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REPORT ON BIMCO AUTONOMOUS SHIPS SEMINAR

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1 Introduction

Autonomous ships are rapidly moving from concept to reality. Thus far, the discussion related to autonomous shipping has largely been driven by the producers of the technology, and so it is essential that those whose maritime interests lie in the day to day aspects of shipping join the debate. Smart shipping is unquestionably the 'way of the future' and the maritime industry must understand what this means for the competence of seafarers, ship design and the future of shipping business.[1] Therefore, BIMCO convened this seminar to enable full and frank discussion about autonomous ships among shipowners and managers, technology suppliers, insurers, and regulators.

The seminar was divided into three tranches. The first, focused on shipowners, the second focused on shipping of tomorrow, and the third looked at business cases and projects. This Report gives an overview of the discussions and opinions shared by speakers and participants.

2 Shipowner focus

Douglas Lang, Managing Director, Anglo-Eastern Group – Keynote Address

The potential for change with the advent of automation is dramatic. However, autonomous technology ought to be part of the development of the shipping industry rather than the goal. The *Yara Birkeland* is set to be one of the first autonomous and unmanned vessels in operation. It is anticipated that the *Yara Birkeland* will launch in 2020 and commence unmanned operations by 2022. The fertiliser company Yara will own the vessel and use it to transport its products in Norway in order to replace 40,000 truck journeys per annum and reduce Yara's CO_2 and NO_x emissions.[2] This is an example of development being driven by cargo owners.

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1 Stefan Bülow, '"Smart ships" – a term that challenges the maritime industry'[2018] Ships & Offshore Smartship 5.

2 Kristin Nodal, Yara Press Kit <https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/> accessed 26 April 2019.

Non-shipowners driving the development of new types of ships is not new. In 1801 the world's first practical towing steamboat (*PS The Charlotte Dundas*) was commissioned by Lord Dundas to operate on the Forth and Clyde canal. He had business interests on both sides of the canal and was the governor of the canal.[3] In 1812, a hotel and spa owner commissioned *The PS Comet* to transport guests from Glasgow to his hotel in Helensburgh.[4] This was the first commercially successful steamboat service in Europe. Historically, shipowners are the adopters of technology rather than the drivers.

Rather than engaging in a superficial polarised debate, the view of shipowners and managers is that the discussion on autonomous ships ought to be part of a development to lead to safer operations, a positive environmental benefit, economic sustainability, that is commercially attractive. Automation is already in operation, for example dynamic positioning is already over 40 years old.

The current vessel operations model may not be sustainable due to developing technology, evolving supplier strategy, transitioning on board skills, and transitioning shore skills. Change will be driven by a number of factors, including the automation of navigation and collision avoidance, black boxes and fault reporting replacing intervention. As the machine learning requires data, there will be multiple agreements as to how the data is captured. Shipowners may be reluctant to share the data but it is expected that they will be placed under pressure to do so by insurers and classification societies.

Per Brinchmann, Vice President, Wilh. Wilhelmsen Holding ASA – Keynote address

In order for technology developments in the maritime industry to be adopted by shipowners, those developments must improve the environment, increase safety and security, and be economically beneficial. In 2011, the European Commission set goals that require 30 per cent of

3 Robert Macfarlane, *History of propellers and steam navigation, with biographical sketches of the early inventors* (1851) 31 (available via HathiTrust).

4 Henry Bell, Scottish Engineer, Encyclopaedia Britannica <https://www.britannica.com/biography/Henry-Bell> accessed 21 July 2019.

all cargo that is currently transported by road on journeys over 300km to be transported by waterways and rail by 2030. This must increase to 50 per cent by 2050. Currently sea transport is only competitive against road transport over long distances. It is anticipated that autonomous feeder logistics will increasingly compete with road transport on significantly shorter distances.

There are five technical enablers for vessel autonomy: situational awareness, autonomous navigation, machinery control, communication via mobile broadband, and the shore control centre. Of the five, only situational awareness and the shore control centre are new technologies.

If a shore control centre is to operate 24 hours a day, seven days a week, it will require at least two or three persons on watch, meaning a minimum of 18 personnel. In order to be cost effective, it will need to serve more than one vessel or it risks being no more than a costly showcase. The Massterly[5] shore control centre is planning to service conventional vessels as well as autonomous vessels.

