cause delays if they failed.

Lastly, various ways of improving cargo loading efficiency were proposed and investigated. One of the most promising ones was the side loading of holds, which would allow the simultaneous loading of decks and holds. However, such a concept would most likely require some form of on-board cargo handling system to carry each container to its slot. Since it would be impossible to access the containers below deck by means of shore cranes, failures in the on-board system would inevitably cause delays. The conclusion was thus that the benefits would come at a higher cost, in terms of possible adverse consequences, compared to the boxes in boxes concept. ●

Christian.Andersson@dnv.com

Optimum ship operation or business as usual?

The operational phase makes up the main part of the ship's life from design to scrapping. The lifetime fuel bill is several times the newbuilding cost. Cost-effective operation can be achieved through decision support systems to reduce fuel costs and the risk of unscheduled off-hire and repairs. In the future, better contracts between owners and charterers will be used to allow a win-win situation regarding the fuel bill. This article demonstrates how Quantum can achieve savings of up to several per cent by using weather routing and hull monitoring.

TEXT: GAUTE STORHAUG

WEATHER ROUTING SYSTEMS

The fuel consumption can be reduced by optimised fuel routing with respect to weather (wind, waves and current) and power management. Calculations have been carried out to demonstrate the effect of routing for the Quantum design. As an illustration, Fig.1 shows the optimised route for one leg on the Europe to South America route for a specific storm situation.

When choosing the shortest track (great circle), the captain has many different power management alternatives:

- Operate on constant rpm
- Maintain the speed
- Speed up before and after the storm.

The different scenarios cause different delays (Fig.2) and fuel consumptions (Fig.3). For lesser storms, you can avoid delays but at the cost of a higher fuel bill. For the biggest storms, it is impossible to avoid a delay by choosing the shortest track. The cost of reducing the delay from about 20 to 10 hours in the worst storm is a 20% increase in the fuel consumption.

Another alternative is to route around the storm, as illustrated in Fig.1. The optimum distance from the storm centre depends on the storm intensity. Assuming that the storm is

located with its centre on the great circle line (shortest path), the optimum distance (radius) from the centre is given in Fig.4.

It is clear that the benefit of routing increases rapidly for storms with significant wave height above 3m. In the case of storms with a 6m significant wave height, the captain should sail 700km away from the storm centre, which reduces the fuel consumption by 6.5% compared to the shortest track. This will depend of course on the storm's path and extent.

The routing and power management in combination need to be optimised given the estimated time of arrival. Comparing and correlating the prediction with onboard monitoring through onshore decision support provides control over the different contributions to, and means to reduce, the fuel bill.

HULL MONITORING AND DECISION SUPPORT SYSTEMS

are also a natural part of the future container ship. A hull monitoring system shows the officer on watch the hull loading and trend. The purpose is to create awareness of the loading and fatigue damage that is accumulated during operation, and to confirm the effect of

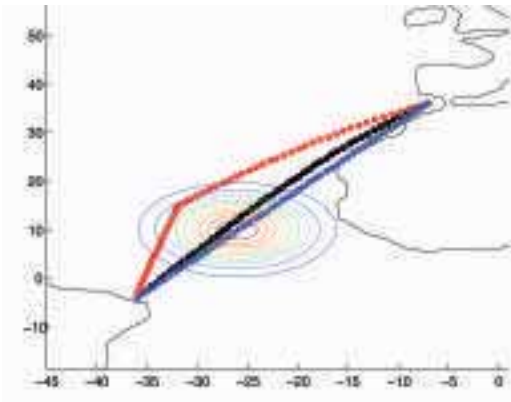
changes in speed and course. Sailing time can also be reduced by increasing speed provided the loading is within acceptable limits.

After the MSC *Napoli* container ship broke in two, the Maritime Accident Investigation Branch suggested that the industry should develop technical means to measure whipping. Whipping is a sudden vibration of the hull caused by bow impacts and may have been a contributing factor to the collapse of the MSC *Napoli*. These vibrations are not yet taken into account when container ships are being designed, but the abovementioned systems do take them into account.

