A Message from ABS Chairman Robert D. Somerville

PRESTIGE CASE DISMISSED

After nine years of exhaustive proceedings, it gives me great pleasure to report that the legal saga of the Prestige casualty is approaching an end. Last month in New York, the United States Court of Appeals for the Second Circuit unanimously upheld the decision of the lower court to dismiss Spain’s lawsuit against ABS. Explaining that Spain, in the facts and law it alleged, failed to establish “a genuine dispute of material fact” regarding whether ABS “breached any duty that they might owe” to that country, the Court concluded that the case could not and should not be allowed to proceed to trial.

I cannot overstate the importance of the Second Circuit’s ruling to the future of classification societies and the work we do. It is an acknowledgement and affirmation that, for more than 150 years, ABS has played and will continue to play a vital role in the advancement of safety upon the high seas. Together with the 1993 Sundancer decision and the lower court's refusal to extend onerous and unfair legal burdens to class societies, this ruling ensures that we will be able to continue furthering our mission without the threat of unsubstantiated, expensive and harassing lawsuits.

Needless to say, this is a gratifying court ruling and a happy day for ABS, particularly for those who worked diligently for the past nine years to see that justice and fairness would be upheld. My thanks to them and to all ABS employees for the exemplary work they do in carrying out ABS’ mission.
Climbing to meet the wind. A worker ascends the first level of an offshore wind turbine tower, ready for a day of maintenance and inspection. The development of offshore wind technologies symbolizes the worldwide drive to develop ‘green’ energy technologies, as does the maritime industry’s growing interest in making natural gas the fuel of the future for big ships – each of which are discussed in articles in this issue of Surveyor.

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Editor’s Note:
The US Coast Guard’s new rule for ballast water discharge in US waters article in the previous issue of Surveyor was inadvertently printed without a byline. The authors, both from the Environmental Standards Division at US Coast Guard Headquarters, are John Morris, Regulatory Affairs Manager, and Regina Bergner, Environmental Protection Specialist.

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Floating Hope in Deepwater Wind Farms

Will the WindFloat raise the starting gate in the race for viable deepwater wind energy?
The world’s first offshore wind farm was inaugurated in 1991, when eleven turbines piled into the shallow Danish coastline at Vindeby offered the European energy grid a total rated capacity of 4.95 mega watts (MW). The technology came into its own ten years later when the Danish Middelgrunden project brought the first ‘utility-scale’ farm online with a total rated capacity of 40 MW. Today, two decades after the starting bell, the European Union (EU) leads the world in offshore wind power with more than 4,000 MW installed. At the end of 2011, according to the European Wind Energy Association (EWEA), a total of 1,371 offshore turbines were installed and grid-connected in European waters, spread over 53 wind farms in ten countries. This, say wind energy enthusiasts, is only the beginning of a major industrial development effort for the region.

Combined land and offshore wind power installations in the EU have increased steadily over the past 15 years, with installed capacity going from 814 MW at the end of 1996 to 9,616 MW (9.6 gigawatts) at the end of 2011, for an average annual growth rate of 15.6 percent. The growth may vary under the ebb and flow of government support, but it shows no signs of stopping. In its latest report, the EWEA predicts that 2012 may be the best year yet for overall European wind energy growth, as an additional 160 turbines totaling 647 MW await connection to the grid.

With land areas viable for wind farm projects in limited supply, the move offshore in Europe was inevitable. In the first six months of 2012, according to the EWEA, 132 new offshore wind turbines totaling 523 MW were fully grid connected in Europe, a 50-percent increase over the same period a year before. As of 30 June, offshore wind generation capacity stood at 4.3 GW – the UK having the largest share with over 2 GW installed, followed by Denmark (857 MW), the Netherlands (247 MW), Germany (200 MW), Belgium (195 MW), Sweden (164 MW), Finland (26 MW) and Ireland (25 MW). During the same period, 13 wind farms were under construction, which, once completed, will bring an additional 3.8 GW online.
If the hopes become reality, the EWEA estimates that the year 2020 could see total installed offshore wind power reaching 40 GW, enough to meet about 4 percent of the EU’s predicted total electricity demand. Between 2020 and 2030, a further 110 GW of offshore wind capacity is expected to be added in European waters, with the total 150 GW covering 14 percent of predicted EU electricity demands.

This projected capacity increase is already starting to push the offshore wind sector into challenging new territory. All current commercial-scale offshore wind developments use seabed-mounted or ‘fixed’ supporting structures, most of these being monopile concepts in shallow areas near the coast. The difficulty in meeting the hoped-for capacity goals is that, in many countries, there are only a limited number of wind farm sites in suitably shallow water to make fixed turbine structures economically viable. Areas faced with this difficulty include Norway and much of the Mediterranean and Atlantic basins.

The potential generating power of the consistently better breezes found over the open sea are drawing wind energy producers to look beyond the horizon, where the technical challenges of bringing electricity to shore are compounded by water depths that are beyond their sector’s present experience. Several consortia are currently trying to adapt the floating structures employed in offshore oil and gas exploration for use as wind turbine supports in deeper waters.

**Bringing Deep Offshore Wind Online**

Unlike in the oil and gas sector, for the wind power world the current deepwater barrier is around 50 meters. While there has been speculation that it is economical to install fixed wind turbines in water depths as great as 50 meters, no commercial projects so far have ventured much beyond the 20-m range. Since payback on investment comes solely from the price of electricity, project economics tend to favor an afloat structure for wind turbines in water depths beyond 50 m. By their nature, floating structures offer a number of economic benefits over fixed structures, including shoreside assembly and commissioning, standard tow-out procedures and traditional mooring installation.

At the moment there are three active floating wind projects. Norway and Portugal each have a full-scale floating turbine (rated at 2.3 MW and 2 MW, respectively), while an experimental floating unit offshore Italy, although decommissioned, is scheduled to reappear as a full-scale unit some time in the future. Of these three concepts, the most recent to be inaugurated is the WindFloat, a 2-MW floating wind turbine moored in 50 m standing water, 5 km off the northern Portuguese coast at Aguçadoura. WindFloat is the first effort by the Windplus consortium, an international group led by Portuguese power provider Energías de Portugal (EDP), which, through its Renewable Energy division, is the world’s third-largest supplier of wind energy. EDP’s partners in Windplus are Principle Power Inc., a US energy technology developer based in Seattle, Washington and holder of the WindFloat patent; Danish wind turbine producer Vestas Wind Systems; Spanish state oil company Repsol; and two Portuguese companies, steel fabricator A. Silva Matos and venture capitalist InovCapital.

The WindFloat design, acquired by Principle Power from Berkeley, California-based Marine Innovation and Technology, is based on the semisubmersible hull concepts that for decades have supported the exploration and development programs of the offshore oil and gas industry.
The WindFloat base is a triangular, column-stabilized offshore platform, one column of which supports a wind turbine mast. The platform utilizes an active ballast system, which adjusts the water level in three columns to keep the unit level. Its four-point mooring is a traditional catenary system using Vryhof drag anchors with chain-and-wire mooring lines connected to the unit via chain stoppers on the lower part of the columns. One advantage it offers over other floating concepts tested to date is that it does not require expensive piled footings like TLP (tension leg platform)-inspired units or the higher water depths required for long-hulled spar types.

Migrating the semisubmersible concept from oil and gas to wind power use required considerable engineering analyses. For example, the WindFloat’s 23-meter-tall columns are constructed as a tube-within-a-tube structure, with simple internal stiffening consisting of three bulkheads that join the very thick inside tube to the outer skin. In addition, the WindFloat has to deal with wind forces acting on the 105-ton turbine assembly at the top of its mast – the nacelle (the turbine gear housing), hub and rotor with three 39-meter blades. This required not only the specialist aerodynamics analyses typical of onshore wind farms and the hydrodynamics, stability and safety analyses typical for oil and gas platforms, but also a combination analysis to account for the interaction between the turbine assembly and the support structure. Model testing was performed in the towing tank at the University of California, Berkeley, where analyses included the interactions between wave-induced dynamics and tower vibrations, vessel motions and hydrodynamic loading, and mooring system behavior.

Windfloat: an International Effort

The first offshore wind turbine in the open Atlantic, WindFloat spent the winter in testing and commissioning, trial operations and a phased ramp-up in power production. The unit is instrumented with strain gauges, accelerometers and wave height detectors that feed a special analytical program that will use the information to help improve future designs.

“The commissioning phase proceeded slowly, as for most of the early winter we were without much rain and had little wind,” reports Filipe Santos, ABS Principal Surveyor-in-Charge stationed in Lisbon, who was the lead surveyor for the WindFloat project. “By April the unit has survived at least ten storms with waves above 10 meters. According to the measurement buoys, average wave height throughout the winter was 6.8 meters, with the maximum measured height being 13.5 m,” Santos reports. “However, a buoy went offline for a few hours during the worst storm and, while it recorded a wave above 12 m we think, based on comparison with other available data, the likely maxima were around 15 m. Divers have confirmed no damage to the submerged structure and the unit reached the fully operational level of 2 MW output by the end of February. EDP tells us they are very pleased with the WindFloat performance so far.”

The full-scale prototype represents the first phase of a planned three-step development of deepwater offshore wind farming off the Portuguese coast:

**Phase I – The 2-MW Prototype**
The pilot project, now successfully installed and operating. A grant from the European Commission provides funding for two years of testing and monitoring; the US Department of Energy contributes to the effort by funding the participation of the US National Renewable Energy Laboratory.

**Phase II – Pre-commercial Development**
The controlled roll-out of the technology with deployment of up to five full-scale WindFloats of 5 MW each, with a target completion date of 2016.

**Phase III – Commercialization**
Commercialization of the WindFloat system involves installation of numerous units totaling up to 1.5 GW.