There are numerous issues that must be addressed by authorities and stakeholders so that autonomous vessels may operate. These include defining the role of the master, levels of manning and competence in the shore control centre, compliance with SOLAS, compliance with the ISM Code, compliance with the ISPS Code, local rules and sailing permits, flag state regulations, class rules and guidelines, legal aspects in general, and insurance and ethics. In Norway, the government asks the private sector to find solutions to these issues and then either agrees or disagrees with those solutions via regulation.

Currently there are a number of projects underway in Norway. In addition to the *Yara Birkeland,*[6] there is the ASKO project which is planned to be a fully electric autonomous RoRo feeder for 16 trailers.[7] It will cross the Oslo fjord and replace 1 million truck-kms per year. Another is the

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5 Massterly is an autonomous ship management company. It is joint venture between Kongsberg and Wilhelmsen <https://www.kongsberg.com/news-and-media/news-archive/2018/wilhelmsen-and-kongsberg-establish-worlds-first-autonomous-shipping-company/> accessed 12 June 2019.

6 Nodal (n 2).

7 Pia Meling, 'Benefits from automation' *Lloyd's List* (London, 17 January 2019).

Seashuttle project,[8] which is a semi-autonomous container feeder running on hydrogen-fuel cells. Each day 2800 trucks cross the Norwegian-Swedish border, 50 per cent simply transiting through Sweden. The purpose of the project (partially funded by the Norwegian government) is to take some of this transport off the road.

Autonomy does not mean unmanned, and autonomy is not the target. It is hoped that autonomy in shipping will contribute to acceptance of lower speed reducing energy consumption, more use of clean technology, and a shift of transport from sea to road. It is expected to create safer navigation and maneuvering, thereby reducing risk to personnel and assets. From an economic perspective, it is anticipated that capital expenditure, operating expenditure and the cost of cargo handling will all be reduced. Future seafarers will need to be able to problem solve, rather than undertaking routine tasks and training will therefore have to change.

3 Shipping of tomorrow

Henrik Tunfors, Chairman of IMO working group, Transportstyrelsen, Sweden – Status of the regulatory work

The IMO first considered autonomation in shipping in 1964.[9] To accommodate autonomous ships, the regulatory landscape must be adapted. In 2017, the IMO agreed to work on a 'Regulating scoping exercise for the use of Maritime Autonomous Surface Ships (MASS)' with a target completion year of 2020.[10] The purpose of the scoping exercise is to review the IMO's international regulatory framework, to determine which provisions apply, or not, to MASS and may preclude or not MASS operations (as currently drafted), and to identify gaps or issues and analyse the best way to address them. The work is to take into account the human element and legal aspects. It is not a drafting exercise.

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8 Press Release Samskip Mulitmodal 'Samskip leads the way for Norway's next generation of sustainable shortsea shipping' 24 December 2018 <http://www.samskipmultimodal.com/news/press-release-1> accessed 12 June 2019.

9 Inter-Governmental Maritime Consultative Organisation (IMCO) Maritime Safety Committee 8th Session (MSC VIII).

10 IMO 'Report of the Maritime Safety Committee on its 98th session' (MSC 98).

The agreed definition of MASS is a 'ship which, to a varying degree can operate independently of human interaction'.[11] For the purposes of the scoping exercise, the IMO has defined four levels of autonomy as follows:

1. Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
2. Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location, but seafarers are on board.
3. Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
4. Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.[12]

The scoping exercise framework methodology has two steps. The first is to identify provisions in IMO instruments that preclude MASS. The second is to analyse and determine the most appropriate way of addressing MASS operations, taking into account the human element, technology and operational factors.

There are 27 instruments to be analysed. Each instrument has a lead country with supporting countries.[13] The analysis is scheduled to be complete by May 2020, followed by a drafting exercise which will be undertaken with the support of shipowners. Any new instrument related to autonomous ships is expected to take between five and ten years, if that is deemed an appropriate measure.[14]

[11] IMO Press Release 'IMO takes first steps to address autonomous ships' 25 May 2018 <http://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx> accessed 29 April 2019.

[12] Ibid.

[13] Singapore is supporting the COLREGs analysis.

[14] Subsequently, the IMO has approved autonomous ship trial guidelines, see World Maritime News 'IMO approves autonomous ship trial guidelines' 21 June 2019 <https://worldmaritimenews.com/archives/279047/imo-approves-autonomous-ship-trial-guidelines/> accessed 28 June 2019.

