

Danish Maritime Authority

Report

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**ANALYSIS OF REGULATORY
BARRIERS TO THE USE OF
AUTONOMOUS SHIPS
FINAL REPORT**

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OVERVIEW – REGULATORY BARRIERS



1. INTRODUCTION

1.1 Background

Developments in digitalisation, automation and autonomous technologies constitute a focus area for Blue Denmark and may have major consequences for the future competitiveness of Blue Denmark and the global organisation of shipping. In line with the recommendations made by the Maritime Strategy Team, the Government has clearly stated that Blue Denmark should – with its basis in quality shipping – be a frontrunner in terms of technological development and autonomous maritime solutions. This requires the availability of the right framework conditions so that neither technical nor regulatory barriers present a hindrance.

From a societal perspective, autonomous ships present a number of different and great potentials:

- An environmental advantage due to fuel savings and new means of propulsion
- Enhanced safety both in open waters and in ports
- Significantly increased cost-efficiency and productivity
- Optimization of the logistics chain via IT solutions
- Improved infrastructure for, inter alia, transport to and from islands as well as for densely trafficked routes.

At the same time, the development and implementation of digitalisation, automation and autonomous technologies presents a considerable potential for Danish companies. Already today, Danish companies hold positions of strength within the maritime industry and within a number of other, closely related areas (such as ship technologies, green shipping, IT and robot technology, GPS technology and other communication technology).

In addition, this market is characterised by a large degree of adaptability among all players in Denmark (shipowners, technological companies, suppliers and employee organisations), which creates unique opportunities for testing and developing new solutions and driving innovation.

Finally, Denmark has a strong tradition for establishing close public-private partnerships in development areas, which significantly improves the possibilities for carrying out research, development and test projects.

Internationally, there is much focus on autonomous ships, and a number of research projects have been launched in cooperation with the maritime industry and research institutions.¹

1.2 Purpose of the analysis

The purpose of the analysis that forms the basis of this report is to identify, systematise and present recommendations for how to handle the regulatory barriers to the development of autonomous ships. It should be possible to use the report as a knowledge base when introducing the necessary amendments of acts and regulations internationally and nationally as well as when possibly rethinking the authorities' regulation in this field.

¹ See, for example, Kongsberg's website on the project YARA BIRKELAND (<https://www.km.kongsberg.com/ks/web/nokbg0238.nsf/AllWeb/EF62A43FFFC2209FC12581A90047B752?OpenDocument>), DNV-GL's website on the project "Re-Volt – next generation short sea shipping" (<https://www.dnvgl.com/technology-innovation/revolt/>), the project Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) (<http://www.unmanned-ship.org/munin/>), Advanced Autonomous Waterborne Applications Initiative (AAWA) (<https://www.utu.fi/en/units/law/research/research-projects/Pages/aawa.aspx>), Norwegian Forum for Autonomous Ships (NFAS) (<http://nfas.autonomous-ship.org/projects-en.html>), Unmanned Multifunctional Maritime Ships Research and Development, the Maritime Safety Administration of People's Republic of China (<http://en.msa.gov.cn/index.php?m=content&c=index&a=show&catid=336&id=165>), MI News Network, 'NAVFOR Takes Maritime Lead For EU Unmanned Vessel Project' on the ENABLE project (Marine Insight, 19 September 2016), (<https://www.marineinsight.com/shipping-news/navfor-takes-maritime-lead-eu-unmanned-vessel-project/>). The above websites were visited on 30 November 2017.

A distinct regulatory approach to autonomous shipping will contribute strongly to ensuring Denmark's possibility of becoming and remaining an attractive test and development country for the autonomous shipping of the future and the associated development and supplier cluster.



2. ANALYTIC APPROACH

2.1 Delimitation

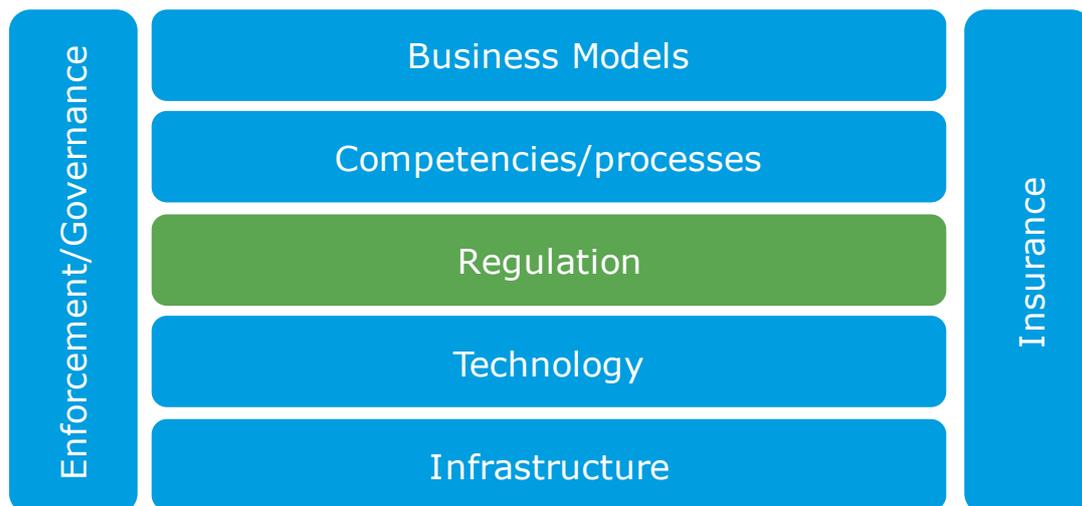
This analysis covers regulatory barriers to autonomous ships in civilian commercial shipping. The regulation of pleasure craft, fishing vessels and warships is not included in the analysis. The analysis covers Danish law as well as EU regulation and international regulation (primarily IMO conventions) that have been transposed into Danish law.

To the extent that Danish law otherwise contains legal barriers to autonomous ships – especially as regards civil and criminal responsibilities and liabilities and insurance issues – this has also been included in the analysis.

The design and construction requirements for ships stipulated in international regulation, especially in SOLAS and MARPOL as well as in the EU regulation mentioned in sections 4.6 and 4.7, depend on the ships' date of construction, type as well as their gross tonnage and length. In this analysis, we have focused on describing in general which regulations could present potential barriers to autonomous ships; but we have not – in relation to each individual chapter and the provisions stipulated in international and national regulation – described the specific preconditions for a rule being put to use or whether it would be possible to grant exemptions from the use of a specific rule on the basis of a ship's date of construction, type, gross tonnage or length.

It is important to bear in mind that regulatory barriers are merely a part of the overall formula for society's response to autonomous ships. In addition to regulatory barriers, a number of other circumstances (see [Figure 1](#) below) are decisive for the use of autonomous ships. These circumstances mutually affect each other, thus increasing the complexity.

Figure 1: Circumstances of importance to the development of autonomous ships



2.2 Terminology

The terms "autonomous vessels" and "unmanned vessels" have not been defined – neither nationally, nor internationally. Furthermore, reference is made to section 4.2.1 (the definition of a "ship" and a "vessel").

For the purposes of this analysis, "autonomous ships" are definitionally considered the overall term for "ships capable of providing – via automatic processes – decision-support or a possibility of taking over parts of or the entire human control and management of the ship, irrespective of whether the control is exerted from the ship or from somewhere else."

For the purposes of this analysis, autonomous ships do not equal ships without a master or a crew. In relation to this analysis, an autonomous ship can also be a ship that uses technology allowing for, inter alia, an occasionally unmanned (physical) bridge/reduced manning or anti-collision systems.

In this analysis, operators of ships at autonomy levels R, RU and A (cf. table 2 below) are defined as “remote operators”.

The term covers “a person with the required qualifications who performs or monitors the navigation of one or more autonomous ships without being on board the ship in person and who is entitled to represent the ship vis-à-vis the authorities”, cf. section 4.5.8.

2.3 Autonomy levels

Lloyd’s Register has developed a definition of ships’ autonomy levels (**Table 1** below) to which reference is often made in the international dialogue about autonomous ships.

Lloyd’s Register’s definition of autonomy levels is based on differences between the technique used as well as the operator’s role.

Table 1: Autonomy levels (adapted from Lloyd’s Register)

| Autonomy level | Description | Operator’s role |
|---|--|--|
| AL0: Manual controlled | Navigation controls or waypoints for course are handled manually. | The operator is on board or controls the vessel remotely through radio link. |
| AL 1: Decision support on board | Automatic navigation according to set references and schedule. Course and speed measured by onboard sensors. | The operator sets course as waypoints and determines desired speed. The operator monitors and changes course and speed if necessary. |
| AL 2: Decision support on board or from shore | Course navigation through a sequence of waypoints. Course is calculated according to a planned schedule. An external system can upload a new schedule. | The operator monitors operation and surroundings. Changes course and speed if needed. Suggestions for interventions may be provided by algorithms. |
| AL 3: Execution by operator who monitors and authorises actions | System recommends navigational actions on the basis of sensor information from the ship and its surroundings. | The operator monitors the system’s functions and actions, and authorises actions before they are carried out. |
| AL 4: Execution by operator who monitors and is able to intervene. | Decisions on navigation and operational actions are calculated by the system that executes on the basis of its calculations following | The operator monitors the system’s actions, and takes correctional actions as needed. Monitoring may take place from shore. |

| | | |
|---------------------------------|--|---|
| | approval from the operator. | |
| AL 5: Monitored autonomy | Overall decisions regarding navigation and operation are made by the system, also assessing consequences and risks. Sensors capture relevant information of the surroundings, and the system interprets the current situation. The system calculates its actions and executes these. The operator is alerted in case of uncertainty. | The system performs calculated actions. The operator is alerted unless the system is very certain of its interpretation of the surroundings, its own state and of the following calculated actions. General goals are determined by the operator. Monitoring may take place from shore. |
| AL 6: Full autonomy | Overall decisions regarding navigation and operation are made by the system, also assessing consequences and risks. The system acts on the basis of analysis and calculations of both own actions and the surroundings' response. Knowledge on surroundings and of past and typical situations are factored in via machine learning. | The system makes its own decisions and actions, calculating own capability and prediction of the behavior of surrounding traffic. The operator is alerted in case the system fails to determine action. General goals may be determined by the system. Monitoring from shore. |

In a legal context, the regulatory barriers are convergent for several of the technical autonomy levels. Therefore, we have, in this analysis, chosen to systematize our approach to regulatory barriers on the basis of the below four autonomy levels, which we have concluded – on the basis of our analysis – are important from a regulatory perspective.