The WindFloat Project involved some 60 suppliers from around Europe, and called for an international effort from the certifying authority, ABS, which aided the Portuguese Administration in assessing the suitability of the structure for deployment in the country’s waters. Project management was headed by ABS in Houston, with design reviews performed in Houston and London; fabrication and offshore installation were overseen by ABS’ office in Lisbon; and equipment certifications handled by ABS offices in Rotterdam and Seattle.
Following its successful deployment and first energy delivery, the WindFloat drew the attention of energy producers around the globe as the potential seed of the world’s first floating wind farm.

“EDP has selected offshore wind energy as one of its five innovation priorities and the WindFloat is one of the most promising technologies in this area. Pending results of this key demonstration stage, EDP will be better positioned to tackle offshore wind challenges worldwide,” says António Mexia, CEO of the EDP Group, commenting on the WindFloat’s inauguration.

Ocean wind and wave energy are sources of great hope for the green power crowd. Although there is temptation to combine the two power generation technologies into a single unit – reflected in some new designs currently on the drawing board – it appears that the two streams will develop independently for now. For example, at one point Principle Power considered adding wave energy converters to the WindFloat, pursuing the concept in a two-year, $1.5 million research effort partially funded by the US Department of Energy’s Advanced Water Power Program. The development team abandoned the idea when economic analysis could not justify the additional technology.

EDP believes that offshore wind and wave energies will provide some of the most important avenues of growth for the group – ocean wave energy being the longer-term ambition. Following this theme, Antonio Vidigal, CEO of EDP Innovation, told the press that the deep ocean would be the ‘next big energy frontier’ in a statement on the WindFloat’s debut.

“Deep offshore wind technology will allow us to harness stronger and more stable winds, and in the medium term deliver sustainable energy into our electrical system,” Vidigal says. “Now is the time for extensive testing and validation, moving forward in the development of this promising technology. The WindFloat positions EDP on the leading edge of offshore wind exploration.”

WindFloat certification was based on ABS requirements:

- Guide for Building and Classing Mobile Offshore Units
- Guide for Building and Classing Offshore Wind Turbine Installations
- Guide for Building and Classing Floating Production Installations
- Guide for the Fatigue Assessment of Offshore Structures
- Guide for Buckling and Ultimate Strength Assessment for Offshore Structures
- Guide for Certification of Offshore Mooring Chain
- Guidance Notes on Review and Approval of Novel Concepts
Wind loads generated by aerodynamic responses of the turbine rotor could contribute a major portion of the loads on the global hull structure. This is much different from floating offshore oil and gas production installations, where wind loads normally are due to the drag effect and primarily affect the design of topside structures and stationkeeping systems.

Effects of turbine control and safety systems play a significant role in regulating the aerodynamic loads by adjusting the yawing angle between the rotor rotating plane, wind direction and the blade pitch angle. The loads generated by a turbine in the power production mode potentially can be higher than those inflicted by design storm winds and wave conditions when the wind turbine is ‘parked’ (still or idling). The definitions of ‘operational’ and ‘extreme’ conditions commonly used in the design of floating offshore oil and gas production installations (for instance, in API RP 2T and API RP 2FPS) are, therefore, not directly applicable to floating offshore wind turbines.

Furthermore, the complex interaction among the turbine rotor, control system, floating platform and mooring/cable system; and the impact that different loading events could have on these systems. ABS was also asked to propose a draft design guideline for the floating support structures and the stationkeeping systems.

In examining the technical challenges of migrating offshore oil and gas technology to the wind power sector, the study indicates that floating offshore wind turbines, like offshore oil and gas production installations, are considered site-specific units and, because of the apparent similarities, many design practices for offshore oil and gas installations can be adapted for the design of the floating wind turbine support structures and stationkeeping systems.

The study identifies major differences that must be considered in determining the overall design philosophy and the intended safety level of floating wind plants. First of all, unlike most of floating oil and gas platforms, floating offshore wind turbines are uncrewed and with a very low risk of causing loss of life and environmental pollutions. On the other hand, the floating support structure tends to be highly optimized, such that the strength capacities of the tower and hull structural members would approach their acceptance limits simultaneously. This could lead to the structure having a less redundant design than a traditional offshore oil and gas production installation.

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Furthermore, the complex interaction among the turbine rotor, control system, floating support structure, mooring and cable requires highly specialized simulation capabilities. Experimental methods and computer simulation tools that can take these interactions into account are currently under active development and validation.

With the change to load modeling and the effect of wind turbine control and safety systems, the sensitivity of global loads on the hull structure to the variation of extreme design environmental conditions could be different from those normally anticipated in the design of floating offshore oil and gas installations. This means that, although many design practices from the offshore oil and gas industry are still applicable, a new design approach needs to be developed for offshore floating wind turbines to take into account their unique features.

A 2008 report by the Department of Energy (DOE), entitled 20% Wind by 2030 (often called the ‘the 20 by 30 Report’), articulates a scenario in which, within 20 years, more than 300 GW of domestic electricity comes from wind power, including 54 GW from offshore wind farms. The US currently has no offshore wind farms, but the report’s authors conclude such a scenario is feasible if certain technical challenges are overcome.

In May 2012, ABS completed a technical feasibility study for the US Bureau of Safety and Environmental Enforcement (BSEE) relating to offshore wind farm development in US waters. The goal of the study was to determine how floating structures and moorings would be affected by interactions among the wind turbine rotor, control system, floating platform and mooring/cable system; and the impact that different loading events could have on these systems. ABS was also asked to propose a draft design guideline for the floating support structures and the stationkeeping systems.

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Banking on Offshore Wind

Antonio Vidigal, CEO of the Innovation division of Portuguese power provider Energías de Portugal (EDP), shares some thoughts with Surveyor about alternative energy, offshore wind and the WindFloat Project.

**Surveyor:** Portugal has no experience with traditional floating offshore energy production. How did EDP initially view this non-traditional proposal? And, how did it develop the confidence to pursue the project?

**Antonio Vidigal:** Back in early 2008 EDP Inovação (Innovation) started investigating possibilities around deep offshore wind. EDP Renováveis (Renewables) had been pursuing wind opportunities on land and in shallow waters, to the point of becoming one of the largest wind operators in the world, and a vision started to develop within EDP in which deep offshore wind/ floating foundations would play a key role. When floating foundations become a commercial reality, the Atlantic and Pacific Oceans and the Mediterranean Sea (just to give some examples) will become addressable markets for wind energy exploration.

The WindFloat fits perfectly into this strategic vision and that was the basis of the rational to develop the project. The project represented a huge challenge as:

- EDP and to some extent the consortium had no former offshore experience;
- The offshore supply chain is not fully developed in Portugal and building in Portugal was one of the key assumptions of the project (given the amount of public support the project has received); and
- The oil and gas and the wind energy sectors follow different approaches and the WindFloat project doesn’t fit completely in either of them.

Still, given the size of the opportunity and the involvement of credible oil and gas and wind players such as Houston Offshore Engineering, ABS and Vestas, EDP decided that the conditions to proceed with the project were present.

The outcome has been great. The fact that it was possible to build in Portugal such a complex system is a very positive sign and we tend to see this success as a platform for the future development of an offshore wind energy cluster here in Portugal.

**Surveyor:** EDP has a large portfolio of alternative energy supply. What is EDP’s perspective on the future of alternative energy for Portugal and for Europe? Where does it see wind energy fitting in, and where does the Windfloat concept fit into that?

**Antonio Vidigal:** EDP believes there are three key trends shaping the energy industry: demographics (leading to significant growth in energy demand in the medium to long term); scarcity (namely, of fossil fuels) and sustainability (namely, incorporation of stricter environmental constraints). These three trends justify strategies with a strong focus in doing more work using less energy and causing less CO₂ and other greenhouse gas emissions, which will likely mean increasing the level of ‘electrification’ of the world, and in producing cleaner energy.

Renewable energy will play a key role in addressing those challenges. Wind energy will be fundamental for the success of this strategy.
Other alternative renewable sources such as solar energy will also increasingly gain weight in the energy mix as technology matures and technology costs come down.

Offshore wind and, in particular, deepwater floating offshore wind will be very relevant in the medium-to-long term because opportunities on land and, to some extent, shallow water applications will eventually slow down and wind resources at sea are stronger and more stable.

WindFloat, being one of the most promising and advanced deep offshore applications, will likely champion the sector, but we keep our eyes opened and further opportunities are presently being analyzed.

**Surveyor:** Would you share your general vision on alternative energy from the sea?

**Antonio Vidigal:** EDP has selected ocean/offshore energy as one of its key innovation priorities. Offshore wind, and deep offshore wind in particular, is presently gaining traction and accelerating in technology development. The fundamentals of such acceleration, for example, vis-à-vis wave energy have to do with the fact that the innovation challenge is substantially smaller. Deep offshore wind is more of an incremental challenge – to reduce the size and cost of oil and gas-type structures and adapt wind turbines for the level of motion intrinsic to such structures – and wave energy is more of a disruptive issue, since no device to date has extracted relevant energy in a sustainable manner.

Portuguese coasts and, generally, the Atlantic and Mediterranean coasts, are relatively deep close to shore. Floating offshore wind solutions will, therefore, become an important tool for renewable energy promoters such as EDP, as they promise to be the most suitable technical and economical solutions for wind energy in depths greater than 40 meters.

Even if we compare floating offshore wind solutions with the fixed-type solutions being used in shallow water applications, we can find some pros for application of floating solutions in transitional (30 to 50 m) depths – or even shallower. Such pros are, for example, a floating solution such as the WindFloat is fully assembled onshore, minimizing the use of complex and scarce (therefore, costly) offshore means – there's no need to have pilling or lifting capacity offshore. In addition, environmentally speaking, floating solutions are much less intrusive and it is easier to decommission the units and leave the sea bottom "untouched," etc.

These considerations, together with the notions that the wind resource is stronger and more stable further from the coast – where the depths are even greater – and that in deep offshore waters reside the largest available areas for potential wind exploration, have led EDP to develop a very promising deep offshore wind project – the WindFloat.