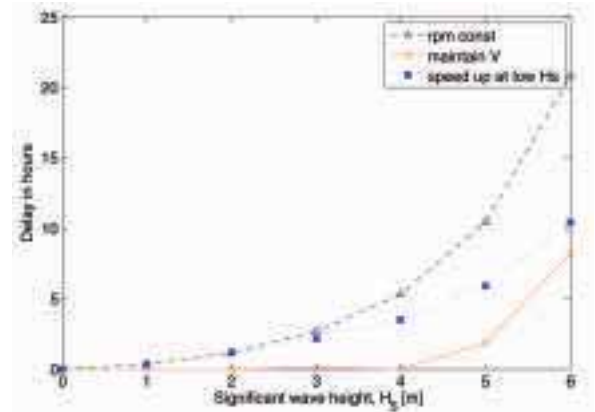
A decision support system is any system on board or onshore that helps to optimise performance and reduce the costs and risk of unscheduled off hire. There are different systems for assessing the fuel consumption, hull and propeller roughness, optimum trim and emissions, avoiding parametric roll and excessive motions (Octopus and VOSS), etc. Only a small fraction of the ships are equipped with state-of-the-art systems today. ●

Gaute.Storhaug@dnv.com

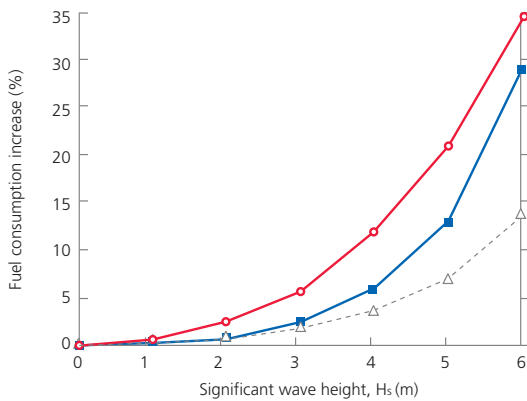
1



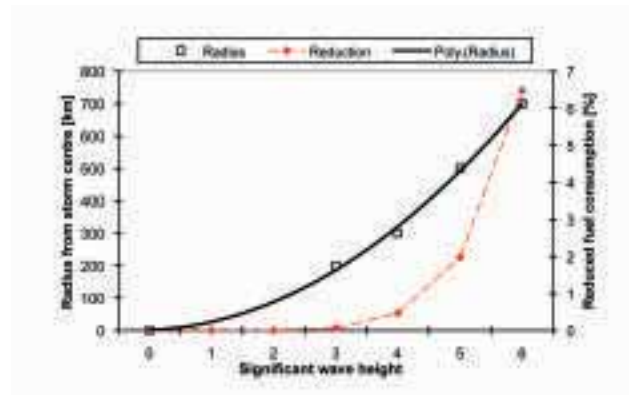
2



3



4



»

Fig.1: Optimised route (red), shortest/great circle (black) and constant course/rhumb line (blue) from Pecem to Algeiras in the case of a storm with a maximum significant wave height of 5m and head sea (referring to constant course).