Table 2: Autonomy levels in a regulatory context

| Autonomy level | Operator's role |
|---|---|
| M: Manual navigation with automated processes and decision support | The operator (master) is on board controlling the ship which is manned as per current manning standards. Subject to sufficient technical support options and warning systems, the bridge may at times be unmanned with an officer on standby ready to take control and assume the navigational watch. |
| R: Remote-controlled vessel with crew on board | The vessel is controlled and operated from shore or from another vessel, but a person trained for navigational watch and manoeuvring of the ship will be on board on standby ready to receive control and assume the navigational watch, in which case the autonomy level shifts to level M. |
| RU: Remote-controlled vessel without crew on board | The vessel is controlled from shore or from another vessel and does not have any crew on board. |
| A: Autonomous vessel | The operating system of the vessel calculates consequences and risks. The system is able to make decisions and determine actions by itself. The operator on shore is only involved in decisions, if the system fails or prompts for human intervention, in which case the autonomy level will shift to level R or RU, depending on whether there is crew on board or not. |

Most projects on autonomous ships are conditional upon the ships having been designed so that it is possible to change between the various autonomy of levels (manual steering, remotely controlled operation and fully autonomous operation). Consequently, reality is that the legal barriers will be dynamic and change depending on the autonomy level at which the ship is specifically operating. It is presumed that autonomous ships will (at least initially) operate via manual steering or remote control in connection with port calls and in densely trafficked areas, whereas the ship will switch over to autonomy level A in open waters.

We have based our analysis on the hypothesis that it is possible to subdivide the regulatory approach to autonomous ships as regards the four autonomy levels into **who has the decision competence** and **where the decision competence is located** (i.e. on board the ship or somewhere else). [Figure 2](#) below illustrates this approach. We have inserted Lloyd's Register's technical autonomy levels from [table 1](#) above (AL0 to AL6) in the model.

Table 3: Stakeholders

| Central stakeholders involved in mapping of relevant regulation | Workshop stakeholders | |
|---|---|--------------------|
| Danish Shipping | Danish Shipping | Danish Ports |
| Danish Maritime Officers | A.P. Møller-Mærsk A/S | Færgesekretariatet |
| A.P. Møller-Mærsk A/S | Svitzer A/S | Danish Maritime |
| Svitzer A/S | Lector, Ph.d. Anders Møllmann, University of Copenhagen | Survey Association |
| CEFOR (the Nordic Association of Marine Insurers) | | CO Søfart |

Furthermore, the analysis is based on articles and reports on the regulation and legal issues in relation to autonomous ships as well as other relevant parts of the legal literature.

A bibliography is found in [Appendix 1](#).

2.5 The abbreviations used

In the report, we use abbreviations for the central pieces of regulation included in our analysis.

The abbreviations are listed in bold below.

COLREG (IMO's Convention on the International Regulations for Preventing Collisions at Sea, 1972)

MARPOL (IMO's International Convention for the Prevention of Pollution from Ships, 1973 as amended)

MLC (ILO's Maritime Labour Convention, 2006 as amended)

SOLAS (International Convention for the Safety of Life at Sea, 1974 as amended)

STCW (IMO's International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 as amended)

The Merchant Shipping Act (Consolidated Act no. 75 of 17. January 2014 as amended, in Danish: "Søloven")

UNCLOS (United Nations Convention on the Law of the Sea, 1982)

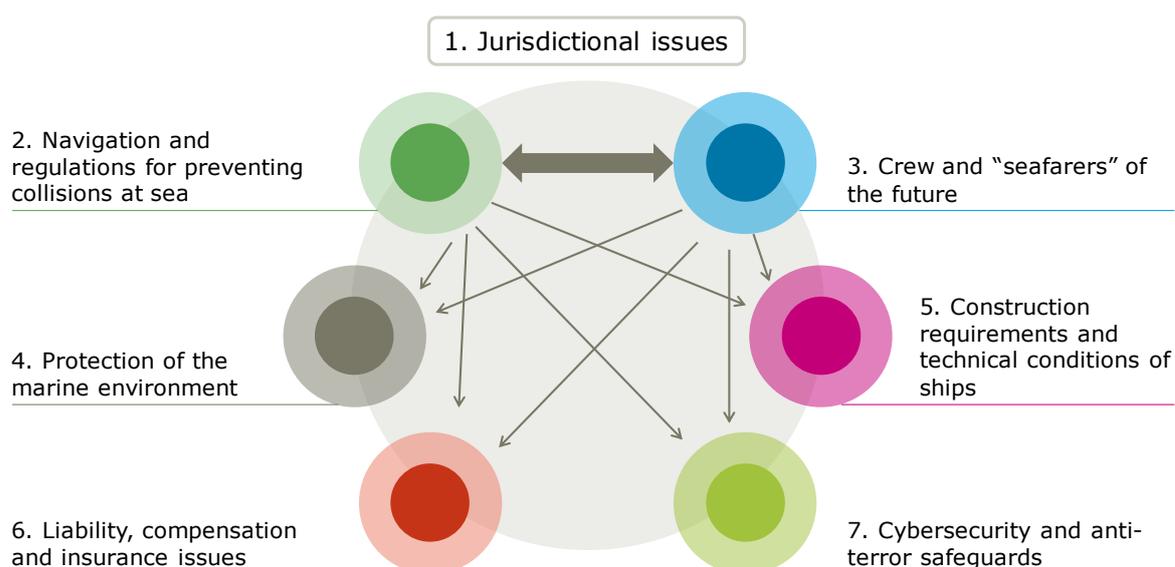
Furthermore, reference is made to the Overview – Mapping of Regulation in [Appendix 2](#).

2.6 Method

We have chosen to subdivide our analysis of regulatory barriers thematically into seven categories:

1. Jurisdictional issues
2. Navigation and regulations for preventing collisions at sea
3. Crew and "seafarers" of the future
4. Protection of the marine environment
5. Construction requirements and technical conditions for ships
6. Liability, compensation and insurance issues
7. Cybersecurity and anti-terror safeguards

Figure 3: Regulatory barriers (subdivided thematically)



For each of the seven categories, we have analysed the potential regulatory barriers from the perspective of the four autonomy levels mentioned in section 2.3 ([Table 2](#)). The analysis covers the following sub-elements:

1. Is the autonomy level compatible with existing regulation (on the basis of an interpretation of the wording and a purposive construction of the specific regulation)?
2. Do existing regulations need to be clarified or amended?
3. Is it necessary to implement new regulations? If yes, which conditions should be regulated?

An overview of the regulatory barriers identified for each of the seven subjects as well as the conclusions and recommendations for handling these is enclosed as [Appendix 3](#).

The figure below provides an overview of the applied method:

Figure 4: Methodological approach



2.7 Regulatory approach

2.7.1 Regulatory bodies

In general, regulation can come about nationally, bilaterally, regionally (for example in Scandinavia or in the EU) or multilaterally (for example through the IMO).

Due to the inherent international nature of shipping and an international wish for homogeneous regulation of shipping after World War II, current shipping regulation is strongly anchored in multi-lateral international conventions that have been developed by United Nations' specialised maritime agency, the International Maritime Organization (IMO).²

Apart from these conventions of international law, there is also an abundance of EU regulation of importance to shipping.

The overall themes of international regulation are the following:

(i) safety, (ii) homogeneous technical standards and product requirements for ships, (iii) regulation of employees' rights at sea as well as occupational health conditions, (iv) protection of the marine environment and (v) shipowners' civil liability in connection with pollution, collision, wreck removal and damage to goods or persons.

In terms of international law, international regulation must be transposed into Danish law by an act or an order in order to become applicable law to the extent that it is not a question of regulations or other EU regulation of a supranational nature that is directly binding due to Denmark's surrender of sovereignty to the EU.

In addition to international regulation that has been transposed into Danish law, shipping is regulated through national Danish rules as well as local rules in the form of, for example, port regulations, cf. section 15 of the port act.³

In general, regulation is made either due to a state's territorial authority over ships as a flag State (section 4.3.1 on the jurisdiction of flag States) or due to a state's territorial authority over its territorial waters (section 4.3.2 on the jurisdiction as a coastal State or as a port State).

As regards the technical regulation of ships, a number of IMO Conventions impose minimum obligations on flag States about the regulation of ships' technical conditions. In each individual flag State, the competence to administer and enforce regulation is often conferred on special maritime authorities that, to a wide extent, delegate their tasks to private classification societies. This is

² The forerunner of the IMO, the Inter-Governmental Maritime Consultative Organization (IMCO), was established through a Convention following a UN conference held in Geneva in 1948. The Convention establishing the IMO entered into force in 1958 and the first IMO meeting was held in 1959.

³ Consolidated act no. 457 of 23 May 2012.

especially of relevance in relation to the SOLAS Convention, cf. section 4.7 (Construction requirements and technical conditions for ships) below.

Our conclusions and recommendations in relation to the regulatory approach are presented in section 3.2 below.

2.7.2 Various types of regulation

In general, regulation may (i) have the form of the issue of regulations by national legislators, or (ii) be based on bilateral or multilateral conventions, or (iii) have the form of sector self-regulation such as non-binding codes of conduct and guidelines/standards (soft law).

In relation to new technologies where the technological solutions are not yet known, the most convenient would often be to use goal- and risk-based framework regulation rather than very detailed (prescriptive) regulation. Subsequently, sector developed soft law such as codes of conduct or guidelines/standards could be used to fill in the frames stipulated in the goal- and risk-based regulation.

Within shipping, the classification societies must be presumed – together with the flag States' national maritime authorities and the many interest organisations representing the players within shipping (including shipowners and the yard industry/marine equipment manufacturers) – to be the driving forces behind the development of technical standards and codes of conduct for autonomous ships.⁴

2.7.3 Legal principles of interpretation

The scope of a legal rule is, in general, established by making a natural, objective interpretation of the wording of the legal rule.

Furthermore, it is a recognised legal principle to look "beyond" the wording of a legal rule if an interpretation of the wording does not provide sufficient clarity and to interpret its scope and application on the basis of the intention behind the rule (purposive construction or teleological construction). This makes it possible to adjust the regulation to societal and technological developments.⁵

The Vienna Convention on the Law of Treaties of 23 May 1969, which has been transposed into Danish law,⁶ contains, in article 31,⁷ principles for the interpretation of treaties and conventions.

"1. A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose.

2. The context for the purpose of the interpretation of a treaty shall comprise, in addition to the text, including its preamble and annexes:

(a) any agreement relating to the treaty which was made between all the parties in connexion with the conclusion of the treaty;

(b) any instrument which was made by one or more parties in connexion with the conclusion of the treaty and accepted by the other parties as an instrument related to the treaty.