The sea and, in particular, its sustainable energy exploration will generate qualified jobs, research and development-intensive activities and in the medium to long term will lead to significant value creation. But the sea is much more than energy: fisheries, transports and logistics and tourism are just some examples of activities that are also developing and will continue to play an important role at sea.

In summary, the potential is huge but the challenges are also immense. Technology development is one of the challenges but projects like the WindFloat will get us closer to a commercial stage when technology will be available to address the enormous deep offshore wind energy potential.

If we consider Portugal, for example, there is a huge challenge in adapting ports and shipyards and the maritime industry in general for the deep offshore wind sector. Also, the technical standards in the oil and gas and wind energy sectors need to converge into adequate standards for the new deep offshore wind paradigm. Other important challenges have to do with defining and implementing sustainable criteria and strategies envisaging the harmonious utilization of the sea. Lastly, energy players such as EDP need to prepare themselves and develop the necessary skills to be able to develop activities at sea, namely partnering with experienced oil and gas and other maritime players.

The sea opportunity is at hand, but the dimension of the challenge is in line with the size of the opportunity. We’ll need to work hard to get there.

Antonio Vidigal, CEO, EDP Innovation
FROM THE FRONT LINES:

LEADING THE GAS REVOLUTION

Late last year, New Orleans, Louisiana-based offshore operator Harvey Gulf International Marine ordered two very special platform supply vessels (PSVs) from Mississippi shipbuilder Trinity Offshore, and brought the gas revolution to the Western Hemisphere. Designed by STX Marine and building to ABS class, the STX SV310DF vessels will be powered by three dual-fuel diesel engines.

When Harvey Gulf extended the order by two more vessels a few months later, upping its investment in the new technology to about $220 million, it made clear that this was no experimental project, but a commitment to the future. When they hit the water in 2013 and 2014, the boats – named Harvey Energy, Harvey Power, Harvey Liberty and Harvey Performer – will become the first natural gas-powered vessels operating in the US waters, and in the Americas.

The four new vessels will have a cargo capacity of 5,520 dwt and a service speed of 13 knots, powered by Wärtsilä 6-cylinder 34DF dual-fuel engines. The turbocharged four-stroke diesels are compliant with MARPOL Annex VI Tier II and Tier III emissions regulations and will each produce 2,610 kW power. Besides the engines, Wärtsilä is also supplying a complete propulsion solution with steerable main thrusters, LNGPac bunkering and storage solution and electrical, automation and cargo offloading systems.

The LNGPac includes the LNG storage tank, the bunkering system, regasification and pressure control equipment, a glycol-water skid for heating the evaporators, an enclosed gas valve unit and an electronic control and automation system. As for bunkering, Wärtsilä and Shell Oil Company signed a cooperation agreement last summer to establish an LNG bunkering network, beginning with supplies from the US Gulf Coast and expanding as need emerges for broader geographical coverage.

“Because these vessels are the first in this market, our first challenge was to find an integrated propulsion system provider that would free the designer, the shipyard and the owner from taking on the responsibility of delivering the LNG system,” says Mike Carroll, STX Marine Vice President, Operations. “We looked at all the engine manufacturers and what they were offering and ultimately chose Wärtsilä, because they offer an integrated package solution. Following that initial challenge, we had to figure out how to wrap a PSV around this LNG system and make a vessel that will allow our client to have the cargo capacity of an equivalent-sized diesel vessel.”

The solution involved arranging the engines on the main deck, with the LNG storage tank located below the main deck on the centerline of the vessel inside the cargo hold. Apart from that, the hull is, fundamentally, a straight-off PSV design used as an envelope for the propulsion system – with, of course, modification to satisfy the requirements of having LNG tanks and a gas transmission system on board.

The revolutionary vessels will also receive environmentally friendly class notations from ABS, including ENVIRO+, for adherence to enhanced environmental standards; POT, for protection of fuel and lubricating oil tanks;
and GP, the Green Passport notation. Green Passport is part of a group of new, voluntary standards, generated within the industry and gaining traction among workboat operators. Green Passport certification requires the operator to inventory the type, amount and location of hazardous materials used in building and operating a vessel. The idea is to promote safe working conditions on board, to protect the marine environment and to provide environmentally friendly recycling.

The dual-fuel PSVs are not Harvey Gulf’s first ‘green’ effort. In October 2011, the company launched Harvey Supporter, the first of six diesel-electric offshore support vessels and the first US-built boat built to carry the ABS ENVIRO+ notation, in addition to the Green Passport. The boats are part of Harvey Gulf’s Going Green initiative, which focuses on reducing the environmental impact of vessels and their operation. This involves not only using clean-burning natural gas engines, but also building vessels using environmentally friendly materials so that, when they go to the breakers at the end of their lives, it will be for ‘green scrapping’.

Clearly, bringing on the future comes at a price. Harvey Gulf estimates the ‘green premium’ for the LNG PSVs to be about 17 percent above the cost of their diesel-powered equivalents – and fully expects to reap the benefits of a first adapter in a market that is ready to support environmental commitment.

“We assumed the increased cost delta on these projects by building to the ENVIRO+ and the Green Passport, which is something no one else is currently doing” says Chad Verret, Senior Vice President, Harvey Gulf International Marine. “When these PSVs are delivered, they will be the cleanest-burning vessels operating in the Gulf of Mexico,” Verret says. “We know that many permits for the eastern Gulf of Mexico already demand the operators use the best available capture technology with regards to particulate matter. In my opinion, the best available particulate matter capture technology is to not have particulate matter to start with – and that’s what burning LNG gives you” he says.

“We believe the vessels will pay back the investment through better charter premiums and longer charter durations going forward.”

Besides the propulsion system, Harvey is also raising the bar on workboat outfitting, through people-oriented interiors. Each boat will accommodate a crew of 12 in single and double cabins, with onboard amenities including lounges, a cinema, internet stations and a gym.

“In terms of interiors and creature comforts, the boats will be on-par with the best European PSVs out there, in their furnishings, feel and look,” Verret says.
In the maritime world, the brilliant future of natural gas has been the talk of the town at least once a decade since the late 1960s. Most of that talk was in the context of cargo movement, as the world liquefied natural gas (LNG) carrier fleet grew in numbers and capacity with the increasing global use of gas for power generation. Lately, natural gas has become big maritime news for another reason: the possibility that it may one day rival oil as a main fuel for the world fleet.

Use of natural gas for a general ship’s fuel always seemed just out of reach – it has fueled many vessels for over 60 years, but that use has largely been limited to LNG carriers and a handful of gas turbine ships. Until fairly recently, virtually all LNG carriers were powered by steam turbines that used the ship’s cargo as fuel (an economical use for the gas that evaporates or ‘boils off’ during transport). For other ships, the clean-burning benefits that natural gas offered as a fuel were typically outweighed by cost, technology, availability, logistics and other challenges. However, that situation may be set to change. According to Finnish engineering group Wärtsilä, the technical, economic and regulatory factors necessary to make the maritime world’s gas revolution a reality are finally all in play.

Wärtsilä kicked off the dual-fuel revolution in the maritime industry in 2003 when it supplied the first dual-fuel (DF series) diesel main engines for an offshore support. This milestone was followed by the first installation of big DF main engines for an LNG carrier in 2006. The engine maker took the technology another step forward in 2011, with the first conversion of a tankship from conventional oil to dual-fuel operation. In recent years the company has seen interest in its dual-fuel marine engine solutions expand across the world.

In 2010, Wärtsilä signed a landmark contract with Brazilian oil company Petrobras to supply dual-fuel diesel engines for the main power modules of a floating production, storage and offloading (FPSO) vessel – considered a breakthrough because, at the time, it was the first instance where an FPSO would use gas reciprocating engines to produce more than 100 MW of electricity. Historically this
As of today, all four are planned for long-term operation in the Gulf of Mexico.

Harvey Gulf is not alone – Wärtsilä reports rising interest for dual-fuel diesel engines among owners of small and coastal vessels operating in the North American area. The reason, according to John Hatley, Vice President of Wärtsilä North America, is that the marine industry is poised for a major paradigm shift. “Millennia ago, the first paradigm shift in ship propulsion was the move from oar to sail; two centuries ago, it was from sail to steam; a century ago steam to diesel; today it’s a new era for natural gas,” he says.

**THE ECA FACTOR**

“The overriding driver for the adoption of gas in the Americas is economics,” Hatley says, pointing to America’s shale gas bonanza as the game-changing resource. Already, US domestic production is lowering world gas prices and freeing supplies that analysts expect will contribute to the development of a global LNG bunkering network.

“We foresee the abundance of available, low-cost shale gas produced in the US will make LNG an increasingly affordable fuel option for maritime users there,” Hatley says. “Europe doesn’t have quite the same economic incentives as the US and Canada, but makes up for that in government mandates and tax incentives to encourage emissions reduction. As Europe pushes for increasingly cleaner water transport emissions, we will see the increasing adoption of natural gas fuel there as well, simply because it is the cleanest-burning fuel option.”

For shipowners everywhere, growth in the number of emissions-protected areas will add to the factors encouraging a switch to gas-fueled ships. With the entry into force of MARPOL Annex VI in 2005 came the method of controlling global sulfur oxide (SOx) emissions by defining certain sensitive regions as sulfur emission control areas (SECA) and, thereby, reducing atmospheric acidification and the resulting acid rain and fog. The Baltic Sea became the first SECA in 2005, followed in 2007 by the North Sea/English Channel
DUAL-FUEL ENGINE – OPERATING PRINCIPLE

Gas Mode
- Otto principle
- Low-pressure gas admission
- Pilot diesel injection

Diesel Mode
- Diesel principle
- Diesel injection

SECA and, this year, the North American ECA. New ECAs expected over the next few years include regions of Japan, Australia, Europe and the Mediterranean – with each new designation placing more of the world’s maritime business in emissions-controlled zones. As environmental regulation spreads, an increasing number of vessels will be spending most or all of their trading lives in ECAs, and will face the choice of regulatory compliance by: burning low-sulfur diesel oil; burning natural gas as fuel; or burning standard diesel oil and using an emissions abatement technology.