Hans Ottosen, CEO Danelec Marine – Connectivity a prerequisite for autonomous shipping

Of utmost importance for the safe operation of autonomous ships is data recording and the transfer of data to shore. The key questions to ask with respect to data are:

(1) What data and information level is required to sufficiently understand a vessel's navigational situation?
(2) How do the data needs compare with current and future satellite capacity?
(3) What type of autonomous vessel principles may be applied within ship-to-shore data transfer satellite capacity boundaries?
(4) What type of data recording and ship to shore data transfer solutions need to apply?

On conventional ships, Voyage Data Recorders (VDRs)[15] enable accident investigators to review procedures and instructions in the moments before an incident and help to identify the cause of any accident. However, satellite capacity and speed does not meet the requirement for continuous vessel data transfer. Some autonomous ships could transfer data continuously to shore but not the entire fleet given forecasted capacity and demand for other data other than navigational data.

Current satellite communication capacity does not allow vessels to be continuously remote controlled. Therefore, remotely controlled ships will be constrained to areas close to shore with access to high bandwidth. However, autonomous ships with a periodically unmanned bridge would be compatible with near future technology.

Satellite development capacity suggests the following principles for data recording and ship-to-shore data transfer solutions. When vessels operate fully autonomously out of harbour as much data as possible should be recorded. Critical data should be sampled and sent to shore continuously. Alert mechanisms should be established and sent to shore. All data should be

[15] Assuming the shore control centre is considered part of the ship there will need to be a VDR in the shore control centre as well.

transferred to the shore control centre when in port for analysis. Finally, technology for high speed ship to shore data transfer in exceptional situations should be investigated.

Bjarke Holm Hansen, CORE – Zooming in on civil liability and insurance

As the IMO commences its scoping exercise, it is timely to consider civil liability and insurance issues. These are not the only legal regulatory issues. Others include navigation and seaway regulation, manning and the role of future 'seafarers', protection of the marine environment, construction and design of ships, and cyber security and anti-terror. It is suggested that a multi-path approach should be taken with respect to the existing framework. This will involve IMO continuing its scoping exercise. In Europe, the regulatory process at the EU ought to align with the IMO, with national or regional test permits feeding up to the EU level.

A multi-perspective approach to liability is necessary. The main industry interests related to an autonomous vessel are as follows: the shipowner, the classification society, the suppliers and shipyard, the remote operator, the insurer, and flag states.

Currently liability rests with the shipowner. P&I Clubs cover liabilities to third parties which, to date, has worked well. The question therefore arises whether the introduction of MASS will bring a change in the risk or liability profile? If so, will shipowners accept residual risks? The reliability of the system is dependent on the manufacturer, not the shipowner. Any 'fault' will be attributed to the vessel, which leads to the further issue whether the autonomous system can be 'at fault' in respect of collision liability. Liability is governed by the standards in the COLREGs and there is a question whether the COLREGs are sufficient to govern MASS. In addition, standards of seaworthiness will have a software dimension.

The exceptions and limitations for shipowners' liability brings challenges with respect to MASS. There is uncertainty related to Article 1(4) of the LLMC 1976. It is assumed that the shipowner will be vicariously liable for the remote operator, but should that liability extend to the programmers and suppliers of software and systems? It is unlikely that they will be considered 'servants of the shipowner' and enjoy the right to limit liability.

The Hague and Hague-Visby Rules contain an exception from liability for shipowners where there is damage to cargo caused by errors in navigation. It is extremely unlikely that cyber risks will be included within this exception.

Given the new technology involved in MASS, classification societies will assume a central role in the verification and certification of MASS and this will extend to ship operations.[16] Such verification will shift from a component perspective to a systems perspective. As MASS will rely on automated systems, it is anticipated that shipowners, insurers and flag states will require more comprehensive verification of each MASS on an individual level. There is no expectation that liability standards for classification societies will change.

The risk profile of suppliers is likely to change. As digitilisation, data exchange and monitoring become increasingly important, suppliers will be brought closer to the shipowners' operations. It is expected that in addition to supplying hardware, suppliers will move towards the provision of services and condition-based/preventative maintenance solutions based on increased data feeds and monitoring capabilities. It is anticipated that, in relation to the suppliers of navigational software, there will be a requirement for a long term mutual commitment between those suppliers and shipowners.