3. There shall be taken into account, together with the context:

⁴ See for example, The Maritime Autonomous Systems Surface MAS(S), Industry Code of Conduct, drawn up by the UK Marine Industries Alliance, March 2016, and the Maritime UK Industry Code of Practice, version 1.0, November 2017 as well as Guidelines on Cyber Security Onboard Ships, drawn up and supported by the industry organisations BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI.

⁵ See about legal method and principles of interpretation: Evald, J.: Legal theory, method and science (in Danish), 1st edition., 2016. pp. 45ff., as well as Blume, P.: The legal system and legal method (in Danish), 3rd edition, 2016, pp. 295 ff., and Hansen, L. and Werlauff, E.: The legal method – an introduction (in Danish), 2nd. edition, 2016, pp. 171 ff.

⁶ Transposed into Danish law through order no. 34 of 29 April 1980.

⁷ See Evald, J.: Legal theory, method and science (in Danish), 1st edition., 2016. pp. 65 ff.

(a) any subsequent agreement between the parties regarding the interpretation of the treaty or the application of its provisions;
(b) any subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation;
(c) any relevant rules of international law applicable in the relations between the parties.
4. *A special meaning shall be given to a term if it is established that the parties so intended.”*

The above principles of interpretation have been used in this analysis in relation to international regulation.

In relation to national Danish regulation, the principles of interpretation within Danish law are used.⁸

⁸ Ewald, J.: *Legal theory, method and science (in Danish)*, 1st edition, 2016, pp. 45 ff., as well as Blume, P.: *The legal system and legal method (in Danish)*, 3rd edition, 2016, pp. 295 ff., and Hansen, L. and Werlauff, E.: *The legal method – an introduction (in Danish)*, 2nd edition, 2016, pp. 171 ff.



3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Introduction

This section contains our overall conclusions and recommendations after having completed the analysis of regulatory barriers in section 4 below. To increase the applicability of the section, we have included the background and the most important considerations in relation to each of the individual conclusions and recommendations.

As regards each individual regulatory barrier, reference is made to the overview in [Appendix 3](#).

The conclusions and recommendations in this section have been tematically subdivided in regulatory approach (section 3.2), jurisdictional issues (section 3.3), navigation and regulations for preventing collisions at sea (section 3.4), manning and “seafarers” of the future (section 3.5), protection of the marine environment (section 3.6), the construction and technical requirements for ships (section 3.7), liability, compensation and insurance issues (section 3.8), as well as cybersecurity and anti-terror safeguards (section 3.9).

3.2 Regulatory approach

3.2.1 Regulatory bodies

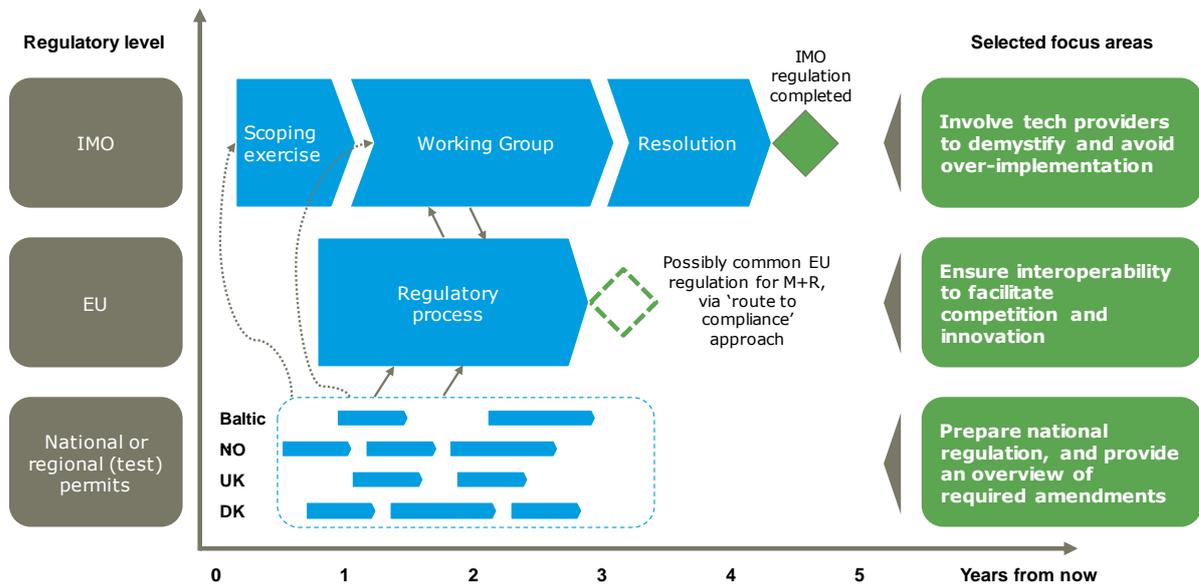
The regulatory approach to autonomous shipping should be considered carefully to prevent regulation from becoming a hindrance to technological developments and the commercial use of autonomous technologies in shipping. In this connection, it is of the utmost importance that the results from tests with autonomous ships are, to the widest possible extent, published; both in order to achieve a knowledge base for regulation and in order to secure wide societal support for autonomous shipping by demonstrating the benefits to society in terms of higher safety levels, less environmental impact and more inexpensive, efficient ship transport.

Considering the complexity of current shipping regulation, it is our **recommendation** that focus be on incorporating autonomous ships into the existing regulatory frame. New regulation of autonomous ships should only cover areas unique to autonomous ships that existing regulation does not take account of.

A realistic approach to international regulation of autonomous ships would be that they must – in terms of equivalence – be at least as safe as conventional ships.

Figure 5 below illustrates possible regulatory approaches to autonomous ships at the national, regional (e.g. the EU) and international (IMO) level.

Figure 5: Regulatory approaches to autonomous ships (conceptual)



It is our **recommendation** that autonomous ships are, to the widest possible extent, regulated internationally by the IMO to ensure that new autonomous ship types can operate in as large a geographical area as possible and to avoid jurisdictional issues, cf. section 3.3.1 below, as well as to ensure that manufacturers gain the highest possible export value. This would be decisive for the product development. Homogeneous regulation and standards for the design and production of autonomous ships will be a major precondition for the spread of them.

Since states can permit tests with autonomous ships in domestic waters or grant exemptions from general maritime regulations without violating international obligations of international law, autonomous ships will, probably, primarily be tested in domestic waters that are subject to the inspection and rule-making of the national maritime authorities until international regulations for autonomous ships have been introduced. It is our **recommendation** that, insofar as possible, test areas are regulated through permits/exemptions on individually adapted terms rather than through general rules. However, national regulation should in general be adjusted to allow for autonomous ships and to ensure that autonomous ships are covered conceptually once international regulations have been adopted. It will be necessary to revise a number of definitions and concepts, such as that of a "master", and to amend provisions that presuppose the physical manning of ships, but national legislators should, generally, be careful to introduce rules on autonomous ships before the IMO approach is known.

As regards EU and other regional regulation, it is our **recommendation** that the EU awaits the scope and subjects included in the IMO regulation of autonomous ships before introducing regulatory initiatives. The EU should assume a coordinating role between its member States in order to reach a common position on autonomous ships within the Community and it should be clarified which EU regulations that need to be amended to pave the way for autonomous ships. Furthermore, it should be clarified whether special focus areas need to be regulated by the EU to promote autonomous ships, such as the interoperability between systems for promoting innovation and competition. It is our **recommendation** that the EU should not, on its own, regulate any issues related to autonomous ships that are regulated at IMO level.

As regards the relation between technological developments and regulation of autonomous ships, for example in terms of the technical possibilities of systems performing the safety functions carried out by human beings on board ships today, it is our **recommendation** to amend existing regulation and to implement new regulation of autonomous ships through the establishment of multi-disciplinary working groups. These working groups should involve technology suppliers, seafarer representatives, lawyers and civil servants as well as any other relevant expert groups.

This could help bring about an increased understanding of the technological potentials and the aspects of transferring control and decision competences from human beings to systems. This must be presumed to create a better balance between regulation and technology and, thereby, prevent over-regulation.

It is our **recommendation** that the regulation of autonomous ships be drawn up so that the role of the classification societies in relation to autonomous ships is changed from being at the component/equipment level to being at the systemic and the operational level, inter alia through the certification of interfaces between various systems on board autonomous ships.

It is, furthermore, our conclusion that the regulatory approach will depend on the result sought for in relation to trade area and autonomy level.

This is illustrated in **figure 6** below.

Figure 6: Approaches to regulation, depending on jurisdiction and autonomy level

| | | | |
|----------------|--------|---|---|
| Autonomy level | RU + A | Individual permits for testing purposes (and potential bilateral/regional arrangements) | Need for new IMO regulation (e.g. new class) |
| | M + R | Individual permits for testing purposes (and potential bilateral/regional arrangements) | Interpretation and amendment of existing regulatory framework ('route to compliance equivalency') |
| | | National (potentially regional) | International |
| Jurisdiction | | | |

For a few ship types and shipowner activities, a national regulatory approach would make sense (for example ferries exclusively engaged in domestic trade or tugs exclusively operating in the same national waters).

Since states Party to the Convention have, in their individual legal systems, different approaches to the interpretation of regulation and legislation, it is our **recommendation** that a common understanding of the application to autonomous ships of already existing convention provisions be clarified within the IMO. Such an approach could clarify many potential regulatory barriers faced by autonomous ships at autonomy levels M and R and, to some extent, RU.

It is our **recommendation** that the regulatory approach to autonomous ships looks to the rules on other autonomous means of transport (autonomous cars, trucks and drones) since some of the challenges faced will be the same. In section 4 of our analysis of regulatory barriers, we have included parallel regulation of other means of transport in relation to autonomous means of transport whenever considered relevant.

3.2.2 Type of regulation

It is our **recommendation** that national and international regulation of autonomous ships has the form of goal-based framework regulation (where the frames are filled out by industry-specific technical standards and codes of conduct for autonomous ships) rather than the form of very detailed (prescriptive) regulation.

Developments of autonomous technology in shipping should be considered in a wider perspective with increased automation and digitalisation across all sectors of society. It is not merely a trend within the transport sector. Many other industries are not subject to regulation as detailed as that applicable to shipping. Consequently, it will not always be possible to use autonomous technological solutions from other industries without some adjustment to meet the special regulatory requirements applicable within shipping. It is our **recommendation** that the regulation of autonomous ships is, insofar as possible, technologically neutral and is focused on protective considerations rather than on a specific technology.