For the moment, the natural gas revolution is taking place among service boats and small vessels in coastwise trades. Oceangoing ships in international service spend days to weeks on the open ocean, closing to shore only when near their destinations – the world’s emissions-protected areas are only a small part of their voyage profile. For such ships, switching to low-sulfur fuels or installing emissions abatement equipment remain attractive alternatives for emissions compliance.

“The more a vessel’s voyage profile lies within an ECA, the more inducement its operator has to switch to natural gas,” Hatley says. “That’s one of the reasons why we see strong opportunities for growth developing in the emissions-sensitive coastwise, ports and inland river areas.”

There are also refit incentives for vessels with a borderline percentage of ECA time in their voyage profile. The additional emissions restrictions coming after 2016, when Tier III of the MARPOL Annex VI emissions restrictions enter into force, will require pure oil operations to employ some form of abatement technology.

“After-treatment systems consume space, weight and resources to run and maintain, as well as bringing additional responsibilities and obligations,” Hatley says. “With scrubbers, for example, although the cleaned exhaust meets the environment emission reduction criteria, the ship is left with a residual product in concentrated form, held in a storage tank on board, which has to be processed ashore in a properly certified manner to ensure it remains in an arrested state. Every choice involves expenses and obligations to make sure things are properly run and that the equipment is operating as intended,” he explains.

MIGRATING TOWARDS GAS

Cost remains a factor for owners contemplating commitment to the gas revolution, particularly as regards existing ships. Hatley notes that there is no retrofit kit to convert old engines to dual-fuel use, except in specific cases where the engine is the right model and at the right evolutionary stage for a parts swap-out to be feasible. For most existing ships, owners contemplating the benefits of dual-fuel diesels must also contemplate refitting their vessels with new fuel storage and control systems. In addition to new main engines, the Wärtsilä solution involves a propulsion package (electric or mechanical drive), gensets and the onboard LNG bunkering station, which includes the fuel intake system, cryogenic storage tanks and gas expansion equipment. Facing expanding regulations and rising fuel prices, many owners are weighing the costs of refitting the future against the expenses of continuing with the past.

Hatley says the expense of a conversion to LNG could still be economically attractive if the ship has sufficient service life ahead of it and will spend a sufficient amount of time in an ECA. For owners considering such an investment, he cautions that, too often, calculating a ‘payback period’ only answers questions of project liquidity and return on investment, which are not adequate for this important decision.

“Payback’s shortfall is that it ignores comparative cash flows that occur after a payback period and their time value of money contributions. A preferable economic measure of merit is life cycle cost (or average annual
cost) which totals both present capex (capital expenditure) and discounted opex (operational expenditure) future costs, then spreads them forward into a stream of equivalent value at a target investment rate,” Hatley explains.

At this moment, there are a few ‘LNG gas stations’ for ships. The primary means of bunkering gas-fueled ships today is through tank trucks, special dockside fueling stands, and a few small-scale bunkering vessels. Many users find trucking in small quantities to be the most expedient, if not the most efficient, means of LNG delivery. This will change as the gas revolution spreads, Hatley says.

“Once the market evolves, the truck will give way to more efficient means, such as a rail car or LNG barge, with eventual development of sophisticated hub and spoke distribution systems that employ small-scale LNG ship logistics to a chain of fueling stations or bunkering vessels. As the industry moves toward maturity we will see progressive investment toward more efficient and capex-intensive delivery means,” Hatley explains.

In response to that rising demand, the liquefied gas shipping industry recently established a cross-industry group to advise on the design, operation, maintenance and training for natural gas marine fuel systems. Organized by the Society of International Gas Tanker and Terminal Operators (SIGTTO), the Natural Gas Marine Fuel Safety Advisory Group held its inaugural meeting in July 2012. “The establishment of the Natural Gas Marine Fuel Safety Advisory Group reflects the gas shipping industry’s desire to pass on the body of knowledge it has accumulated to a rapidly emerging LNG bunkering community to ensure a continuation of the excellent safety record,” SIGTTO said in a statement.

“Although there are currently only a handful of LNG-powered vessels that are not LNG carriers in service, the orderbook is growing and LNG bunkering operations are poised to blossom.”

Similarly, he notes that vessels typically spending little or none of their voyage time in an ECA might not fully capture the economic benefits of gas usage. These vessels may prefer the use of multiple compliant fuel oils and/or the scrubber option.

The ‘green premium’ extends a little further beyond payback on investment. Those owners considering the natural gas option also have to consider the issue of cargo space versus bunker space. Non oceangoing vessels using natural gas as fuel today choose to carry the LNG bunkers in cylindrical IMO Type C tanks located on or below deck. The alternative, the self-supporting prismatic tank from Japanese shipbuilder IHI, would be built into the hull of the ship – this has not yet been done. Each type tank has its own advantages, and share one disadvantage. Because LNG has a lower volumetric energy density than traditional fuel oils, you need about 1.65 times more of it to provide the same calorific energy. Hatley says that, as a practical matter, a Type C LNG tank consumes about 3.5 to 3.8 times the space of an equivalent energy traditional fuel oil tank once three key elements are considered – LNG’s lower energy density, the containment vessel structure and the fact that the spaces available to host the cylindrical tank within the ship are, generally, rectangular.

For most existing ships, owners contemplating the benefits of dual-fuel diesels must also contemplate refitting their vessels with new fuel storage and control systems.
Dual-fuel engines run on natural gas or a range of fuel oils, with the latest models claiming the switch between fuels can be accomplished with relative ease during operation, without loss of power or speed.

Altogether, Wärtsilä has more than 600 dual-fuel (DF series) engines of all sizes on order or in operation in the marine sector. Its entry into the dual-fuel diesel market for big ships, the 50DF, passed a milestone in May 2012 with installation aboard its 100th LNG carrier. First installed aboard an LNG tanker in 2006, the engine now powers nearly one-quarter of the current global LNG fleet. With wider availability of low-cost natural gas and increasing regulatory pressure for low-emissions operations, the manufacturer sees good potential in opening big ships in other marine sectors to dual-fuel operation.

The DF engine’s fuel system uses a gas delivery system and a fuel injector that combines two components, a small nozzle for the pilot and larger nozzle for the main fuel. The engine operates on the lean-burn principle, meaning there is more air in the cylinder than necessary for complete combustion of the fuel (the air-fuel ratio is typically 2.2:1), which enables a high compression ratio that in turn contributes to efficient operation.

Fuel combustion is initiated by injecting a small amount of pilot fuel into the cylinder, which is ignited in the conventional compression manner and, in turn, provides high-energy ignition for the main gas charge. During all-gas operation, the pilot fuel amounts to less than 1 percent of full-load fuel consumption. The engine's overall emissions profile is maintained by an electronic control system that monitors and optimizes combustion in each cylinder.

Operating in the natural gas mode reduces nitrogen oxide (NOx) emissions by nearly 85 percent. In addition, when running on natural gas and low-sulfur fuels, dual-fuel diesels produce near-zero levels of SOx and particulate matter emissions.
The finite element method of analysis stands firmly among the fundamental engineering design tools of modern civilization. Developed almost five decades ago to bring advanced military aircraft concepts to reality, it has since been adapted to the needs of every sphere of industrial activity and is routinely applied today to help optimize new designs, assess the fitness of existing structures, predict service performance and evaluate new ideas. As a key component of computer-aided design and engineering, it has helped enable concepts without precedent to be realized as viable and safe constructions.

Once it became available to the maritime sector, the finite element method helped make ship structural design a matter of scientific calculation, rather than the derivation from accumulated experience that it had been throughout history. The methodology has helped ships and other marine structures evolve by leaps and bounds, rather than by incremental steps, and is so deeply part of the modern maritime industry that one can scarcely imagine a time without it. Yet it was only 45 years ago that a major oil company, a young academician and a leading classification society combined forces to develop the finite element method for specific application to ship structures.

ABS was one member of a tripartite team that developed finite element analysis for maritime applications and opened the door to the future of naval architecture.

TRAPPED BY HISTORY

Until about 1970, a perfectly good, high-quality cargo ship could be designed without even the aid of a slide rule. All the designer had to do was decide the length and breadth of the vessel, open a book of classification Rules and search through the many tables therein for prescribed frame spacing, plate thicknesses, scantling sizes and so forth – the important design parameters were already established. Knowledge of ship structures, of vessel performance at sea and of the scantling thicknesses appropriate to ship safety was based entirely on experience, on many decades of careful observation of ships at sea and their physical condition after years of service, and on the scientific accumulation and analysis of that data. It had been that way, more or less, since man first put ships to sea. As a consequence, ship sizes and structural technologies built on the past and advanced very slowly (with a few daring exceptions) for an extremely long time.

However, the same was not true for ship shapes. Hullforms could be engineered and refined ever since William Froude developed the mathematical discipline of ship hydrodynamics and built the first experimental towing tank circa 1861. For a century, hullforms could advance scientifically, while the structures supporting them had to advance...
empirically. By the mid-1960s that gap had to close. The size of merchant ships had been increasing at an alarming rate for a decade, to the point where safety authorities became concerned that existing knowledge could no longer testify to the long-term structural integrity and safety of the biggest ships afloat.

Oil and ore carriers began routinely attaining size records after World War II, striving for ever greater capacities by the increasing needs of a rebuilding world. In a period of less than twenty years, ships increased almost sevenfold in size. The biggest ships afloat in 1948 were tankers like Bulkpetrol, which had a capacity of 30,000 dwt and a length of 640 ft. By 1953 the biggest ships at sea were around 45,000 dwt and 720 ft long. In 1958 the ABS-classed tanker Universe Apollo crossed an ‘impossible’ barrier at 104,000-dwt and nearly 950 ft long, and in 1966 the ABS-classed Idemitsu Maru grabbed headlines around the world with a 205,000-dwt capacity and 1,122-ft length VLCC, the 205,000-dwt Idemitsu Maru, which operated between the Persian Gulf and Japan; the 170,000-dwt Esso Malaysia, on regular runs between the Persian Gulf and Northern Europe; the 74,200-dwt Fotini L., sailing between Japan and the west coasts of North and South America; and the 63,041-dwt R.G. Follis, running between the Persian Gulf and Newfoundland. The following year they were joined by the latest world’s largest ship, the 316,000-dwt Universe Ireland. The program wound down in 1969, when the collected data was processed and made available to industry, and the resulting conclusions published in the ABS Rules. In 1971, Little, Lewis and Bailey presented a landmark technical paper on the subject, “A Statistical Study of Wave-Induced Bending Moments on Large Oceangoing Tankers and Bulk Carriers.”