One risk includes finding a balance between data sharing and breaches of competition law (particularly in the EU). Liability and allocation of risks will be determined by the contract between the shipowner and supplier. It is expected that, given the increased information available to suppliers, they will be able to offer extended warranty periods and increased performance guarantees.

Suppliers do not have any statutory right to limit liability. Third party liability is unquantifiable and subject to choice of law and jurisdiction. Stakeholders in the project considered how this can be dealt with. One suggestion was to create a contractual regime whereby the shipowner

[16] CORE Advokatfirma and Cefor 'Maritime autonomous surface ships - Zooming in on Technology' December 2018 <https://cefor.no/globalassets/documents/industrypolicy/news/mass---zooming-in-on-civil-liability-and-insurance---10-december-2018.pdf> accessed 12 June 2019.

indemnifies the supplier for claims above a certain threshold. This was rejected.[17] Similarly, the idea of placing the supplier's liability under the shipowner's insurance coverage was met with reluctance.[18]

An alternative approach could be to allow suppliers of navigational software and/or algorithms, to be covered by a global limitation of liability scheme. This could be achieved by including suppliers within the LLMC or by creating a separate regime specifically for MASS.[19]

Cyber risks are not unique to the marine industry. However, the introduction of MASS will significantly increase the exposure to cyber risks. Cyber risk is regarded as an operational issue as the consequences of such a risk include business interruption, damage to reputation and data loss. As such, the inclusion of cyber risk management under the ISM Code from 2021 is a welcome development.[20]

The role of the remote operator must be considered. Thus, is the remote operator employed 'in house' by the shipowner or by an external organisation? There will be issues surrounding jurisdiction and enforcement between flag states, coastal states, port states, and third parties. The master's regulated functions will be divided between IMO level Conventions, such as the ISM-code and STCW, and land based regulation.

For insurers to cover the new risk profile and the changing levels of autonomy, they will require access to data shared by shipowners. It is presumed that insurers will require access to operational data, in the event of a claim, as part of the terms and conditions of the policy. Potentially underwriting and renewals will rely on operational data, for example in relation to near miss incidents, condition monitoring and voyage planning.[21] This raises interesting questions as to who owns the data and whether or not access to data ought to be regulated. It

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17 Ibid 11
18 Ibid.
19 Ibid.
20 International Maritime Organisation 'Maritime Cyber Risk' <http://www.imo.org/en/OurWork/Security/Guide_to_Maritime_Security/Pages/Cyber-security.aspx> accessed 29 May 2019.
21 CORE Advokatfirma (n 16) 17.

will not be a problem to insure MASS but insurers will require access to data. However, if MASS are subject to strict liability it will come with a matching price.

Jens-Uwe Schröder-Hinrichs, World Maritime University – Automation, technology, employment – The future of work

On 28 September 2018, the Secretary General to the United Nations stated:

> Technological advances may disrupt labour markets as traditional jobs change or disappear, even as the number of young job-seekers continues to grow. Re-training will be needed at previously unimaginable scales. Education must adapt, from the earliest grades. And the very nature of work will change. Governments may have to consider stronger social safety nets and eventually universal basic income.[22]

The World Maritime University, tasked by the International Transport Workers' Federation, undertook a two year project examining these issues in relation to the maritime industry and in January 2019 published the Report, 'Transport 2040: Automation, Technology, Employment – The Future of Work'.[23] The main conclusion of the Report was that qualified human resources with the right skills will continue to be needed in the transport industry.

The overall findings were that the introduction of automation and technology will be gradual and influenced by economics benefits, demographic trends and safety factors. There will be higher demands for transport resulting from continuous growth in trade. The effects of automation and technology are predictable and impact low and medium skill jobs most. Finally, automation and technology is influenced by the local context.[24]

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[22] Antonio Gueterres, 'Address to the General Assembly' <https://www.un.org/sg/en/content/sg/speeches/2018-09-25/address-73rd-general-assembly> accessed 14 June 2019.

[23] Available at <https://commons.wmu.se/cgi/viewcontent.cgi?article=1071&context=lib_reports> accessed 14 June 2019.

[24] World Maritime University 'Transport 2040 Automation, Technology, Employment: The future of work' January 2019 <https://commons.wmu.se/cgi/viewcontent.cgi?article=1071&context=lib_reports> (accessed 31 May 2019), xv.