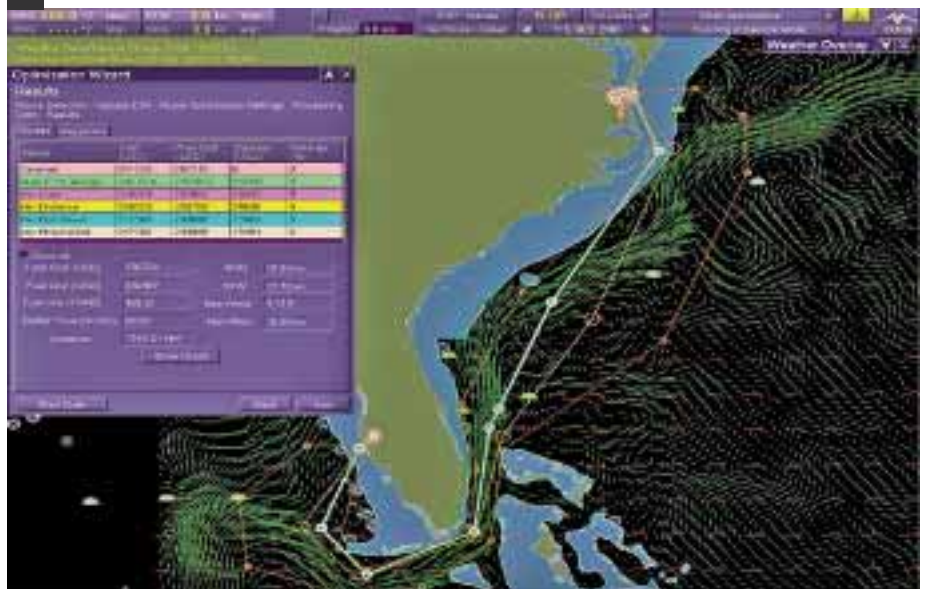
Fig.2: Delays for three scenarios in which the shortest distance is sailed. In this case, the captain has also decided to speed up before entering significant wave heights of more than 2.5m, thereby moving from a 'constant rpm' to 'speed up' scenario when the storm intensity increases.

Fig.3: Increased fuel consumption on shortest track as a function of the significant wave height for three different scenarios.

Fig.4: Benefit of routing and optimised distance (radius) from the storm centre as a function of the maximum significant wave height.

Fig.5: Sperry Marine with Fuel Navigator is one example of a supplier with a fuel routing system. Here the weather overlay (current) is shown on the ECDIS system, with the optimised route reducing the fuel consumption by 8% compared to the normal route.

5



Feedback from DNV German technical committee

A concept study like Quantum will have new and novel solutions. The presentation of this study for DNV's German technical committee resulted in a good discussion, and we asked a few committee members to kindly summarise some reactions to the study.

1. How do you feel about DNV proposing such a concept study to the industry?

COMMITTEE MEMBER 4: Development is not possible without constructive discussion, and constructive discussion is often initiated by a kind of provocation. In this sense, I appreciate the Quantum project.

The Quantum is on the one hand an engineering exercise based on selected parameters (this should never be forgotten), which in the process led to a slightly futuristic result, although it is clear that it can be achieved using today's techniques. On the other hand, the project opens the mind for a more 'out of the box' way of thinking, which is often lacking in day-to-day business. In this sense, Quantum can be seen as an example and can motivate not only engineers.

COMMITTEE MEMBER 1: In view of the important challenge of reducing emissions and protecting our valuable environment, we are thankful for every possible idea that leads to technical improvements.

The more experts working on the topic, the faster we will make further progress. However, it is important to understand that there is often a big gap between theory and real life. This study

could be an interesting basis for further discussion and technical research. It should not be understood as the one and only thoroughly developed strategy to solve the problem. It will take a lot more time to develop and find the most promising ideas and finally to design a reliable product ready for the market.

2. LNG is proposed as a primary energy source for Quantum. Do you see LNG as a viable alternative for the future?

COMMITTEE MEMBER 1: As regards emission reductions, LNG seems an interesting way forward. On the other hand, due to technical reasons and regulations, it leads to a loss of container-carrying capacity. This issue needs further careful evaluation and thorough cost-benefit analysis as carriers want to maximise emission reductions while continuing to offer a reliable service to customers.

COMMITTEE MEMBER 2: In general, YES. LNG and, in the future, other natural/biological gases have to be used for combustion drives around the world. Why not on ships too? We have to handle the implementation phase with care, so as not to destroy the possible technical advantages by too many discussions

about difficulties in front of all the involved parties before such a system is well implemented.