3.2.3 Specific recommendations for the Danish Maritime Authority and the Ministry of Industry, Business and Financial Affairs

On the basis of our analysis, we have the below specific **recommendations** for the Danish Maritime Authority and for the Ministry of Industry, Business and Financial Affairs for promoting autonomous ships.

In general, we **recommend** that the Danish Maritime Authority continues its work promoting international regulatory work on autonomous ships within the IMO together with a number of other member States.

In addition, we recommend the following specific measures:

- Adaptation of national regulation to allow for fully autonomous ferries on short domestic crossings.
- Adaptation of national regulation to allow for periodically unmanned (physical) bridges and electronic lookout in order to attract suppliers of technology and systems and to acquire valuable insight for use in the international regulatory work within the IMO.
- Preparing national regulation by generally eliminating the barriers to autonomous ships, thereby paving the way for fast implementation of international regulation once adopted.
- The first intermediate goal in terms of preparing national regulation could be to adapt the definition of the concept of the "master" and to lay down new definitions of the concepts "autonomous ships" and "remote operator" and to clarify which rights/obligations should rest with a "remote operator". In addition, it would be important to amend national regulation requiring ships always to be manned or documents to always be physically available on board.

3.3 Jurisdictional issues

3.3.1 International recognition of autonomous ships

States' right to ban ships from its ports and inner waters and to lay down special regulations on foreign ships' port calls under UNCLOS, articles 25(2), 211(3) and 22, will present a general barrier to autonomous ships to the extent that port and coastal States do not want autonomous ships in their waters, cf. section 4.3.2 (jurisdiction as a coastal State and a port State).

For this reason, it will be important for the spread of autonomous ships to reach international agreement on the regulatory requirements so that the trade area of autonomous ships is not limited to national waters where the national maritime authorities have a positive attitude to autonomous ships.

3.3.2 Port State Control

Provided that autonomous ships are designed so that it is physically possible to subject them to a PSC inspection, there are no regulatory barriers to autonomous ships in SOLAS, MARPOL, STCW, Paris MoU or Directive 16/2009.

However, in relation to unmanned autonomous ships (autonomy levels RU and A), it will be necessary to make amendments to clarify which person can act on behalf of the ship since SOLAS, MARPOL, STCW, Paris MoU and Directive 16/2009 presuppose that there is a master on board, cf. for example Paris MoU, paragraph 3.10, and Directive 16/2009, article 17. It will presumably be natural to have the shipowner, as defined in regulation 1(2) of the ISM Code, assume the functions and responsibilities of the master in connection with PSC inspections.

3.3.3 Exercise of authority

The exercise of authority (for example maritime surveillance, customs authority, maritime authority and court authority) vis-à-vis autonomous ships presents challenges in connection with unmanned ships (autonomy levels RU and A). The exercise of authority in relation to autonomous ships is considered in section 4.3.5 below.

Under current regulation, the master is the shipowner's and the ship's representative vis-à-vis the authorities and can receive guidance about navigational conditions and orders related to a change of course, stopping, detentions (including arrest) as well as access to the ship. In addition, the master is the representative vis-à-vis the authorities when it comes to presenting certificates and other documents on board as well as for any other communication purpose.

It would be natural to have the remote operator assume the function as the ship's and shipowner's representative vis-à-vis the authorities in relation to ships at autonomy levels R, RU and A. Whether amendments to existing regulation are necessary in this connection is described in connection with each individual barrier in sections 4.4-4.9 below as well as in [Appendix 3](#).

Many legal acts require certificates or other documents to be kept physically on board. In general, it is our **recommendation** that all flag States adapt their regulation so as to enable flag States to issue certificates and other documents digitally. In addition to promoting autonomous ships, it would also make simplified PSC inspections possible if it becomes possible in the longer term to access a common database containing all certificates.

Denmark has already adapted its regulation to the issue of digital ship certificates and has, furthermore, concluded a Memorandum of Understanding (MoU) with the Singaporean and Norwegian maritime authorities on 24 April 2017 on the spread of digital certificates internationally.

In relation to orders issued by the authorities and requiring a physical presence on board ships, it will not be possible for the remote operator to perform the function held by the master today. Presumably, the solution will consist in delegating compliance with such obligations (for example the obligation to "show and open or cover all accessways to cargo, spaces and hideaways" stipulated in section 17(1) of the customs act from the shipowner to port representatives or agents. Regulation must allow for this. Reference is made in particular to section 4.3.5.2 on customs clearance as well as section 4.5.7 on the concept of a master and section 4.5.8 on remote operators.

3.4 Navigation and regulations for preventing collisions at sea

3.4.1 COLREG

It is a fundamental principle of COLREG that ships are controlled by human beings and that navigational decisions are based on a seamanlike assessment of the specific situation.

It is our conclusion that the core element of COLREG is a *simultaneous human decision competence*. In other words, it is decisive *who* is controlling the ship and not *from where* it is

controlled. Furthermore, it is decisive that decisions are taken in real time (simultaneously) and are not an expression of pre-programmed choices. For as long as human navigational decisions are being taken, they can be taken in accordance with COLREG irrespective of *where* the decision is taken; naturally, provided that it is possible to procure a sufficient decision base (situational awareness) from the location from where the human control and decision competence are performed.

To the extent that it is technically possible to replace human vision and hearing with cameras, sensors, radars or other technical means (electronic lookout), it is our conclusion that electronic lookout will be possible under COLREG, regulation 5, provided that the electronic solution corresponds at least to human vision and hearing and offers the same level of safety.

If, in the future, technology makes it possible for ships to communicate directly with each other and to calibrate their course/speed, etc., we are at a technological level that COLREG, regulation 5, has not taken account of. The types of anti-collision systems used in air transport would require new international regulation if introduced on ships.

3.4.1.1 Autonomy levels R and RU

Remotely controlled ships with or without a crew (autonomy levels R and RU) could meet the fundamental principle of human control and simultaneous decision competence in COLREG if a human being in real time is remotely controlling the ship and taking navigational decisions.

If it is possible to reach international support for the interpretation above, it will not be necessary to amend COLREG as regards autonomy levels R and RU.

However, new regulation will be required in relation to the following:

- (i) Technical requirements for electronic lookout, remote control and communication and network systems, including requirements for latency, redundancy and prevention as well as readiness in case of failure of ship communication (presumably as part of SOLAS);
- (ii) A special assessment of the operational risk management for remotely controlled ships should be included as part of shipowners' Safety Management System under the ISM Code;
- (iii) Educational and qualification requirements for the remote operator (using the STCW Code structure, if relevant);
- (iv) Principles of shifts in the navigational obligation.

3.4.1.2 Autonomy level A

Fully autonomous ships steering on their own according to pre-programmed algorithms as regards choice and consideration (autonomy level A) could hardly meet the requirements for human control and simultaneous decision competence stipulated in COLREG. This would require the algorithms to reflect human intuition, common sense and seafarers' experience.

Among the possible solutions, it has been considered whether autonomous ships at level A could be considered "*not under command*" or "*restricted in her ability to manoeuvre*" in accordance with COLREG, regulation 3, and that all other ships would consequently be obliged to "*keep out of her way*".⁹ It is our conclusion that a ship at autonomy level A, capable of navigating, cannot be considered "*not under command*"; not even if the ship is not navigated through *simultaneous* human decision competence, but by means of pre-programmed choices.

Rather than to seek to develop algorithms adjusted to COLREG (presupposing simultaneous human decision competence), it is our **recommendation** to draw up new international

⁹ See Carey p. 13.

regulations for preventing collisions at sea for autonomous ships at level A. New regulations must take account of the fact that the ships are not subject to simultaneous human decision competence, but will act on the basis of pre-programmed choices and considerations. Such regulations for preventing collisions at sea, as described in item (iii) below, can be drawn up as an annex to COLREG that applies only to ships at autonomy level A.

Considering the ethical dilemmas related to fully autonomous ships, ethical guidelines must be developed internationally for the programming of fully autonomous ships' algorithms and prioritisation of preventive considerations. These guidelines must establish how much and which decision competence should be left to systems and pre-programmed choices as well as principles for the co-existence of autonomous and non-autonomous systems.

It is our conclusion that, in addition to the required new regulation for autonomy levels R and RU (as described in section 3.4.1.1), new regulation must be implemented for the following additional areas for ships at autonomy level A:

- (i) The prioritisation of protective considerations/navigational decisions when programming autonomous ships at level A on the basis of ethical considerations.
- (ii) Definition and indication of which type of decision should be left to human beings.
- (iii) Provisions on navigation/regulations for preventing collisions at sea and provisions on signalling/communication between fully autonomous ships and ships at lower autonomy levels as well as between fully autonomous ships.

It will be necessary to regulate who has the navigation obligation at any time (and thus assumes criminal as well as civil liability) for autonomous ships at levels R, RU and A and to establish procedures for how to change the navigational obligation in an environment with dynamic levels of autonomy. Section 4.8 below contains an analysis of the possible changes in liability that will follow from the transfer of navigational decisions and control of the ship from the master locally on the ship (autonomy level M) to a remote operator (autonomy levels R and RU) and to navigation taking place on the basis of pre-programmed choices/considerations without any simultaneous human decision competence (autonomy level A).

Section 4.5.7 (the concept of a master) and section 4.5.8 (the concept of a remote operator) below shed light on the changed roles of the master and the remaining crew in relation to autonomous ships and the new job functions that will presumably arise in the wake of autonomous ships.

3.4.2 Periodically unmanned (physical) bridge

Periodically unmanned (physical) bridges on ships may increase the level of safety by preventing fatigue, while simultaneously making it possible to commercially use the crew better and liberate resources for tasks other than navigation. This would be interesting for more or less all ship types and sizes.

3.4.2.1 Autonomy levels M, R and RU

If it is technically possible to change the bridge watch from the ship's physical bridge to an "electronic bridge" in some other place with the same or an improved functionality, it is our conclusion that it will presumably be compatible with COLREG and the STCW Code that the physical bridge of the ship is periodically unmanned (autonomy levels M, R and RU). This is the case with a change of the bridge watch to an electronic bridge ashore or below deck. The provisions stipulated in the STCW Convention and the STCW Code on change of the bridge watch should be met in these cases. The navigating officer cannot leave the physical on-board bridge without having left the bridge watch to another person who has the competences required to perform the same functions with simultaneous decision competence. Thus, it is not possible for

the navigating officer to leave the bridge and to be “on call” from the ship’s navigation system under current regulation.