ABS’ efforts in rational ship design were supported by computers through a new Electronic Data Processing (EDP) initiative. One reason why ABS established its EDP program in 1965 was to simplify calculations involved with determining new freeboard assignments for ships under the 1966 International Load Line Convention. Another was to deal with what pop culture had christened ‘the data dilemma’ – the general problem of efficiently collecting, storing and extracting information that, thanks to

Industry’s First Vessel Instrumentation Program

By 1966, ABS Rules included longitudinal strength standards for ships 1,000 ft long, but no service data existed on how such large ships reacted to severe sea states. ABS filled the gap by having the measurements made in situ.

The ABS Vessel Instrumentation Program employed a division of Teledyne to install, maintain and gather data from sensitive measurement equipment placed throughout the hulls of four large tankers. The first such project in the industry, it enabled real-time recording of stresses, strains and bending behavior in big ships at sea. Its purpose was to learn more about the behavior and longitudinal strength of tankers and bulk carriers in waves and, in particular, to determine the expected extreme bending moments in random seas encountered by these large ships over a period of time. The program was funded by ABS and conducted under the leadership of Robert S. Little, ABS Vice President of Research and Development. Professor E.V. Lewis of Webb Institute directed the project and F.C. Bailey of Teledyne Materials Research performed the full-scale measurements and data reduction.

Initially, four large tankers in different ocean zones were instrumented: the world’s first

![An unsung critical element in the chain of maritime safety: the painstaking plan reviews performed by classification society engineers.](image-url)
– removing all doubt that tanker sizes would continue to grow and astound.

The groundbreaking ships of this evolutionary period were, in reality, scaled-up versions of earlier, smaller designs. The Idemitsu Maru, for example, was scaled up from a 30,000-dwt vessel. While it was clear that an enormous engineering effort had gone into developing the ships, it was also clear to operators and regulators alike that extrapolating on the past was no longer sufficient to build vessels of the future. Their main concern was the inability to predict what would happen to such large ships over years of service at sea.

This problem was tackled in a three-year, joint research and development effort between Chevron Shipping, the American Bureau of Shipping and the University of Arizona, which produced what has been called one of the greatest advances in the history of naval architecture: developing the finite element analysis method for application to ship structures.

**LIBERATION BY SCIENCE**

The adventure that brought the finite element method to the maritime industry began in 1968, when oil major Chevron started developing specifications for its first series of very large crude carriers (VLCCs). The term VLCC had only recently been coined to describe tankers with a capacity of two million barrels or more – at the time there was only one at sea and, consequently, there were no shipbuilding Rules specific to such big ships. So, even though the new vessel was to be built at one of the most technologically advanced yards of the period, Kockums Mekaniska Verkstad in Sweden, Chevron had some serious issues to address.

Concerned that simply scaling up existing shipbuilding Rules might not provide for modern communications, was suddenly arriving from around the world in ever-increasing quantities and at ever-increasing speeds. Within a few years, ABS was using computers to solve complex engineering problems and to serve as the memory bank and processor for vital ship statistics.

By today’s standards, ABS’ first computing system would be called primitive. Programmers sat at teletype machines, writing their programs in BASIC language on punched paper tape. A finished tape would be run through the teletype, which linked to a General Electric mainframe computer housed in GE’s midtown Manhattan office, accessing the electronic brain via a time-sharing system. It wasn’t the most advanced system available even then, but was the best in the maritime industry and attracted to ABS the first members in a generation of bright young minds whose collective efforts eventually changed naval architecture and marine classification forever.

“"I can understand that EDP seems somewhat alarming on first acquaintance," said Dr. E.G. "Doc" Baker, Manager of the nascent EDP program, in 1967. "Many people must feel that computers may take over their jobs – may even take over their lives in the not-too-distant future. But really it’s not something to be afraid of. The computer can’t think; it can’t take over from the human brain. What it can do is handle a set of figures in a few minutes which would take a man his whole life to work out. It can eliminate many of the dreary routines of our workaday lives and help free our minds for more constructive thinking." ◆

Located several miles from headquarters in mid-town Manhattan, the General Electric computer performed ABS' electronic data processing through a time-sharing program.
long-term structural integrity at this great size, the oil major wanted to apply the latest analytical technology in designing its ship. Although computerized structural analysis was available to maritime users at this time, all existing software programs had been derived from civil engineering and were not suitable for assessing anything about a ship beyond tiny details of internal structure. For Chevron, the answer was to be found in the aerospace industry, where leading companies were designing advanced aircraft using the recently developed finite element method of structural analysis.

In the finite element method, engineers construct a detailed mathematical model of a structure that enables its real-life behavior to be simulated and analyzed. This model can be visualized by thinking of a giant fish net slipped tightly over a ship’s hull, such that it hugs the vessel’s shape perfectly. The threads of the net form a mesh, a pattern of discrete quadrangles, all around the hullform. These quadrangles are called ‘elements’, and the corners of the elements are called ‘nodes’. The method derives its name from the fact that the number of elements, although large, is finite – and, as such, each can be quantified and analyzed.

Each element is assigned attributes – for example, thickness, elasticity and strength – that correspond to the properties of the physical material that is intended to be at the location the element represents. Once these properties are assigned, the elements can mathematically ‘react’ to loads that the analyst places upon them – for example, waves striking the vessel amidships. These loads are represented by forces at the thousands of node points in the model. The behavior or response that each element experiences is calculated in the form of deformations at the node points and stresses in the elements.

Once the forces at each node are quantified and applied, thousands of equations must be solved simultaneously so that all the elements respond in a consistent and compatible manner. While this is going on, additional calculations have to be performed for investigators to be sure that the model remains mathematically ‘balanced’ – that is, consistent with such real-life phenomena as gravity.

Finite element mesh models, if properly proportioned and arranged, reflect the real-life response of a structure to forces it encounters. Models using a ‘coarse mesh’ (larger elements) are typically used for ‘global’ or overall structural response, while progressively finer-mesh models are used to zero-in on local areas requiring more detailed analyses. Given enough time and computing power, extremely accurate modeling can be done – a capability that made finite element analysis ideal for investigating the behavior of advanced aircraft designs.

In the 1960s, commercial aircraft designers, not unlike naval architects, were striving for higher cruising speeds and airplanes of unprecedented size. Boeing, for example, was developing the 747 during this time. These designers, like their maritime counterparts, had to be sure their aircraft could deal with forces of types and complexities never before quantified or even understood. Thus, when Chevron decided to build a VLCC it turned to the airline industry for technical assistance.

One reason that led the oil major to aircraft designers was that a ship hull and an airplane fuselage are both ‘plated surfaces’ – structures having a skin of plates attached to a skeleton of internal stiffeners. Since Boeing had successfully used finite element analysis to tackle its design challenges, it seemed a short step to apply the methodology and software to ship structures.

When Chevron asked Boeing for access to its finite element software, the airplane maker replied that that could not be done, for proprietary reasons. In consolation, Boeing’s head of structures suggested that Chevron develop its own finite element program and directed the team to a friend of his, a newly arrived professor of aerospace engineering at the University of Arizona named Hussein Kamel. Dr. Kamel had studied at the Imperial College in London under Dr. John Argyris,
one of the inventors of the finite element method, and had worked with NATO on development of the ASKA computer program, a forerunner of large-scale finite element programs for aircraft structures.

It was soon discovered that, despite any similarities in their nature, ships and airplanes have such different service and environmental loading conditions that the finite element method as developed for aeronautical use could not be applied to ships. This brought the oil major a new problem: how to create a development team that could adapt the finite element methodology for application to ship structures. Chevron Shipping was a top-notch engineering company, but didn’t have computer programmers. Professor Kamel was a cutting-edge expert in the finite element method, but wasn’t a naval architect. The missing piece needed to take the project forward was to find a person who knew ships, naval architecture and computer-aided design, and who could also program computers. Serendipity provided the solution.

It happened that the Vice President of Chevron Shipping, Gordon Colberg, was a former college classmate of ABS Senior Vice President Robert Little. He knew of ABS’ early developmental role in ship structural analysis and its commitment to the rational ship design movement – the goal of which was to quantify, in engineering formulations, the true behavior of ships at sea. When he asked his friend if ABS would join the project, Little replied he had just the man for the job: a young whiz-kid in the Electronic Data Processing Department named Don Liu.

Liu was one of the bright young minds ABS hired in 1966 when it began to computerize. His graduate work at the Massachusetts Institute of Technology had involved computer-aided design and the application of electronic computing to naval architecture. He was drawn to ABS because it was among the first maritime companies to embrace computerization and wanted to develop computer programs for ship stability, structural analyses and other naval architectural procedures. The Chevron project fit perfectly with this goal and gave ABS a rare opportunity to help author a new chapter in the history of naval architecture.

**THE ARIZONA PROJECT**

In 1968, ABS sent Liu to the Tucson campus of the University of Arizona to work with Dr. Kamel and engineer Bill Reid of Chevron Shipping in producing computer programs for the finite element analysis of ships. Known as the Arizona Project, the work had two main goals. Kamel led development of the software program that would actually perform the finite element analysis, ultimately christened DAISY (for Displacement Automated Integrated System). Liu focused on writing a suite of pre-processing programs that would produce the ship data, create the mesh model and loads and feed the input to DAISY. These pre-processing programs would, among other things, define hullform geometry, calculate hull girder bending moments and shear forces and develop ship structural finite element models and sea loads – together forging the world’s first link between naval architecture and finite element analysis.