From this point of view, it would be an advantage to implement the first step of the Aux Eng drive in the ECA only, in order to reduce stowage problems and guarantee safe fuel oil operations in case of any danger.

3. The public perception of danger may play a role when container ships carrying LNG call at a port near their home, especially after the recent accident at the power plant in Connecticut. How important do you consider public perception to be? How can this challenge be overcome?

COMMITTEE MEMBER 3: Of course it is important to have this aspect in focus, but LNG carriers are also not seriously viewed by the public as an unacceptable transport mode (although in most cases people do not want them too close to residential areas). With container ships, it is important to pro-actively show and prove a very high safety standard and professional handling of this technology in order to eliminate any possible negative public perception right from the beginning. I would not overestimate the importance of public perception in this respect, as long as the industry handles this in an appropriate and responsible way. This must also be seen in context – that LNG will be far more environmentally friendly, especially for estuaries and ports.

“DEVELOPMENT IS NOT POSSIBLE WITHOUT CONSTRUCTIVE DISCUSSION, AND CONSTRUCTIVE DISCUSSION IS OFTEN INITIATED BY A KIND OF PROVOCATION. IN THIS SENSE, I APPRECIATE THE QUANTUM PROJECT.”

4. The suggested location of the LNG storage tanks is under the superstructure. Psychologically, this may not be the best choice. How important is this?

COMMITTEE MEMBER 1: Basically, the LNG stowage position has to comply with the relevant rules. From a technical point of view, the space below the superstructure seems to be ideal as no container carrying capacity is lost. However it might create acceptance problems with the crew living “on top of the gas cylinders”. I, at least, would not feel comfortable with this. I would urge engineers to find a more psychologically friendly stowage position for the LNG. This should help to gain more acceptance for this kind of technology.

COMMITTEE MEMBER 2: The crew has to be informed and familiarised in detail about the possible risks and danger from LNG systems and storage tanks. For the time being, the lack of information leads to apprehension.

5. Cold ironing is a challenge when it comes to implementation in different ports around the world. Do you see LNG as a viable alternative?

COMMITTEE MEMBER 2: YES. The existing cold ironing systems around the world (in some ports only as yet) perfectly reflect the difficulties of worldwide standardisations. It is almost impossible to install a cold ironing systems ready to use in all ports around the world without transformers and converters. Energy is

lost during all these processes.

Further on, all combustion drives are operated during manoeuvring using “normal” fuel oil with high emissions. If the fuel oil spec is changed when entering the ECA, the emissions are reduced but the risk relating to the fuel oil change and the additional stowage capacity losses are counter-productive for such solutions too.

Using LNG or alternative gases enables the entire combustion machinery or auxiliary engines and boiler (depending on the operator’s choice & equipment) to be operated as from entry to the ECA, while manoeuvring, during port stay, and out to the end of ECA, to run with reduced emissions and without any transforming losses or fuel oil change over risks.



»

Members of the German Technical Committee and representatives from DNV gathered at the roof of the DNV office in Hamburg. From left: Knut Døhlie, Christoph Amian, Jörg Langkabel, Richard von Berlepsch, Frank Jungmann, Holger Schönhoff, Wolfgang Bühr, Heino Eckerich, Thorsten Beiler, Jon Rysst, Alfred Sørensen, Jost Bergmann, Harald Schlotfeldt, Paul A. Thomson, Horst-Dieter Spang, Capt. Stefan Bülow, Prof. Stefan Krüger, Audun Grimstad, Klaus Bruckmann, Frans Paardekooper, Vebjørn J. Guttormsen, Frank-Wilhelm Heidrich

“WE ARE THANKFUL FOR EVERY POSSIBLE IDEA THAT LEADS TO TECHNICAL IMPROVEMENTS.”

6. Future legislation, including carbon tax and ECA restrictions, presents the industry with challenges and uncertainty. Do you think decision makers will be prepared to invest today to meet uncertain, but probable stricter requirements, in the future?