If it is technically possible – with an equivalent level of safety and functionality – to perform the functions associated with the ship’s bridge from another location than the ship’s physical bridge (an “electronic bridge”) under human surveillance, it must be presumed that the bridge will still be “manned” under the STCW Code and, thus, be in accordance with current regulation.

Furthermore, the technical provisions on bridge design stipulated in SOLAS must be met when designing the electronic bridge, especially regulation 15 of SOLAS chapter V on “*Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures*” and regulation 22 on requirements for the visibility and visual field from the wheelhouse.

A special challenge will remain in relation to chapter VIII, regulation 2(2)(1), of the STCW Convention, which contains an obligation for flag States to ensure that the master makes sure that the officer of the watch is (our emphasis) “*physically present on the navigating bridge or in a directly associated location such as the chartroom or bridge control room at all times*”. If it is to be possible to have a periodically unmanned bridge in international waters, this provision needs to be amended to make it possible for the officer of the watch to periodically be located in other places than on board the ship.

Furthermore, regulation 37 of SOLAS chapter II-1 on communication between the navigation bridge and the engine room requires two independent means of communication between the physical navigation bridge and the engine room. This provision will present a barrier at all autonomy levels since it does not allow for the use of an electronic bridge. This provision will need to be amended so that it becomes possible to use an electronic bridge. The regulation of requirements for several means of communication will also be essential in relation to an electronic bridge.

Clarification of understanding and interpretation

It is our **recommendation** that a common understanding and interpretation of the regulatory requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) be acquired within the IMO in relation to autonomous ships at levels M, R and RU.

Amendment of existing regulation

Regulation 2(2)(1) of chapter VIII of the STCW Convention must be amended to make it possible for the officer of the watch to periodically be located in other places than on board the ship.

Regulation 37 of SOLAS chapter II-I must be amended to allow for an electronic bridge. Regulation of the requirements for several means of communication will also be essential in relation to an electronic bridge.

New regulation

New regulation is required in relation to the following:

- (i) Technical requirements for equipment allowing for electronic lookout and an electronic bridge, such as cameras, sensor, communication and network systems as well as equipment allowing for logging of who has the bridge watch;
- (ii) Requirements for the design and construction of electronic bridges;
- (iii) Educational, qualification and certification requirements for operators (navigating officers) of electronic bridges;

(iv) Principles of changes of the bridge watch.

3.4.2.2 Autonomy level A

The regulation of requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) requires human control and simultaneous decision competence.

Especially regulation 5 of COLREG and regulation 15 of SOLAS Chapter 15 will, in this connection, present a barrier to fully autonomous ships (level A).

Ships at autonomy level A navigating on their own according to pre-programmed algorithms when it comes to prioritising choices and considerations will not meet the requirement for human control and simultaneous decision competence.

New regulation

In addition to the required regulatory measures to allow for autonomy levels M, R and RU in relation to periodically unmanned (physical) bridges (section 3.4.2.1) and the regulatory measures needed to allow for ships at autonomy level A under COLREG (section 3.4.2.2), new regulation will be necessary within the following areas for ships at autonomy level A to allow for unmanned (physical) bridges:

- (i) Technical requirements for the recognition and assessment of objects/conditions at sea; and
- (ii) Definition and indication of which type of decision could be left for human beings.

3.4.3 Pilotage

To the extent that shore-based pilotage is technically possible and will provide the pilot with the same "situational awareness" from the electronic bridge as from the physical bridge, international regulation does not present any regulatory barriers. It requires that it is legally possible to make use of remote ship control as well as an electronic bridge, cf. the requirements for this in sections 4.4.1 to 4.4.3.

However, pilotage is subject to various national regulation in each individual coastal and port State. As regards autonomous ships, it will be important that national and local regulation of pilotage and mandatory pilotage does not prevent them from calling at ports.

Ships at autonomy levels M and R will presumably not present great challenges since the on-board crew could perform the navigational obligation in connection with port calls and could act according to a local pilot's advice in case of mandatory pilotage.

As regards ships at autonomy levels RU and A, pilotage could, however, only have the form of shore-based pilotage or, alternatively, an exemption from the obligation to take a pilot if the national authorities of the port State at which the ship call can accept that the ship is remotely controlled to the berth by the remote operator. To the extent that national or local regulation does not allow for shore-based pilotage or exemptions from the obligation to take a pilot, this would limit the trade area of autonomous ships and present a regulatory barrier. It is our **recommendation** that international regulations on shore-based pilotage be adopted within the IMO, especially concerning requirements for the pilot's access to the ship's electronic bridge (by using an electronic certificate) and requirements for the communication connection's redundancy and security.

In Danish law, section 15 of the pilotage act contains the legal basis for the Danish Maritime Authority's stipulation of more detailed provisions on "*Trials with and the possible establishment of shore-based pilotage*". Thus, Danish law allows for pilotage without the pilot actually being physically present on board the ship.

As autonomous ships are gaining ground, it will become necessary to assess regulatorily what could be considered “relevant voyages” and “voyage frequency” as regard pilotage experience, including whether navigation of a ship from ashore on the basis of “situational awareness” could be considered navigation experience according to the pilotage act.

Liability issues

Shore-based pilotage will presumably give rise to liability issues in many jurisdictions.

In relation to liability, it must be presumed under Danish law that the pilot’s liability would be the same in case of shore-based pilotage as in case of pilotage with the pilot physically on board a ship. The basis of the liability would be the professional liability norm which would be subject to the general compensation provisions of Danish law.¹⁰ The shipowner will be liable for the pilot’s misconduct and neglect according to section 151(1) of the merchant shipping act and the pilot will be entitled to limitation of liability according to the Convention on Limitation of Liability for Maritime Claims of 1976 (see more on limitation of liability below in section 4.8.3).

It is our **recommendation** that the remote operator be legally subjected to the same navigational obligation (and liability) as a traditional master. In case of shore-based pilotage, the assistance provided by the pilot should only have the form of advice just as is the case for pilots today. The remote operator will be responsible for navigational decisions. As regards fully autonomous ships (level A) subject to mandatory pilotage, it must be presupposed that the operation is transferred to level RU with a remote operator who takes over the navigational obligation (and thus the liability) with the pilot as an adviser. It is difficult to imagine that the pilot will have the control of a ship at autonomy level A on his own and assume the related liability.

3.4.4 Reporting obligations (EU regulation and Danish law)

Danish law

The regulation of Danish waters contains special reporting obligations for ships passing the Sound and the Drogden dredged channel (SOUNDREP)¹¹ and the Great Belt (BELTREP)¹². According to the regulation, passing ships are obliged to report a number of information via VHF to call stations and to report the ship’s name and time of arrival when entering the reporting areas. In addition, the ships are obliged to keep a continuous listening watch on the relevant work channel as well as on channel 16.

It is our conclusion that these obligations can be performed by a person in control of the ship whether or not on board the ship. Thus, the reporting obligation will not present a barrier to autonomous ships at levels M, R and RU. The reporting obligation will present a barrier at autonomy level A. The solution will presumably be to amend the regulation so as to allow for automatic reporting in digital format.

EU regulation

In addition to the reporting obligation in the Sound and the Great Belt, EU law also contains reporting obligations for ships entering the territorial waters of EU member States.¹³

The purpose of the EU regulation is to enhance navigational safety and the authorities’ possibilities of reacting in case of accidents, incidents or dangerous situations at sea.

¹⁰ Falkanger, Bull and Rosenberg Overby, p. 156.

¹¹ Cf. order no. 924 of 25 August 2011 on the ship reporting system SOUNDREP and on reporting when passing the Drogden dredged channel for ships the height of which exceeds 35 metres.

¹² Cf. order no. 820 of 26 June 2013 on the ship reporting system BELTREP and on navigation under the East Bridge and the West Bridge in the Great Belt.

¹³ Directive 2002/59/EC of the European Parliament and of the Council (especially articles 17 and 18) establishing a traffic monitoring and information system for shipping in the Community, as amended by Directive 2009/17/EC of the European Parliament and of the Council as well as Directive 2010/65/EC of the European Parliament and of the Council on ships’ reporting formalities.

The provisions as transposed into Danish law¹⁴ impose a number of reporting obligations on masters of ships flying the Danish flag calling at a port of a member State as well as on ships flying foreign flags with a gross tonnage of or above 300 tonnes calling at Danish inner and outer territorial waters.

In addition, the provisions contain special obligations for masters of ships in Danish waters to report accidents and incidents at sea that impair the safety of the ship or the voyage as well as observations of drifting objects in the sea and to submit information about dangerous goods in case of an accident. None of these reporting and notification obligations presupposes that the master is physically present on board the ship. Thus, they will not present a barrier to autonomous ships at levels M, R and RU as long as it is possible to perform the obligations from other locations.

To the extent that ships at autonomy level A are technically capable of identifying the mentioned accidents and incidents at sea so that it is possible to make the required reports, the provisions will not present a barrier to ships at autonomy level A either. It must be presumed that the reporting can be made either directly from the fully autonomous ships in digital format or via a remote operator.

3.5 Manning and "seafarers" of the future

3.5.1 Requirements for the manning of ships in international regulation

UNCLOS, article 94(4)(b), requires all ships to be: *"in charge of a master and officers who possess appropriate qualifications"*.

It is our conclusion that ships at autonomy levels M, R and RU must be considered to be *"in charge of a master and officers who possess appropriate qualifications"* to the extent that a human being (master or navigating officer) with the necessary qualifications has control of the ship irrespective of whether the person concerned is on board the ship or somewhere else.

A fully autonomous ships (level A) without any human involvement in navigation and steering will, on the other hand, not be in compliance with UNCLOS, article 94(4)(b). It is necessary to amend UNCLOS, article 94(4)(b), if the provision is not to present a barrier to ships at autonomy level A.

In relation to "safe manning levels", it is our conclusion that neither UNCLOS, article 94(4)(b), nor SOLAS chapter V, regulation 14(1), will present barriers to unmanned ships (autonomy levels RU and A) provided that it can be validated that an autonomous ship is capable of operating without being manned according to the ship's type, size, machinery, equipment and voyage plan. It cannot be presumed that the provisions presuppose that the ship must always be manned if it is capable of operating safely without being manned.

The safe manning level is subject to the flag State's subjective specific assessment of whether the ship's manning is *"appropriate in qualification and numbers"* and whether the ship can be considered *"sufficiently and efficiently manned"*. It must be presumed that flag States' different approach to safe manning levels could present a regulatory barrier in itself.

Regulation 2.7 of the MLC contains provisions on safe manning levels, cf. section 4.5.5. To the extent that unmanned autonomous ships (autonomy levels RU and A) are sound and safe without any manning on board in relation to UNCLOS, article 94(4)(b), and SOLAS chapter V, regulation 14(1), regulation 2.7 of the MLC will not present a barrier to ships at autonomy levels RU and A.