As intended, DAISY was first employed to analyze the design and model the hull of the VLCC John A. McCone. Launched in 1969, the McCone served 25 years at sea,
Education Spreads the Revolution

At the University of Arizona (Tucson), Dr. Hussein Kamel and Dr. Donald Liu gave the maritime industry’s first courses in the application of finite element analysis to ship structures. Not only did these pioneers help revolutionize the capabilities of naval architecture in ship design, they were first to spread the seeds of that revolution through education.

Education remains close to Dr. Liu’s heart. Today, he uses education as a preemptive strike against the potential for mental complacency that he sees in the ease with which sophisticated analyses can be accomplished — a threat he helps young engineers guard against.

“Sophisticated tools are so user-friendly now that it is possible to read a manual and conclude you know how to do the analysis,” Liu says. “I meet a lot of people who figure that if you just input data, and push the button, whatever answer you get must be right. But these tools are not for the uninitiated,” he cautions.

“Forty years ago, Professor Kamel told me that, in applying the finite element method you should ‘always know the answer before you do the analysis’. I’d say the same to anyone today: You have to know what to expect,” he says. “Then, if you get unexpected results, you’re able to question them and figure out if you made a mistake somewhere, if the software is just not working right, or if your expectations were off. The more you know, the more you get out of an analysis tool,” he adds.

“That is why I instituted engineer training at ABS. The one or two semesters in college that young engineers typically have had are not sufficient for understanding structures. We train them how to use the various software programs, and to review the theory, logic and application of finite element analysis. "No matter how sophisticated your analysis tools, you still have to use good sound, engineering experience and judgment. If your loads are correct, your assumptions are correct, and your programming is right, you can compute what can really happen to a structure. That’s what engineering is all about.”

◆
over a decade longer than the other mega-
ships of its time, which were not designed
using finite element analysis (FEA). Right
after completing review of the McCone,
Chevron began analysis of a second
VLCC design, to be built at Mitsubishi
in Japan, assisted by revolving teams of
ABS engineers.

Just as that project was winding down,
containership pioneer Sea-Land approached
ABS with its groundbreaking SL-7
containership project. Conceived by
Malcolm McLean, father of the containership
and Sea-Land’s founder, the sleek 120,000-
dwt, twin-screw SL-7 series was designed to
be the fastest ships in commercial trade, with
an unheard-of 33-knot service speed. These
vessels ultimately became key elements
of the US Military Sealift Command’s
prepositioned fleet, but before they could be
realized their advanced design raised a slew
of unprecedented technical challenges. For
example, the vessel’s wide hatch openings –
nearly 85 percent of the beam – required
intense torsional loading studies, and the
abrupt change in deck stiffness where
the deckhouse was joined raised serious
questions about longitudinal stresses and
warping restraint.

In 1970, ABS used DAISY for complete
ship motion and stress analyses on the SL-7
design — the first containership subjected to
FEA. The studies included structural model
testing, mathematical analysis and towing
tank tests to determine the wave-induced
torsional, vertical and lateral bending
moments that might be experienced in
both regular and irregular sea conditions. In
addition to validating the design, the studies
provided a firm basis for comparing measured
and predicted values that helped refine the
DAISY program.

FROM DAISY TO DLA
DAISY also figured prominently in the
evolution of a special kind of tanker,
the liquefied natural gas (LNG) carrier.
Natural gas is over 80 percent methane,
which is a cryogenic liquid — it only
liquefies through deep refrigeration. Chilled
to -162°C (-260°F), it is transported at
atmospheric pressure in insulated cargo
tanks, or containment systems. Several
alternative containment technologies
developed over the years and are currently
in use, but most of the world LNG carrier
fleet uses either independent spherical tanks
or membrane tanks.

The free-standing spherical tank, a thick-
walled aluminum globe with its own
supporting structure, was, until about a decade
ago, the most common LNG containment
system. It remains the most recognizable; the
silhouette of a ship with a line of large domes
on deck has become the universal symbol of
LNG carriage. A majority of all LNG carriers
built in recent years use the ‘membrane’ tank
system, so called because its primary barrier
(the part in contact with the cargo) is a thin
membrane of stainless steel or Invar (a nickel-
steel alloy). Depending on the specific design,
this primary barrier will be supported by
structured layers of insulation or by plywood
boxes filled with insulating material, which are
in turn supported by the inner hull of the ship.
Membrane systems are built into the hull so
that, ultimately, the hull structure supports the
weight of the cargo.

By 1970, new designs for these ships began
pushing the limits of industry experience with
shipboard LNG containment, proposing an
increase in cargo capacity of about 75 percent
above any LNG carrier then in service. The
largest LNG tankers of the period could carry
71,500 m³ of liquid gas, but the new designs
were reaching for 125,000 m³. This raised safety concerns for both major containment technologies, particularly regarding whether the internal forces generated by such large liquid cargoes as they sloshed around during the voyage would damage the containment systems and escape. The energy transport industry asked ABS to provide the solution through finite element analysis.

This led ABS to incorporate motion into the FEA method and, through that, to develop what became the dynamic loading approach (DLA). “We started including motions and accelerations in our DAISY model so that, if you had liquid cargo and the ship is accelerating, you could calculate the additional dynamic forces of the cargo against the containment system,” Liu recalls. “That was the start of bringing seakeeping and ship motions into finite element analysis.”

In 1972, ABS conducted a conceptual review of the spherical tank design for an order of ten ships of 125,000-m³ capacity to be built by the General Dynamics shipyard in Quincy, Massachusetts. ABS worked closely with the shipyard and the containment system designer, supervising welding of the thick aluminum tanks and performing detailed finite element analyses, ship motion studies and heat transfer and vibration analysis of the ships. During the same period, similar studies helped develop a new series of 125,000-m³ membrane tank ships. FEA remains a critical tool for developing an LNG carrier; ABS’ work during the 1970s laid the foundations for the sophisticated analyses, widely used today, that continue to advance LNG transport technology.

From tankers, containerships and LNG carriers, DAISY soon moved to structural analysis of jackup and semisubmersible-type mobile offshore drilling units. By 1975, ABS was actively marketing the DAISY program throughout the maritime industry, with major shipyards and universities among the first to make use of the tool. By the end of the decade it was being employed at numerous manufacturing facilities and design shops. In the early 1980s, DAISY was retired and replaced by commercial finite element software developed at NASA, named NASTRAN (for NASA Structural Analysis); the pre-processing suite remains in use today, albeit in a much-evolved form.

Liu and Professor Kamel offered the first courses and seminars in FEA for naval architects at the University of Arizona in 1971 and 1972. By 1986 the genie had left the bottle – finite element computer programs from a variety of vendors were on the market and the technique was well-established throughout the shipping and offshore industries – but the computer-aided ship design revolution was far from over, and ABS would soon have the lead role in its next step forward.

TROUBLE & TRAGEDY SPUR TECHNOLOGY EVOLUTION

In response to the 1989 Exxon Valdez oil spill, the US Government enacted the Oil Pollution Act of 1990 (OPA 90), which included mandates affecting the design, operation and liabilities associated with tankships. The law required that all new tankers trading to the United States would have to be built with double hulls and provided a phase-out schedule for single-hull tankers, which would ultimately be banned from US waters. Double-hull construction was to be the law beginning in 1993.
Seeds of the Modern Age:
The Rational Ship Design Movement

When ship sizes began growing rapidly in the late 1950s, service information about how the forces of the sea affected big hulls was quite limited. Consequently, so was the ability to predict their performance. Once the 100,000-dwt barrier was crossed in 1958, it seemed ships would grow in size as quickly as plans could be drawn up, which raised serious questions about the long-term safety and pollution potential of large ships at sea.

The issue was tackled by the US Ship Structure Committee (SSC), a Government-led think-tank and research sponsor. In a 1959 report, the SSC concluded that achieving a better understanding of loads (the forces a ship experiences at sea) was key to establishing “rational, less empirical design procedures.” That report, A Long-Range Research Program in Ship Structural Design, kicked off a research program that ran throughout the 1960s, in which full-scale stress data was collected from a number of ships in service. This data contributed to the first understanding of the true loads and responses of ships in service.

The report introduced ‘rational ship design’ as the means by which: the functions and requirements for the hull structure can be explicitly stated at the outset of the project; all loads expected in service can be determined and combined; structural members can be arranged in the most efficient manner to resist those loads; and adequate, but not excessive, scantlings can be determined using a minimum of purely empirical factors.

One goal of the rational ship design movement was to develop weight-saving ship structures. Another was to develop a theoretical basis for analyzing new designs. All the goals in rational ship design depended on obtaining a better understanding of the loads a ship experiences at sea and how the vessel’s structure responds to them.

The key to achieving this understanding was learning how to predict wave forces. Good measurement of wave forces became possible during the 1960s and, under a variety of research programs, hundreds of thousands of at-sea wave observations and measurements were collected and analyzed by computer. Ocean scientists were then able to describe the sea surface in terms of wave spectra – for any given time period, a spectrum could be developed that described the many components of waves, with different lengths, heights and directions all superimposed in a random fashion.

In 1960, ABS sponsored a long-term research program at the Webb Institute of Naval Architecture in New York to “develop a procedure for establishing rational design standards for wave-induced bending moments on ship hulls (the vertical and lateral bending stresses encompassing the entire hull), making due allowance for ship size and speed, hull form, and expected weather conditions.” Out of this study and an SSC research program into dry cargo ships grew the ABS Vessel Instrumentation Program, a multi-year data gathering mission begun in 1967 that focused on the behavior of large hulls at sea.