COMMITTEE MEMBER 3: This will largely depend on whether an early investment already makes sense, as we cannot afford to make investments in unclear technical and organisational solutions. As there is no doubt that requirements will become stricter, there is certainly also a general preparation for investments in the future today. As long as it is clear that such an investment will make sense, I am sure that the answer to this question is YES. However, there are plenty of examples of premature investments in unfinished technologies (e.g. Ballast Water Treatment Systems, Inert Gas Systems on tankers, etc) and these have to be avoided. On the other hand, it is in most cases an advantage to be able to plan investments at an early stage provided the technical and organisational presuppositions are acceptable.

7. Slow steaming and extra slow steaming have proven to be important today. Quantum has been designed to operate efficiently without modifications at speeds ranging from 22.5 knots down to less than 10 knots. How important will this flexibility be in the future? Would you be prepared to invest to achieve such flexibility?

COMMITTEE MEMBER 1: In view of increasing fuel oil costs and fuel oil connected costs, the optimum cruising speed will be lower than in the past. This development is driven not only simply by the fuel oil price, but also by future regulations such as the required use of improved fuel oil quality and possible GHG fees. However, I would require a

crystal ball to make an exact prediction of future developments. Based on this uncertainty, carriers presently prefer to stay as flexible as possible to be prepared to cope with any future market developments. This flexibility seems especially important since a decision has to be based on a vessel's average lifetime of 25 years.

8. How important is “carbon footprint” now and in the future?

COMMITTEE MEMBER 3: As the industry is continuing to ask container liner operators (and oil and chemical majors are asking tanker owners etc) to provide this information, the “carbon footprint” is an important factor for the shipping industry and will become even more important in the future. This is independent of how this information is used or misused and therefore we should monitor and comment on this in order to prevent nonsense from being used to drive certain (political) interests.

“LNG HAS TO BE USED FOR COMBUSTION DRIVES AROUND THE WORLD. WHY NOT ON SHIPS TOO?”

9. A commercial study of Quantum indicates that requirements as to emissions and higher fuel prices are prerequisites to make the concept commercially viable. Would the expectations as to the future be enough to justify investment today?

COMMITTEE MEMBER 4: In general, this is the old question of what you base an investment calculation on, what influencing factors you assume and what ROI you expect.

In the present market, it is hard to believe that someone can or is willing to invest in something extra which might be of advantage in the future. This may change in the next few years, when the emissions' 'fine' is clearer and if the oil price rises.

The present answer is slow/super slow steaming, and new standard speed ranges that are much below today's fig-

ures can be expected to be established for different container vessel sizes.

Furthermore, there is a difference between a vessel ordered by a liner operator for its own, possibly specified trade, bearing the operational and technical lifetime cost in mind, and a fund-financed vessel that is to be chartered out and possibly have a number of different charterers during her lifetime. Vessels with a lot of 'extras' will not necessarily earn appropriately higher charter rates which will recoup the investment.

10. Azipods (360 degree rotation) are proposed for the design. These have been used on cruise ships for several years. How willing would you be to consider such an alternative for container ships?

COMMITTEE MEMBER 3: The very high maintenance and repair cost of Azipods as well as the lack of reliability does not lead me to have an optimistic view or any reason to propose Azipods for container ships. The commercial

advantages are quite slight (due to the obligatory use of tugs in various areas and/or for large vessels). There are far more efficient propulsion systems than the one using Azipods proposed by DNV for the Quantum project

COMMITTEE MEMBER 2: In general, container vessels from a certain size upwards are obliged to use TUG assistance in ports anyhow. Smaller vessels are not able to accommodate the relatively high investment in Azipods.

A detailed cost analysis and body line optimisation have to be conducted to increase the number of stability containers in order to find “pro-arguments” for the Azipods. Nevertheless, during the past few years, the Azipods' technical performance was below any acceptable level. This is still an unreliable component.