It will be necessary to consider whether to lay down new technical requirements for the safety of ships at autonomy levels RU and A in SOLAS taking account of unmanned ships. Reference is

¹⁴ Order on technical regulation on a traffic monitoring and information system in Danish waters and ports (order no. 1021 of 26 August 2010, as amended by order no. 417 of 9 May 2012).

especially made to section 4.5.2 below in relation to emergency equipment as well as to section 4.7 in general.

3.5.2 Obligation to provide assistance to persons in distress at sea

Considering the dangers that have always been related to shipping, it is a fundamental maritime principle that seafarers are obliged to assist persons in distress at sea provided that it will not jeopardise the safety of the ship, its crew or passengers.

In relation to autonomous ships, the question arises whether there is an obligation to maintain a certain manning level or whether there will be certain structural limitations when it comes to meeting the obligations to provide assistance at sea.

UNCLOS, SOLAS and the Convention on Salvage stipulate the master's obligation to "*render assistance*" or to "*provide assistance*" to persons in distress at sea.

It must be presumed that the obligation to inform search and rescue services in relation to persons in distress at sea could be met from ashore to the extent that an autonomous ship is fitted with sufficient electronic lookout to detect persons in distress. The challenge met by autonomous ships is the obligation to physically provide assistance at sea and be able to rescue and salvage persons, ships and goods.

The fact that an autonomous ship is unmanned or only poorly manned would hardly exempt the master from his fundamental obligation to provide assistance to persons in distress at sea. There is only a legal basis for exemption if assistance to persons in distress at sea could jeopardise the safety of the ship or those on board. It could be argued that the master's obligation to physically provide assistance to persons in distress at sea does not go beyond the technical capability of the autonomous ship. In other words, the master (remote operator) is not obligated beyond his power in relation to the specific ship's design, equipment and arrangement. This interpretation of the purpose is supported by the wording of UNCLOS, article 98(1), and SOLAS chapter V, regulation 33, which stipulates that the master is only obligated if he is "*in a position to be able to provide assistance*" and "*in so far as such action may reasonably be expected of him*". Such an interpretation of UNCLOS, article 98(1) and SOLAS chapter V, regulation 33, implies that the provisions would not present a barrier to autonomous ships irrespective of their autonomy level.

Considering the fundamental nature of the obligations, it is our **recommendation** that the contents of the provisions be clarified within the IMO in relation to autonomous ships at levels RU and A so as to acquire a homogeneous protective level internationally.

Furthermore, new requirements must be introduced for the technical arrangements needed on board unmanned autonomous ships in order for them to provide satisfactory assistance, inter alia in the form of liferafts, emergency rations and other emergency equipment. It will be necessary to consider the possibilities of providing assistance in emergencies when designing autonomous ships so that unmanned autonomous ships can provide such assistance at a satisfactory level that is not significantly different from that of fully manned ships (equivalence).

3.5.3 The FAL Convention

The provisions of the FAL Convention on human treatment of stowaways at sea, including the master's obligation to ensure the "*security, general health, welfare and safety of the stowaway while he/she is on board, including providing him/her with adequate provisioning, accommodation, proper medical attention and sanitary facilities*",¹⁵ will according to the wording present a barrier to autonomous ships to the extent that autonomous ships cannot meet the requirements in terms of manning (levels RU and A). Furthermore, the requirements will result in design limitations when designing autonomous ships since the structure must take account of the

¹⁵ The Annex of the FAL Convention, paragraph 4.4, as well as the order on technical regulation on stowaways on ships, section 9.

possibility for providing “*provisioning, accommodation, proper medical attention and sanitary facilities*”.

Though the wording of the Annex of the FAL Convention, paragraph 4.4, does not render it legally possible to grant exemptions from the obligation, it cannot be presumed that the intention has been to extend the obligation beyond what is technically possible for each individual ship. When the provision was written, it was inconceivable that ships could, in the longer term, be unmanned (autonomy levels RU and A) and would, thus, not necessarily be arranged with a possibility for providing “*provisioning, accommodation, proper medical attention and sanitary facilities*” on board. It could be argued that the provision should be interpreted in the light of the possibilities and technical arrangement of each individual ship.

Since the obligations are of a fundamental humanitarian nature, it is our **recommendation** to introduce an amendment to the FAL Convention, stipulating the requirements for the technical arrangement of unmanned autonomous ships (levels RU and A) in order to detect and avoid stowaways on board, and also stipulating which facilities and equipment must be available on board as regards provisioning, medical attention and sanitary facilities for stowaways who have succeeded in embarking.

Stowaways covered by the concept of a refugee in the UN Refugee Convention¹⁶ enjoy special legal protection. When deciding on the obligation of unmanned autonomous ships to take care of stowaways under the FAL Convention, account will need to be taken of this, cf. the Annex of the FAL Convention, paragraphs 4.1 and 4.4.

3.5.4 Scope of STCW and MLC

Article 3 of the STCW Convention stipulates that the Convention applies only to “*seafarers serving onboard seagoing ships entitled to fly the flag of a Party (...)*”. Thus, according to the wording, the STCW Convention does not apply to remote operators of remotely controlled ships (autonomy level R) and unmanned ships (autonomy levels RU and A).

When it was developed (1978) and during subsequent revisions, the STCW Convention has not taken account of ships’ possibility of being unmanned in the longer term. However, it must be presumed that the obligations of an *operational nature* imposed on seafarers by the STCW Convention will apply analogously to persons performing similar work functions related to autonomous ships as those prescribed by the STCW Convention, though these work functions will be performed from places other than on board the ship. This assumption is based on the wider purpose of the STCW Convention (“*to promote safety of life and property at sea and the protection of the marine environment*”) and the legal basis stipulated in article IX of the Convention for flag States to lay down special:

“educational and training arrangements, including those involving sea-going service and shipboard organization especially adapted to technical developments and to special types of ships and trades, provided that the level of sea-going service, knowledge and efficiency as regards navigational and technical handling of ship and cargo ensures a degree of safety at sea and has a preventive effect as regards pollution at least equivalent to the requirements of the Convention”.

The purpose of the MLC is to “*secure the right of all seafarers to decent employment*”, cf. the MLC, article 1(1). Pursuant to the MLC, article 2(2), the Convention applies only to “*seafarers*”. In the MLC, article 2(1)(f), seafarers are defined as “*any person who is employed or engaged or works in any capacity on board a ship to which this Convention applies*”. On the basis of the definition of a “*seafarer*” as well as the purpose and protective considerations of the MLC

¹⁶ UN Convention relating to the Status of Refugees, 1951, as amended (deriving from article 14 of the UN World Declaration on Human Rights, 1948), transposed into Danish law through the order on Danish ratification of the Convention Relating to the Legal Status of Refugees signed in Geneva on 28 July 1951 (order no. 55 of 24 November 1954), as amended by the promulgation of the Protocol of 31 January 1967 relating to the Legal Status of Refugees (order no. 21 of 12 February 1968).

("decent employment rights for seafarers"), it must be presumed that the MLC will not apply to persons involved in the operation of autonomous ships at autonomy levels RU and A, but only to "seafarers" on board ships at autonomy levels M and R. The MLC does not contain any barriers to ships at autonomy levels M and R.

3.5.5 The Polar Code

Chapter 12 of the Polar Code on "Manning and Training" presupposes that ships operating in polar areas are manned. Thus, the Polar Code will present a barrier to autonomous ships at levels RU and A. Chapter 12 of the Polar Code will need to be amended if it is to be possible to operate unmanned autonomous ships (levels RU and A) in polar areas. New regulation will need to consider which technical solutions can replace the crew's functions and safety preparedness.

3.5.6 The concept of the master

Under current international and national regulation, the master is – together with the shipowner – the central obligated and liable party, both under civil and criminal law.

Many of the rights and obligations vested in the master under current regulation could be assumed by a remote operator *mutadis mutandis*. Particularly, the navigational obligation as well as the role as the ship's/shipowner's representative vis-à-vis the authorities and, to some extent, the obligation to take care of the cargo after it has been loaded.

However, in connection with a number of obligations, it must be established which requirements apply to ships at autonomy levels RU and A when the master is not physically present on board the ship. These obligations will be mentioned in the individual sub-sections of section 4 where they belong thematically. Here, reference is especially made to the obligations to provide assistance to persons in distress at sea (section 4.5.2) and stowaways (section 4.5.4).

As regards unmanned ships (autonomy levels RU and A), the exercise of authority on behalf of the flag State on board the ship and the managerial authority vis-à-vis the crew (see under Danish law, section 4.5.9) would probably no longer be of relevance.

In relation to autonomous ships at levels R, RU and A, it is our **recommendation** that the responsibility for the ship's seaworthiness be imposed on the shipowner rather than on the remote operator. The responsibility must follow the legal entity capable of checking compliance with the obligation and of arranging the operation of the business. The remote operator will have the operational responsibility, but has no possibility of checking the ship's seaworthiness since it will require technical insight anchored in the company as an organisation.

Especially in relation to the carriage of goods, current regulation and the standard documents used (especially bills of lading and charter parties) presuppose that the master acts as a representative of the shipowner vis-à-vis the cargo owner. Naturally, it will be necessary for the shipowner to delegate these obligations/functions to others (for example local port agents). It will, for example, not be possible for the remote operator to check the quantity and quality of the goods being loaded and unloaded in different ports. Due to the changed roles, the remote operator will probably not have the same right as that held by the master today to act as a representative vis-à-vis a third party. It must be presumed that the right to represent the shipowner and to conclude agreements on behalf of the shipowner will be regulated by the contract concluded between the remote operator and the shipowner. To the extent that a new business area arises for remote operators as independent legal entities – independent of the shipowners and responsible for the operation of a number of ships from different shipowners – this will give rise to separate liability considerations (see section 4.8.3 below on remote operators' liability).

It must be presumed that the obligations and rights resting with the master under current regulation in relation to ships at autonomy levels R, RU and A will be distributed between the remote operator, the shipowner's shore-based organisations (where a "designated person" will

presumably become the key person) as well as local representatives/agents for the shipowner. This will require amendments of existing regulation to the extent that the provisions are not so abstract that the delegation of the master's rights and obligations can be covered within the existing regulatory frame and wording.

3.5.7 Necessary amendments of Danish law

The merchant shipping act

In Danish law, it will be necessary to make a number of amendments to part 6 of the merchant shipping act in relation to the rights and obligations of the master. These amendments are described in section 4.5.9 below.