The Report looked at four clusters of technology trends, namely, automation, new interfaces, maintenance, and new services. It then considered the six main factors that determine technology adoption. These are: whether the technology is ready for large scale application; whether there are economic benefits to adopting the technology; whether there is a shortage of labour, or if labour is expensive; whether the regulations are ready; whether society accepts the technology; and whether users are able to master the technology.[25]

By 2040 it is estimated that 11-17 per cent of the global shipping fleet will be autonomous ships with human supervision.[26] At the same time, seaborne and inland waterway transport is likely to increase with a reduction in road transport.[27] The largest increase in seaborne transport is anticipated to be in the Asian and Indian Ocean regions.

Of the 168 million transport workers world-wide, 3.3 million work in sea transport. Of those, the majority are employed in medium-skilled work activities.[28] The Report examined where automation may replace current occupations and found that it was most likely to occur in low skill occupations. Highly skilled occupations, such as a ship engineer or officer are likely to be unaffected. Nevertheless, demand for seafarers is likely to fall by 22 per cent by 2040 due to the introduction of highly autonomous ships.

The factors identified as enabling or delaying autonomous ships were identified. The hurdles are the cost of the development, a lack of economic benefit, physical infrastructure, regulation, and governance. The enablers include economic benefits, international regulation and government support. In addition, the Report undertook country profiling to determine the readiness of each nation for the implementation of autonomous ships. The profiles of 17 countries representing five regions in the world,[29] revealed that:

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[25] Ibid 7.

[26] Ibid 17.

[27] Ibid xix

[28] 15% are in low skill occupations, 72% are in medium skill occupations, 12% are in high skill occupations, ibid 48.

[29] Africa: Ghana, Nigeria and South Africa, Americas: Brazil, Panama, Peru and the United States of America, East Asia and the Pacific: Australia, China, Japan, Philippines and the Republic of Korea, Europe: Denmark, France, Norway and Sweden, Middle East: Turkey, ibid 67.

1. New and emerging technologies will be implemented in varying degrees in different regions in the world.
2. A clear gap exists between developed and developing countries in the maritime sector.
3. Most countries have not developed long-term plans for automation in the maritime sector.

To prepare for the advent of the 'fourth industrial revolution', the Report recommends raising awareness for the implications of further introduction of automation and technology into transport systems. Intensive dialogues between stakeholders in global transport should be facilitated for a better understanding of the different position of all parties concerned. National strategies and policies should be established to address the ramifications of further automation and technology in transport. Developing countries should be supported in coping with the effects of the introduction of more automation and technology in transport and identifying the essential skills needed to work effectively in a world of advanced automation and technology in transport and implementing them in education and training.

The conclusion reached by the speaker was that automation is here to stay. Nations need to anticipate adjusting to the changing nature of work. Education and re-training systems are essential to prepare workers for the new skills required. The ITF-WMU study provides the facts for developing a discussion that can effectively ameliorate the effects of technology in the world of labour.

The discussion among participants raised the concern that developing countries, as the traditional source of seafarers, were unprepared. The seafarers of tomorrow must be provided with education to enable them to operate the technology. The paradox is that as automation increases, there will be more training of crew to do less.

4 Business Cases and Projects

Ørnulf Jan Rødseth, SINTEF Ocean, Norway – Economic aspects for deep sea autonomous shipping

There are various economic benefits of unmanned ships. There is no crew, so there are no crewing costs or safety equipment costs. As there is no crew accommodation, the ship requires less power and can carry more cargo. However, there will be a need for remote control and therefore a human will be in the loop to keep the vessel under control.

Industrial automation is cost effective in commercial operations. However, an autonomous ship is a high-value asset with high damage potential if improperly used.

While remote control ships are not a new concept, interest in them has spiked in recent years with the advent of the fourth shipping revolution (following on from mechanised power, mass production, and computerised control.) Global needs and solutions have converged. The global need for sustainable development. combined with new integrated transport systems, autonomous transport. and connected transport has created an ideal environment for the development of autonomous ships.

Shipping is described as a 3D industry: dull, dirty and dangerous. Autonomous ships enable a completely new transport system concept. They can reduce total logistics costs and environmental impact by providing more flexible transport and smaller ports. By having less crew, there are fewer occupational hazards.