ABS had started on this issue in 1958 with basic research into vessel dynamics, using the facilities of the Stevens Institute of Technology in Hoboken, New Jersey for investigations in wave-induced hull bending moments. The results of this work improved industry understanding of the influences of form, speed and sea conditions on the overall longitudinal bending moments in ship’s hulls. The results of this and other research led ABS to determine that it was possible to develop new methods for estimating the probable bending moments and deck-edge stresses in actual ships under a wide range of realistic form variations and sea conditions. Working with the Webb Institute, ABS collected and analyzed data in an attempt to develop a mathematical approach for predicting probable hull bending stresses. This was the first step toward developing an accurate prediction of long-term maximum bending stresses in ships at sea, as well as a realistic mathematical modeling of a ship hull in motion on the sea.◆
Apart from a few double-hull tankers built to ABS class in the mid-1980s, this was a ship type without service history and, therefore, was not adequately covered by existing classification Rules. At the time, all classification Rules were still the experience-based empirical instructions they had been for decades, even if they were written as formulae instead of tables. While DLA helped bring to life the most advanced ships of the previous two decades and offered a true engineering alternative to the empirical Rules, the simpler prescriptive Rules remained the mainstay of ship design.

Without service experience, safety authorities and shipowners with questions regarding the long-term structural integrity of double hulls could get no sure answers. This was one reason why ABS decided to use DLA technology to develop a completely new set of Steel Vessel Rules that would help designers create new vessel designs. Another reason for developing DLA-based Rules lay in what ABS identified as a dangerous trend in shipbuilding towards light scantling, short life ships.

The light scantling trend had its roots in the tanker boom of the 1960s, when designers started using high-strength steels to save weight in their increasingly larger vessels. These new steels offered strengths equal to traditional ‘mild’ steels, but at lower thicknesses and lighter weights. The new steels were initially used in above-water locations, but by the mid-1980s builders discovered that applying them extensively in the hull allowed them to offer ships that were lighter and cheaper to build, but which still satisfied all applicable hull strength requirements. Pressure from certain powerful shipyards then started a steelweight reduction competition among classification societies that exploited the empirical nature of classification Rules and the fact that the various societies promulgated different standards.

At the height of this, one major class society proudly announced that its Rules allowed a thousand tons of steel to be removed from a standard tanker design. Scantlings became so light that brand-new vessels left their builders looking prematurely wasted. Side-shell plating of many new ships in the late 1980s was so thin that it warped inward between the internal stiffening frames, resembling a starving animal’s ribcage – the ‘hungry horse’ look had become the new face of shipping. Despite the tragic aesthetics, the empirical Rules could be satisfied and steelweight reduction received wide acceptance as an effective commercial strategy. First evidence of its negative impact on structural integrity came as an increasing number of young ships experienced debilitating, premature fractures.

By 1990, ships as young as two years old were experiencing side shell plating fractures and severe cracking of structural details. Many owners and operators were overwhelmed by the constant maintenance and repair their new ships required. The situation became so bad that one major repair yard was able to build a nice business prefabricating generic hull sections for wholesale replacement of areas where tanker structural failure was most common.

All through this period, ABS resisted extensive use of high-strength steels and, as a result, its Rules developed a reputation among shipowners for producing ‘heavier’ ships (more steel and higher cost), and the company suffered the expected economic consequences. Seeking to prove conclusively the dangers in light scantling design, ABS embarked on a technology development effort that would leave an indelible imprint on the maritime industry.

RULES ‘RESTATEMENT’ FORGES THE FUTURE

In 1990, newly elected ABS Chairman Frank J. Iarossi saw in DLA the foundation of a new, modern and more competitive ABS, and became the corporate-level champion of a technical revolution in marine classification. That year, he inaugurated Rules 2000, a project to be led by Don Liu that would ‘restate’ the ABS Steel Vessel Rules so as to give them a true engineering basis and, thereby, surpass the confines of accumulated experience. This effort was described as moving to a ‘first principles’ engineering approach.

First principles engineering is a design development process in which engineers determine loads, analyze load effects (the ways in which loads on a structure translate into physical reactions, such as stresses and deflections) and apply specific criteria to assess a design. The process gives designers...
access to a thorough quantification of the stresses to which a proposed design would be subject and, thereby, enables them to know everything about the structure in terms of its fatigue, yielding and buckling performance.

A ship is subject to ever-changing external and internal forces, which are exacerbated by its own complex motions as it pitches, rolls and heaves through the sea. To take an explicit engineering approach to ship design means to account for stresses and moments affecting the vessel in each phase of its motion. Using ship classification Rules based on engineering first principles, designers would be able to calculate structural scantlings based on their various interactions within the ship and, in turn, be able to know how they fit into the broad band of acceptable strength requirements. The end result of this would be a hull that uses materials efficiently, in a manner consistent with the loads and failure modes considered to be dominant during its lifetime.

Prior to the ABS Rules restatement, there was no guide available from any source that could predict how a ship design would perform in service. If, for example, a designer wanted to reduce the steel in a section of hull plate by half a millimeter, there was no place he could turn to find out what effect the change might have on the fatigue life of the vessel.

The Rules restatement project opened Phase One of the Rules 2000 initiative, in which ABS engineers developed computer programs, specific design tools, that helped solve such problems by using direct engineering analysis of important locations in the hull structure.

To get there, ABS engineering teams literally took apart the prescriptive Rules, determining the loading cases and relationships that made them work and, using DLA, were able to rewrite the Rules based on engineering strength of materials formulations. They then applied finite element analysis to the same loading cases and were able to determine how the ship structural components interact. This provided the ability to account for novel designs, and to know the effects that a single structural change will have throughout a ship.

ABS was able to prove that there was a correlation between the increasing number of vessel fractures and the increased use of high-strength steels in ship construction and, ultimately, was able to identify the cause as fatigue failure. Fatigue failure is the phenomenon whereby forces that do not cause deformation can cause a material to fracture when applied cyclically over time – like repeatedly bending a paper clip until it breaks. Although fatigue cracking was not unknown in ships, the modern problem had taken on new dimensions that existing classification Rules were not prepared to address.

The strength criteria then used in ship design represented the best practice of the time, but had been developed entirely on long-term use of mild steel. Thus, they were only sufficient for designs using that material. Because yielding is the dominant mode of failure for mild steel, that was the chief failure mode the Rules considered. Buckling and fatigue are failure modes related directly to the thickness of the steel employed and could, for the most part, be ignored because the heavy construction required of a mild steel ship

In the early 1990s, ABS deconstructed the empirical Rules and reconstituted them as engineering formulations.
effectively prevented them from occurring. As ships used increasingly high percentages of high-strength steel – and, thus, used the thinnest scantlings possible – these failure modes became more common. In order to tell designers how to adequately account for buckling and fatigue, it would be necessary to give them an engineering sense for the aspects of design that had always been done empirically.

To begin restating the ABS Rules, engineers in ABS’ Research, Rules Development and Ship Structures departments spent a year quantifying all they knew about vessel design and behavior at sea, in order to identify design criteria and develop generic methodologies for defining loads. The first step of the project was to establish general methods, for which they needed to choose a ship type to be the subject of the initial analyses.

They chose the double-hull tanker because OPA 90 was to take effect in 1993.

The second step of the process was to identify knowledge gaps. Identifying them was easy, but resolving them was not. In many cases solutions had never before been attempted in the context of ship structures. Over the course of two years the ABS teams developed a set of methodologies and analytical models for ship design.

The various design and analysis software that ABS developed were calibrated against real ships with known service histories, through a long process of subjecting the original ship’s plans to analysis and verifying where the programs accurately predicted the vessel’s life experience. After countless iterations they eventually reached the point where the programs performed faultlessly.

THE SAFEHULL REVOLUTION

In 1991, ABS released a version of DLA for public use. This gave the maritime industry its first commercially available ‘design by analysis’ procedure, which allowed more accurate modeling of expected ship loads and dynamic stresses than previously possible. As a practical matter, it told designers where steel should be put in the hull to achieve the most good.

DLA was available but not very accessible. DLA analysis was extremely labor-intensive and took a very long time to complete – too long to apply to every ship design or to fit into normal commercial shipbuilding schedules. For many shipowners it was also a prohibitively expensive exercise, particularly in the depressed markets of the time, so ABS began working to create a ‘portable’ version that designers could easily use on a desktop computer.

During this same time period, the Rules 2000 research and development team reached two important goals: the 1992 release of ABS’ Guide for the Fatigue Strength Assessment of Tankers with its supporting software; and the 1993 release of the Guide for the Dynamic-Based Design and Evaluation of Tanker Structures and its accompanying software. By 1993, ‘portable DLA’ had been achieved and integrated with these advanced fatigue and strength programs.

ABS employees were subsequently engaged in a friendly contest to name the new product and submit logo designs. The winner in both categories was a young engineer with a talent for scrimshaw named Todd Grove (currently...
ABS Chief Technology Officer), who named the product SafeHull and created the etched bow-and-grid logo for it that became known the world over.

In September 1993, ABS released its SafeHull system for oil tankers, a complete technical resource that included the new strength and fatigue criteria, dedicated software applications and technical support. With the new software and its built-in simplified DLA, SafeHull gave designers the ability to explicitly account for loads and strength characteristics in new designs. It provided a new freedom to make appropriate scantling selections based on the actual loads and failure modes that the vessel would have to resist. For the first time, even radical new designs could be developed within the context of a classification society’s Rules. Industry reaction was immediate – the first copy of SafeHull was sold to shipowner Ole Skaarup three seconds after its introductory press conference concluded.

With the ability to explicitly account for loads and strength characteristics in their proposed designs, as well as new freedom in making scantling selections appropriate to the actual loads and failure modes that the vessel needs to resist, SafeHull made ‘design by analysis’ a practical reality for any naval architect in the world.

These techniques had been used by ABS on special projects for over a decade at that point, but SafeHull made them available for the first time for widespread use on routine designs. This gave many designers their first encounter with realistic loads and methods of quantifying their effects on ship structures – a truly revolutionary design tool that showed the way to improved designs and enhanced structural safety for every ship type to which it was applied.