11. Lightweight structures have been introduced in various parts of the ship, resulting in a lightweight reduction of some 3,000 tonnes. How willing would you be to start using such new technology?

COMMITTEE MEMBER 2: A 3,000 t saving was mentioned, including the reefer containers. These containers do not belong to the ship and should not be included in the calculations in such a way just to demonstrate a possible benefit.

How much would the real weight savings be on the ship body?

It seems useful to install “sandwich” plates as bulkheads in the superstructure area only. Such design ideas are more useful for passenger vessels or car carriers.

“BASED ON THIS UNCERTAINTY, CARRIERS PRESENTLY PREFER TO STAY AS FLEXIBLE AS POSSIBLE TO BE PREPARED TO COPE WITH ANY FUTURE MARKET DEVELOPMENTS.”

12. The “wide-deck” concept provides increased carrying capacity. Pilot access and fendering are presented as potential problems. If these points are solved by providing access through the sloping part via a hatch opening and pilot ladder and fendering is solved by a drop-down inflatable solution, what other objections do you see to this idea?

COMMITTEE MEMBER 3: The so-called ‘inflatable solution’ is no real solution as I see it. Practical experience shows that it is not a realistic scenario because handling, strength and other objections in world-wide ports show that this idea is unfortunately not optimal or workable. The tide situations and pier constructions are often not as ideal as they might seem to be from the ‘green desk’. Too much and too extensive damage to equipment and hulls will also most probably be the result.

COMMITTEE MEMBER 2: To me, the fendering system will continue to be dif-

“IN VIEW OF INCREASING FUEL OIL COSTS AND FUEL OIL CONNECTED COSTS, THE OPTIMUM CRUISING SPEED WILL BE LOWER THAN IN THE PAST”

ficult and maintenance-intensive equipment which does not exist as long the ship’s body is designed in the traditional way.

The positions of the fenders are very inconvenient for maintenance and no reliable design is available today. Furthermore, there is a very high risk involved in “setting” the upper area of the outside

shell on the quay side during tide variations and loading operations. It will be very difficult to manoeuvre such vessels during mooring and TUG boat operations caused by decreased visibility of the ship side.

The one advantage of such a design is the better protection against piracy attacks. ●



»

The DNV office building is centrally located close to the business district and harbour in Hamburg. Here pictured with a detail from the Brooks Bridge in the foreground. The picture of the DNV German Technical Committee (previous pages) was taken on the roof of this building.

Innovation on display

Six of the extraordinary innovation projects have been concluded and presented in front of a commentary board including DNV CEO Henrik O. Madsen. Container ship of the future was one of the projects.



»» DNV Technical Director Olav Nortun learns about one of the extraordinary innovation projects from Kian Seng Tok.



»» The Quantum model.

»» Right: Atle Ellefsen, left, and Erik Brodin, right discussing the Quantum concept with DNV president Tor E. Svensen.

»» Far right: DNV's CEO Henrik O. Madsen and Quantum project manager Eirik Byklum.



Although not all the projects resulted in proposals for future DNV investments, all six were well received at the exhibition held at head office on 21 January, 2010.

“Very solid work went into these projects,” says DNV CEO Henrik O. Madsen. “Not all first ideas pass, of course, but that’s typical in innovation and can lead to more ideas in the future. It’s important to allocate the

time and best technologists, giving them the freedom to explore. It’s a good investment for DNV.”

Henrik O. Madsen was part of a commentary panel that included DNV president Tor E. Svensen, DNV Technical Director Olav Nortun, Director for Classification Department Eirik Andreassen and DNV Technical Director Kim Mørk.

CONTAINER SHIPS OF THE FUTURE:

“We have developed a new ship design in which we were able to significantly improve on performance, efficiency and lessening the environmental impact,” says project manager, Eirik Byklum. “Now we’re in the process of moving that design forward.

The six projects will be on display in the main lobby at Høvik for those who may be visiting. ●





MANAGING RISK

DNV