On the other hand, the systems will be more complex. The risk profile is unclear and will need higher safety requirements. Shore control centres will be required, more automated shore infrastructure will be required, and it is likely to be a long time until international legislation is in place. Initially tramp shipping and voyage charterparties will not be possible using unmanned ships. The ships require specific infrastructure in port and trained personnel and need agreement to operate from the port state and the port itself.

As container ships have increased in size, there are fewer and larger ports to accommodate them. The cost of door-to-door transport is significantly higher than the deep sea leg of the voyage. Smaller ships can use smaller (and possibly cheaper ports), the transshipment costs will be reduced, but smaller ships are less efficient and fuel costs rise. Automation can integrate into the supply chain by providing storage on the ship, enabling 'just in time delivery'.

The goal of reducing greenhouse gas emissions by 50 per cent by 2050 can be achieved by slow steaming or by using new and more expensive fuels. Green energy generally has a low energy density and/or a high price. Therefore it is critical that the technology has high energy efficiency.

Unmanned ships may be suitable to use the Northern Sea Route. They will not use heavy fuel oil, and as there will be no crew they will not need an escort for fast assistance. It is suggested that perhaps they could sail as convoys following an ice-breaker. Other external factors that are influencing the interest in unmanned ships are subsidies, public infrastructure investment, international legislation and green businesses.

There remain legal and contractual barriers. Thus, international regulation is not prepared. Nonetheless, there are national initiatives, bilateral discussions, and discussions at the European Union. The ships will need class and flag state approval. The classification society, DNV-GL is already providing guidelines. The ships will need insurance and the insurer Gard is taking the lead by underwriting the *Yara Birkeland*.[30]

There are new players coming into the shipping industry, for example Yara and ASKO in Norway.[31] Autonomous ships may change the game. In the transport chain, the ship is only a part. This means, the cost of the ship becomes less important than the total cost in the supply chain. Cargo owners and logistics providers are showing increasing interest and the barriers for new entries may be lower than expected.

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[30] Jarle Fosen, 'Maritime Autonomous ships on the horizon' Gard Insight 13 February 2019 <http://www.gard.no/web/updates/content/27107214/maritime-autonomous-surface-ships-on-the-horizon> accessed 14 June 2019.

[31] Meling (n 7).

Capt Tomoyuki Koyama, Managing Corporate Officer, NYK Line and Hideyuki Ando, Senior General Manager of MTI, (NYK Group) – Demonstration project for autonomous ships in Japan

From the perspective of the ship owner, digitalisation in shipping brings benefits. Shipowners can use the data to make better business decisions, optimise logistics, and anticipate failure. Using this data to continuously learn and improve means there can be incremental automation of ship functions while monitoring fleet performance and seeking ways to improve. This in turn leads to safer, more consistent operations.

The Internet of Things (IOT) is used to enable a ship information management system. The data is collected on-board the ship and then transferred via satellite to shore operations for monitoring and analysis. This analysis is used to assist in understanding seasonal risks, improve the performance of underperforming ships, to identify anomalies with the engineers, and to encourage open collaboration between industry partners in areas such as collision risk and autonomous operations.

Shipowners will use autonomous ships to improve safety and reduce workload. In order to achieve this they require advanced support from computer systems that complement human operations. This will require input from experienced captains and collaboration with industry partners.

NYK are developing a manned autonomous ship.[32] The ship will have an advanced support system with additional functions to assist the human operator based on the existing navigation system. The operation of the ship will be autonomous but require the approval of a human operator. Economic evaluations indicate that manned-autonomous navigation has the highest economic

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[32] This is classed as AL 3) 'Active' Human in the loop: Decisions and actions are performed with human supervision. Data may be provided by systems on or off-board. See Lloyd's Register 'ShipRight Design and Construction, Design Code for Unmanned Marine Systems' <https://www.cdinfo.lr.org/information/documents/ShipRight/Design%20and%20Construction/Additional%20Design%20Procedures/Design%20Code%20for%20Unmanned%20Marine%20Systems/Design%20Code%20for%20Unmanned%20Marine%20Systems,%20February%202017.pdf>, 2 (accessed 7 June 2019).

feasibility and practicality. The measures taken to achieve this goal are enhanced situational awareness, supporting decision making with support from shore and remote control.