It is our **recommendation** to insert a new part 6a in the merchant shipping act stipulating the rights and obligations of remote operators. This part should contain a definition of a "remote operator" as well as a definition of "autonomous ships".

On the basis of this analysis, the following definitions are recommended:

"autonomous ships": "ships capable – via automatic processes or systems – of providing decision support or making it possible to take over parts of or the entire human control and steering of the ship, irrespective of whether the exercise of control/steering takes place from the ship or from somewhere else."

"remote operator": "a person holding the required qualifications who takes care of or monitors the navigation of one or more autonomous ships without being physically on board the ship and who is entitled to represent the ship vis-à-vis the authorities."

As a general principle, the remote operator should be considered equal to the master in the merchant shipping act and have the same rights and obligations with the amendments following from the changed nature of the position. As regards navigation, the remote operator should be subject to the principles of section 132 of the merchant shipping act. The remaining issues to consider when regulating the remote operator's rights and obligations are described below in section 4.5.9.

Act on safety at sea

In addition to the merchant shipping act, it will also be necessary to amend section 10 of the act on safety at sea as regards the seaworthiness obligation that rests with the master. In relation to ships at autonomy levels R, RU and A, it is our **recommendation** that the seaworthiness obligations in relation to autonomous ships rest with the shipowner rather than with the remote operators.

Section 4.5.9.1 below contains a proposal for a new wording of section 10.

Act on the manning of ships

It will be necessary to make a number of amendments to section 3 of the act on the manning of ships in order to allow for ships at autonomy levels R, RU and A.

Apart from establishing that a master need not always be physically present on board, it is our **recommendation** that the term "a crew required to ensure the safety of human lives at sea" stipulated in section 3 of the act on the manning of ships be clarified in relation to unmanned ships (autonomy levels RU and A).

Finally, it is our **recommendation** to insert the legal basis in the act on the manning of ships for the Danish Maritime Authority to stipulate educational and certification requirements for remote operators.

Section 4.5.10 below contains a proposal for the wording of the necessary amendments to the act on the manning of ships.

Order on ship logs and radio logs

Section 2 of the order on ship logs and radio logs¹⁷ must be amended to make it possible to keep the radio log electronically from ashore for ships at autonomy levels RU and A.

Section 4.5.11 below contains a proposal for the wording of the necessary amendment.

3.5.8 Requirements for remote operators

On the basis of COLREG regulation 2 on sound seamanship (section 3.4.1 above), it must be presumed that remote operators will, as a minimum, be required to have completed ordinary education and training as a navigating officer and to meet the relevant requirements under the STCW Convention.

To this should be added other competences necessary to steer an autonomous ship, i.e. especially education, training and qualifications within operational technology ("OT") and other relevant technology of importance to the steering of autonomous ships.

It is our **recommendation** to draw up an Annex to the STCW Convention regulating the special conditions that will apply in relation to qualification, education, training, certification and watchkeeping schemes and watchkeeping principles for remote operators of ships at autonomy levels R, RU and A so as to acquire international standards. The regulation should be based on an equivalence approach. A special issue to take account of is how to replace practical navigational experience with virtual simulator experience.

Furthermore, it should be considered introducing an amendment to the ISM Code, stipulating the principles applicable to remote operators. Such regulation could include organisational and decision structures, means of communication and emergency procedures and should be based on the principles and requirements made in relation to the *"Master's Responsibility and Authority"* in the ISM Code, part A, regulation 5.

It must be presumed that remote operators will be considered *"masters"* in relation to UNCLOS article 94(2)(b). Thus, the flag State will have the jurisdiction vis-à-vis the remote operator and could lay down regulations applicable to the remote operator. However, the flag State's enforcement vis-à-vis remote operators could give rise to considerations to the extent that remote operators are operating from another jurisdiction than the flag State.

Remote operators will presumably become specialised as either operators with navigation tasks or operators with engineer officer tasks. In the longer term, the operator role will presumably include elements from the work functions of both the navigating officer and the engineer. In this connection, the Danish approach to education and training in the form of the *"dual officer"* training programme¹⁸ will presumably become more widespread.

Conditions of employment

The remote operator's status under employment law gives rise to considerations. In Danish law, the act on seafarers' conditions of employment, etc. does not contain a definition of the concept of the *"master"*. Considering the act's definition of a *"seafarer"* in section 1(1) as *"any person, except the master, employed, engaged or working on board a Danish ship who does not exclusively work on board while the ship is in port"*, it must be presumed that a purely shore-based remote operator could not be considered a *"seafarer"* under employment law and would, thus, not be covered by the act and its regulation of the employment relationship. In Danish employment law, a shore-based remote operator will presumably, given the nature of the work,

¹⁷ Order no. 978 of 20 July 2007.

¹⁸ <http://www.simac.dk/education/study-ships-officer/> (visited most recently on 30 November 2017).

be considered a salaried employee (in Danish: "*funktionær*") according to section 1(1)(b) and (c) of the salaried employees act.¹⁹

One further consequence is that shore-based remote operators will not be entitled to be covered by the net wage scheme under Danish law according to the act on taxation of seafarers.²⁰ Naturally, this is of commercial importance when it comes to assessing whether autonomous ships are interesting and where shore-based operational centres should be located geographically.

3.6 Protection of the marine environment

One of the main purposes of autonomous ships is reduced environmental impact. Much of the current environmental impact on the seas is caused by the discharge of garbage from ships (food, packaging and sewage²¹). This impact will be eliminated through unmanned ships (levels RU and A) and considerably reduced through lower manning levels at autonomy levels M and R. However, as regards the environmental impact, autonomous ships must prove that they do not present an increased risk of pollution catastrophes, especially from the ship's own oil tanks and from its cargo, and that the crew's emergency preparedness against pollution accidents (prevention and risk mitigation in case of damage) can be replaced by technical means.

Reporting obligations under MARPOL

It must be presumed that the obligations resting with the master under MARPOL Protocol I as well as article 4 of the OPRC Convention to report incidents that could result in pollution of the marine environment could be met by a remote operator for ships at autonomy levels R, RU and A to the extent that it is technically possible to collect the required information about the incident and any pollution of the sea. This is supported by the provisions of MARPOL, Protocol 1, article 1, as well as of article 4 of the OPRC Convention that impose the reporting obligation on "*the master or other person having charge of any ship involved in an incident*". Thus, MARPOL, Protocol 1, article 1, as well as article 4 of the OPRC Convention and the transposition hereof into Danish law will not present a barrier to autonomous ships as long as "*a person having charge*" is able to make the reporting.

It is our **recommendation** to amend the order on reporting under the act on protection of the marine environment in order to clarify that reports could be made by a remote operator in relation to autonomous ships, with reference to the future definitions of a "remote operator" and "autonomous ships" in the merchant shipping act, cf. section 4.5.9.

Requirements for a local pollution preparedness on board ships

MARPOL and the OPRC Convention contain requirements for special emergency preparedness plans in relation to pollution of the marine environment by oil²² and other hazardous/noxious liquid substances.²³

These preparedness plans presuppose the presence of a crew on board ships in the form of a local emergency preparedness in case of unintended incidents.

The same is true of the special precautions and procedures stipulated in the order on the transfer of bunker oil between ships in Danish territorial waters²⁴ as well as the order on the transfer of

¹⁹ Consolidated act no. 1002 of 24 August 2017, as amended.

²⁰ Act no. 386 of 27 May 2005, as amended.

²¹ See: MARPOL Annex IV, Regulations for the Prevention of Pollution by Sewage from Ships, and Annex V, Regulations for the Control of Pollution by Garbage from Ships.

²² MARPOL Annex 1, chapter V, regulation 37, requires a "*Shipboard Oil Pollution Emergency Plan*", MARPOL Annex 1, chapter VIII, regulation 41, requires a "*STS Operations Plan*" and article 3 of the OPRC Convention requires an "*Oil Pollution Emergency Plan*".

²³ MARPOL Annex II, chapter VII, regulation 17, requires a "*Shipboard marine pollution emergency plan for Noxious Liquid Substances*" and article 3 of the OPRC Convention's HNS Protocol (2000) requires an "*Emergency Plan*".

²⁴ Order no. 733 of 25 June 2007.

liquid cargo between ships in Danish and Greenland territorial waters.²⁵ In Danish law,²⁶ the requirements for special emergency preparedness plans also cover ships carrying hazardous and noxious substances classified as polluting under the IMDG Code²⁷, the BC Code²⁸ or the ICG Code²⁹.

The above requirements will present barriers to ships at autonomy levels RU and A.

It will be necessary to introduce new regulation for ships at autonomy levels RU and A in MARPOL, the OPRC Convention and Danish law. This new regulation is to list technical requirements that could, in a safe manner, bring about an emergency preparedness that can replace the manning on board the ships concerned.

3.7 Construction requirements and technical conditions for ships

3.7.1 General remarks about SOLAS

SOLAS contains a number of structural requirements that could present barriers to autonomous ships. These are presented in sections 4.7.2-4.7.9 below for each individual SOLAS chapter and in **Appendix 3**.

In general, SOLAS contains barriers to autonomous ships especially in relation to fire-safety (section 4.7.3) and life-saving appliances and arrangements (section 4.7.4).

3.7.2 Fire-safety, life-saving appliances and life-saving arrangements

The crew has a central role to play in terms of fire emergency preparedness (safety, detection, fighting) and evacuation preparedness on board. Naturally, this is especially the case on passenger ships. The provisions of SOLAS chapter II-II will generally present a barrier to autonomous ships at autonomy levels RU and A.

Passenger ships

In relation to passenger ships, it will need to be assessed – in terms of the technical possibilities – whether acceptable technical solutions can be found that are capable of replacing the role of the crew, in part or fully, relating to the fire and emergency preparedness in case of accidents, and whether it would thus be possible to lay down new regulations in SOLAS on fire safety and accident emergency preparedness for ships on autonomy levels RU and A.

It will be necessary to have a crew on board in accordance with SOLAS chapters II-II and III until sufficient experience has been gained with the safety level of alternative technical measures.

Another possibility could be to improve the qualifications of the on-board personnel who are not seamen to enable them to perform the safety and emergency preparedness tasks imposed on the crew today besides providing service to the passengers on board.

Non-passenger ships

In relation to ships that do not carry passengers, the risk of personal injury and human lives will, of course, be different, but due to protection of the cargo, the risk of danger to other ships and the risk of pollution of the marine environment, the conclusion will presumably be the same as that reached in connection with ships carrying passengers.