Over time, versions of SafeHull were developed for other vessel types: SafeHull for dry bulk carriers in 1994; containerships in 1996; floating production, storage and offloading (FPSO) units in 2000; and for LNG carriers in 2004.

Where the old Rules were used to validate designs, SafeHull-based Rules could be used to develop them. It became possible to explore daring new designs on a desktop. SafeHull also allowed engineers to analyze existing vessels for fatigue life and structural strength, to assess proposed repairs before any steel was cut, and even to accurately predict the areas where owners would see structural cracks appear in their ships. As a practical matter, these predictive analyses more than any other demonstration proved what a unique tool SafeHull was, and remains.

By early 1994, a version of SafeHull had been developed specifically for analysis and assessment of existing tanker and dry bulk vessels, including those not classed by ABS. Soon, the SafeHull Condition Assessment Program was being used all over the world to give owners, operators, regulators, charterers and underwriters a new, clear and comprehensive evaluation of the strength and true condition of existing ships, and a prediction of their fatigue life going forward. SafeHull proved to shipowners and regulators alike that the light scantling movement had led to the production of structurally inadequate ships. The value over time of that single contribution to safety at sea is probably incalculable.

Altogether, SafeHull drew to ABS a flood of new clients – many won from societies that had supported light scantling shipbuilding – and paved the way for the greatest period of growth in its history.

“Through SafeHull, ABS revolutionized ship design by creating a practical, easy-to-use system of formulations representing the complex, real-life experience of a ship at sea; we were first to offer a basis for accurately predicting what designs would be structurally sound and what the expected lives of ships would be,” Don Liu recalls. “We set out to use advanced technology to improve structural safety at sea and we succeeded – and that’s what we’re all about.”

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Through Hamburg’s maritime museum, a prominent maritime journalist shares his lifelong love of ships, shipping, seafaring and history.

As the city of Hamburg develops into a techno-media hub and transitions from an industrial to a knowledge economy, it has found many safe places to cradle its past. The latest addition to the city’s fine collection of museums is the International Maritime Museum Hamburg (IMMH).

The IMMH shares stories of man and the sea throughout time, from cavemen and conquerors to seamen and shipbuilders. The visitor can travel three millennia of human history, tracked through nine floors (called decks) whose 11,000 m² of exhibition space span the glories and the tragedies, the achievements and the failures, the hopes and the hubris that have carried mankind from the age of the dugout canoe to the era of offshore wind power.

The basis of all this is the private collection of maritime memorabilia started in 1934 by Peter Tamm, a prominent maritime journalist who became chairman of the board of the Axel Springer publishing group. The accumulation began when Tamm, now 85, received a miniature model boat from his mother when he was six years old. Over the ensuing decades, Mr. Tamm collected more than 26,000 miniature ship models, 50,000 vessel construction plans, 5,000 maritime paintings and graphics, 2,000 films, 1.5 million photographs and 120,000 books, nautical instruments, uniforms and assorted maritime artifacts. For years, this historic hoard was crammed into a mansion on Hamburg’s posh Elbchaussee, and was viewable only by appointment and in small bites.

All that changed in 2008 with the opening of the museum, which is housed in the historic waterfront neighborhood known as the Speicherstadt (Warehouse City). The Speicherstadt is an imposing array of monumental red-brick buildings that once were at the very heart of trade in the riverfront city that is often called Germany’s premier port.

The museum building was for over a century known as Kaispeicher B (quay warehouse B), the oldest standing warehouse in Hamburg. Built in 1878 on the Magdeburg and Brooktor dock
as a combination grain elevator and storage facility, its brickwork gables, cornices and pointed arches – fine examples of the neo-Gothic style – make it one of this special zone’s most impressive structures. Barges and ships unloaded from the Magdeburg dock while smaller vessels did so on the Brooktor dock; their commingled deliveries making their way into the rest of the country via a rail link on the building’s ground floor. About ten years older than the other structures lining the byways of the Speicherstadt, most of which are now being converted into modern dwellings and high-tech business sites, Kaispeicher B was declared a ‘cultural heritage site’ in 2000 but remained a functioning warehouse until 2003.

The IMMH is run by the ten-year-old Peter Tamm Sen. Foundation and was made possible by the Hamburg city government, which gave the foundation a 99-year, zero-rent lease on the building and a grant of €30-million ($47 million at the time) for its refurbishment and adaptation.

Possibly the best-known section of the museum is the ninth deck, which holds the founder’s immense collection of 1/1,250-scale ships models, but the other floors hold some equally impressive items. There are, for example, displays dedicated to the ill-fated Shackleton expedition, to marine research and to naval warfare, a fine set of ship engine models and a huge reproduction of the ocean liner Queen Mary II made from more than one million Lego bricks. Other exhibits tell tales of underwater exploration, life at sea and the arts of navigation, engineering and shipbuilding.

Among the most unusual and impressive displays is a group of highly detailed sailing ship models carved from animal bones and assembled by captured French sailors held in English prisons during the Napoleonic wars. Altogether, the visitor would be best advised to bring a second memory card and battery for his camera, because all are likely to become exhausted trying to take in the museum’s offering in one day.

Every museum has a philosophy behind it, and the animating force of the International Maritime Museum Hamburg was best described by Peter Tamm in the preamble to his foundation’s statutes:

“Over the course of my life I, have built up an extensive collection of international seafaring and naval history with the aim of preserving history and bringing it within the experience of future generations. It is my deep conviction that it is one of the duties of every responsible adult citizen to preserve history, to learn from history and to visualize historical events in order to help shape the future,” Mr. Tamm writes.

“I founded the Peter Tamm Sen. Foundation with the aim of enlivening subsequent generations about sea travel and helping them to understand its importance to the prosperity of the world population,” Tamm adds. “My intention is to help people to learn about history from documents, to facilitate scientific research, to preserve art and culture as the historical conscience of a nation and to learn from these, free of political influences and the transitory demands of the modern age.”

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The Brighter Side of EEDI
Captain Richard von Berlepsch, Senior Director, Hapag-Lloyd

These days, it is not enough to know how good you are; you must also be able to prove it.

Large customers are auditing their suppliers on efficiency and environmental friendliness, and using the data in deciding which of them to employ. For shipowners, it is now important to be able to prove their performance in these areas. That was very difficult to do in the past. Formerly, you could only tell the customer that you have installed the latest technology; that you constantly strive for better efficiency; that you pursue continuous improvement and better operations; and that you always try to be a responsible operator – and the clients would say “nice story, but you can’t prove it.” The Energy Efficiency Design Index (EEDI) gives a benchmark to render that proof.

At Hapag-Lloyd we see EEDI in a very positive light, like a stamp of quality for the hardware that everyone can understand – somewhat like the sticker that tells you how ‘environmental’ your new refrigerator is. It will be very helpful for ships to have an indicator that gives an easily understandable idea of their efficiency and environmental friendliness. It will also provide an excellent benchmark for the charter market, where, in the future, vessels with better EEDIs will be preferred. Fear of the consequences of a bad EEDI may be one reason why some shipowners are nervous about it.

But the quality shipowner should not be nervous. If you have done a proper job in the past and if you have concentrated on environmental friendliness and fuel efficiency, then you don’t have to worry because EEDI will work to your benefit in the future.

Nobody should be surprised by his EEDI results – after all, even if you have not done the calculation, you should already know how good your vessel is.

This brings us to the existing fleet. We are very much in favor of applying EEDI to existing ships because it will benefit quality carriers. We, for example, have always focused on having environmentally friendly and efficient ships, and have already certified most of our existing fleet to EEDI. Responsible owners and operators have always tried to be as efficient as possible, so EEDI should change nothing in their personal targets and should justly reflect their efforts.

That said, with existing vessels the big question is where to draw the limit lines. If it is necessary to set up EEDI limits for existing ships, they should not be the same as for new ships. First, existing ships cannot be easily retrofitted; also, there is a wide range of ships out there – some owners have invested in electronic engines, high-performance hulls and other advanced technologies and, as a result, have very efficient vessels, while some owners have done less – and any efficiency index should fairly account for that.

On this point, I must say the current mathematical formula for the EEDI could be better. I would say of the present formula that it is more responsive to reduced speed than to technical innovation, and does not encourage technical innovation in an appropriate manner. For example, if an owner invests in a fantastic technology that increases efficiency by 5 percent, he will find the ship’s EEDI improves very little; but if instead he installs an inefficient old engine with less power output, it will get a better EEDI. Similarly, European shipyards report that they are disadvantaged by EEDI because their main selling points are high efficiency and state-of-the-art technology; these yards say the current formula will destroy their business. Clearly, there is still some way to go before achieving the ideal.

So, while I agree that the formula for EEDI could be better, could be fairer, and could more properly encourage innovation, I support the EEDI itself because it’s a start, a benchmark that can be used and, with use, can be improved. I am convinced that, once it is in place, everyone will work very hard to make it better. It will take time, but eventually we will have a correct formula and EEDI will bring many advantages to the industry.
The amount of energy that wind can generate increases by the cube of the wind speed – doubling the wind speed would yield eight times the energy, for example. Because even a small difference in average wind speed can have a major impact on the generating potential of a wind turbine, it is essential the units be placed in the best possible air streams within a wind farm site. That is one reason why wind speed maps, like the one above, are such valuable resources for the wind power sector.

This map – properly called a ‘false color image’ – uses a range of hues to indicate surface wind speeds over the world’s oceans. The data were derived from measurements of sea surface roughness made by radar altimeters on board the NASA/CNES Jason 1 and 2 satellites. The data were mapped to a regular spatial grid using three days’ worth of wind speed data from the two satellites, centered on 11 January 2012.

Radar altimeter-derived wind speed data are used for scientific studies, as well as for such operational applications as weather forecasting and ship routing. NASA altimeters on board a series of satellites have been measuring wind speed over the global ocean since 1993, in joint missions with French space agency CNES. This image was kindly prepared for *Surveyor* by scientist Robert Leben of the University of Colorado. ✤