The view of NYK is that it is imperative that shipowners work with class societies for risk assessment and testing. The shipowner focus is currently manned-autonomous as full remote control operation for deep-sea voyages is costly and risky at this time. In addition, manned-autonomous ships can comply with existing regulations. Therefore manned-autonomous should be seen as a 'technological waypoint' towards a fully autonomous ship.

Lennart Swoboda, Bernard Schulte GmbH & Co KG – En-route to more autonomy

The Schulte Group shares this approach. Autonomy will not happen as a sudden disruption but gradually and an 'autonomous' ship is not (necessarily) 'unmanned'. The goals in promoting autonomous systems are seen as increased safety, improved environmental performance, and improved cost efficiency.

Fraunhofer CML[33] has developed a collision avoidance algorithm which was tested on a 2500 TEU ship (constructed in 2006) on a three port voyage in the Mediterranean Sea. The system was connected to data sources such as AIS, radar, ECDIS, and machinery data on the ship. The results of the test found that the system correctly identified more than 100 ships and the system always suggested manoeuvres compliant with the COLREGs.

The next step towards vessel autonomy requires the development of different partnerships, for example between industry and science. There will need to be testing, learning, and evaluating of results. Harvesting and sharing data will be critical from cameras and LIDAR, inertial measurement units and wave radar, engine management system, and condition sensors. Data from other ships, ports and terminals, and maritime rescue co-ordination centres will also be required

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[33] A logistics systems developer based in Germany.

The benefits of automation are to assist the crew in safe and efficient operations and to automate ship operations and routine work. In order to implement automation it will be necessary to define the parameters under which ships can operate autonomously. Automation also has potential for ballast water management, fuel oil management, inspections (e.g. tanks), and predictive maintenance of machinery.

Shipowners are looking at where crew are unable to take hours of rest as a result of bad weather. This data allows shipowners to assess when autonomy can be used a ‘window of safe operation’.

Obstacles to the introduction of autonomous technology include the following. Approval of systems for (even periodically) autonomous ships will take time as plenty of different (national) authorities will be involved. The approval process needs a valid and comprehensive database in order to take proper decisions.

In order to overcome these obstacles, positive support from shipping bodies such as BIMCO is crucial. Systems will need to be standardized to communicate properly and thus to ease mass usage and user training. Crew acceptance and training is essential. Autonomous shipping is technically feasible and has significant potential but the implementation of a regulatory framework and seafarers acceptance is crucial for the technology to be adopted by the shipping industry.

Guri-Anette Kjelgum, Wilhelmsen Ship Management – Taking autonomy to reality; about challenges and opportunities

Technology for autonomous ships is emerging but so far discussions have focused on the technology rather than the operations, thus, there are important questions to consider. For instance, how will these vessels be operated? Under what rules and guidelines will these vessels operate? Will a Shore Control Centre (SCC) be required? Autonomous technology will be different from buying a product and using it, instead there will be a continuing relationship with suppliers.

The regulatory landscape is complex and will require acceptance for exceptions from both flag states and coastal states. A suggested solution is to use the ISM Code as a framework:

ISM Code objective (§1.2.1) is

> To ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular to the marine environment and to property.

There will be gradual development and implementation of new technology. Vessels with different levels of autonomy will operate side-by-side with conventional vessels for the foreseeable future. Autonomy will transition from a role based to a function and goal-based approach.

The ISM code is applicable to autonomous and remote controlled vessels, but the current regulative framework only allows regulation by a coastal or flag state. From a short-term perspective, autonomy ought to be seen as a type of operation, not a new type of ship. Adopting the ISM as a model for a goal-based regulation means asking what is required to make operations safe and then examining whether that solution can be used to create regulations or not. The knowledge gained from autonomous ship development is an excellent opportunity for the optimisation and modernisation of conventional ship operations.

5 Conclusion

The themes that came through strongly from the seminar were that autonomy is part of the development of the shipping industry and not the end goal. Autonomous shipping is a reality and technically possible but its uptake by the industry and users will be dependent on it being demonstrably safer, cleaner, and economically beneficial.

From a legal perspective, in the short term, autonomous ship trials and testing can only be undertaken in coastal waters where the coastal state regulations permit. However, it is likely that those domestic regulations will 'feed up' to the IMO as it begins the drafting exercise for MASS operations.

Autonomy is going to shape the future of shipping. What that future will look like remains to be seen. As one participant said, 'good luck to us all.'