The current provisions of SOLAS chapter II-II are based on the fundamental principle that efforts must always be made to rescue the ship in case of fire or accidents. Within the IMO, it should be considered whether this should also be the fundamental principle of unmanned autonomous ships

²⁵ Order no. 570 of 4 June 2014.

²⁶ The order on technical regulation on shipboard emergency plans in case of pollution incidents caused by dangerous or noxious substances, section 1(1) (order no. 765 of 22 July 2009).

²⁷ The IMO International Maritime Dangerous Goods Code.

²⁸ The IMO Code of Safe Practice for Solid Bulk Cargo (BC Code). The Code is included in chapter VI of SOLAS.

²⁹ The IMO International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

or whether the general principle should be that the most important is a ship's technical capability of evacuating everyone on board quickly in case of a fire or accident, and that the same protective considerations need not be taken of the ship's cargo and the ship as such as in the case of manned ships. This idea will probably vary according to the ship's type and size and the type of cargo carried.

Within the EU, directive 2009/45/EC of the European Parliament and of the Council³⁰ contains additional safety regulations and standards for passenger ships on domestic voyages within the EU member States.

The directive supplements SOLAS and contains provisions on (i) Communication between the engine room and the navigation bridge, (ii) Fire safety, detection and extinction and (iii) Life-saving appliances, all of which require a trained on-board crew as well as a manned engine room and bridge.³¹ The EU member States will have to consider this directive which will present a barrier to all autonomous passenger ships on domestic voyages within the EU.

3.7.3 The use of the exemption provisions of SOLAS

Chapter I, part A, regulation 4(b), of SOLAS contains an exemption clause for ships "*which embodies features of a novel kind*" in relation to the structural and technical requirements of SOLAS.

The provision leaves a large degree of discretion to the individual flag States.

In addition to these general possibilities of granting exemptions, the individual chapters of SOLAS contain a number of exemption possibilities which are all based on the principle of an equivalent safety level.

However, it will hardly be a navigable road for flag States in general to use the exemption provision stipulated in SOLAS, chapter I, part A, regulation 4(b), or specific exemptions stipulated in the individual SOLAS chapters in relation to autonomous ships since the challenge presented by the lacking international recognition of standards for autonomous ships will continue to be a hindrance to autonomous ships' international trade, cf. section 4.3.2 on the jurisdiction of coastal States and port States.

This analysis concludes that flag States should not use the exemption provisions stipulated in SOLAS, which are intended for isolated exemptions in general in relation to autonomous ships.

Considering the drastic amendments that autonomous ships would necessitate regulatorily, it is our **recommendation** to instead stipulate international rules and standards on the structural and technical requirements for autonomous ships within the IMO with a view to securing international consensus and recognition and to making it possible for autonomous ships to engage in international trade. This will also be necessary in relation to securing the "documentary seaworthiness" of autonomous ships, as described in section 4.7.13 below.

3.7.4 Technical seaworthiness

Especially within common law jurisdictions, technical seaworthiness is considered a major challenge for autonomous ships.

In Danish law, it is, however, our conclusion that the concept of technical seaworthiness stipulated in section 2(1) of the act on safety at sea will not present a barrier to autonomous as long as "*human lives at sea are fully secured*" and the ship is "*suitable for its intended purpose at any time*" (cf. also section 4.7.12.1).

³⁰ Amended by Commission directive 2010/36/EU of 1 June 2010.

³¹ Directive 2009/45/EC of the European Parliament and of the Council, chapter I, Part C, 9 and 10 (regulations 37 and 38), Chapter II-2 – Fire safety, detection and extinction and chapter III – Life-saving appliances.

3.8 Liability, compensation and insurance issues

3.8.1 Liability issues in general

It is our conclusion that the shipowner will presumably remain the overall liable party within commercial civil shipping and be liable vis-à-vis third parties for any persons or legal entities performing work in his service, including the remote operator (see section 4.5.8) or the representatives to whom the shipowner may delegate competence, such as local representatives/agents for the shipowner in relation to the cargo owner or the shipowner's "designated persons", cf. section 4.5.7.

In connection with fully autonomous ships (autonomy level A), there is reason to presume that it will not make sense to refer to liability based on fault to the extent that the navigation is performed and decisions of importance to the ship's course and speed are taken by an autonomous system without any human interference. It must be presumed that this could, in the longer term, change the liability norm, at least in connection with collisions, to strict liability on behalf of the shipowner.

If the liability norm in future regulation of ships at autonomy level A becomes strict liability, this gives rise to considerations about the principles of distribution in case of collisions or causation of damage vis-à-vis third parties of two or more ships with strict liability. Such principles are, for example, found in the regulation of collisions between motor vehicles in section 103 of the road traffic act.³²

Until such strict liability is laid down in international or national regulation, the shipowner will still have a culpa-based responsibility, where the arrangement of the shipping operation, including appropriate maintenance and updating of the navigation system, as well as compliance with the guidelines/standards according to which the system has been designed will presumably be the most important liability parameters in relation to autonomous ships.

Irrespective of whether the liability norm may be changed over time, there is reason to assume that the overall responsibility for ships' causation of damage will continue to rest with the shipowner as the largest stakeholder in terms of the ship's operation and the primary party who can include the risk in his business and acquire insurance coverage.

The right to limitation of liability

Considering the conclusion that an autonomous ship, cf. section 4.2, will be considered a ship in regulatory terms, it is our conclusion that nothing will prevent a shipowner from continuously having the right to limitation of liability in connection with autonomous ships as is the case with conventional ships. The shipowner will continue to be faced with the same risks, including especially collisions, groundings, damage to goods and injury to persons as well as environmental pollution.

The question is whether the right to limitation of liability under the 1976 Convention on Limitation of Liability can be extended to remote operators and manufacturers and programmers of autonomous ships' navigation systems.

It is our conclusion that a remote operator of autonomous ships must also be presumed to be covered by the right to limitation of liability under the 1976 Convention on Limitation of Liability (section 171(2) of the merchant shipping act) since the remote operator performs a work function on behalf of the shipowner. The application of the provision should not depend on whether the work function is performed from ashore rather than at sea. A remote operator's right to limitation of liability is, however, connected with uncertainty, especially if the remote operator has not been hired by the shipowner, but is an independent company acting as an operator for several shipowners. It is our **recommendation** that agreement be reached internationally about

³² Consolidated act no. 38 of 5 January 2017.

a remote operator's right to limitation of liability under the 1976 Convention on Limitation of Liability since this would be of the utmost importance to the spread of autonomous ships.

It is our conclusion that the right to limitation of liability can hardly be extended so that manufacturers and programmers of autonomous ships' navigation systems also get access to limitation of liability since they will not be considered persons or companies that the shipowner is responsible for.

3.8.2 The liability of manufacturers and programmers of autonomous ships' navigation systems

It is our conclusion that the liability of manufacturers and programmers of navigation and steering systems for autonomous ships will be covered by existing regulations and principles under Danish law (cf. section 4.8.4) and that it will not be necessary – neither contractually or non-contractually – to establish special liability provisions for these.

It is our conclusion that manufacturers and programmers will be more exposed to liability and at risk of being met directly with claims from third parties or with third party claims from shipyards or shipowners (and their insurance companies) to the extent that their supplies must be considered to have caused damage resulting in claims against the shipowner and its insurance companies from third parties (product liability). In relation to non-contractual claims, risk-management will be difficult.

3.8.3 Carriage of goods – seaworthiness and liability

General cargo

In relation to ships at autonomy levels RU and A, it is our conclusion that they must be presumed to be seaworthy under article 3 of the Hague and Hague-Visby rules (section 252(2) of the merchant shipping act) to the extent that they will be capable of operating without a crew in technical and safety terms, cf. also section 4.5.1.

Seaworthiness issues may arise if the ship encounters challenges the handling of which requires the presence of a human being on board the ship, and which could have been handled with a crew on board.

Furthermore, the Hague and Hague-Visby rules, article 3 (section 262(1) of the merchant shipping act) contains an obligation on the part of the shipowner to "care for the cargo".

The obligations could present a barrier to unmanned autonomous ships (levels RU and A) to the extent that it is not technically possible to arrange/fit the ships with technical functions capable of monitoring and handling goods and, thus, performing the same function as that of the on-board crew today, depending on the type of goods.

A special issue may arise for unmanned autonomous ships in relation to the handling/disposal of dangerous goods during the ship's voyage; both goods that have been declared non-hazardous, but turn out to be hazardous, and goods that have been declared hazardous goods that jeopardise the safety of the ship and the other goods on board.

The scope of application of the Hague and Hague-Visby rules, article 4(2)(a) (transposed into Danish law through section 276(1)(i) of the merchant shipping act), on exemption from liability for "Act, neglect, or default of the master, mariner, pilot, or the servants of the carrier in the navigation or in the management of the ship" will need to be clarified in relation to autonomous ships. As regards ships at autonomy levels R and RU, the remote operator will presumably be considered a "pilot" in relation to the ship's navigation, but faults committed in "the management of the ship" by other shore-based persons in the shipowner's organisation or cooperative partners will not necessarily fall within the scope of the provision.

In relation to ships at autonomy level A, it is our conclusion that it will hardly be possible to invoke exemption from liability for navigation errors, considering that they are based on pre-programmed algorithms.

Chartering of ship and charter parties

In relation to chartering, it is our conclusion that seaworthiness will not present a barrier to autonomous ships under Danish law since part 14 of the merchant shipping act is non-mandatory, and the parties to the transport agreement are free to agree on conditions adjusted to the specific ship/transport.

On the other hand, seaworthiness will presumably give rise to problems in relation to charter parties subject to a choice of law in jurisdictions where seaworthiness in the form of manning is a mandatory condition. This is especially relevant in relation to the widespread use of English law in international chartering.

3.8.4 Taking and preservation of evidence

Traditionally, evidence presented by the master and the crew as well as the contents of ship's logs, engine logs and radio logs have been central to elucidate the liability issues of ships under civil law as well as in relation to the authorities' investigations of marine accidents.

Furthermore, ships are – according to SOLAS chapter V, regulation 20 (and Annex 10 to chapter V) – required (depending on the ship's type, date of construction and gross tonnage) to be fitted with a Voice Data Recorder (VDR) which continuously records on-board communication.

As regards autonomous ships, satisfactory technical solutions must be expected to be needed when it comes to preserving evidence. It is our **recommendation** that requirements for electronic logging of data on ships' operation (inter alia course, speed, planned voyage, etc.) be laid down within the IMO. Considering that autonomous ships will continuously be connected to shore for communication and data exchange purposes, regulations should be laid down requiring operational data to be stored in more than one place so as to ensure access in case of incidents. In relation to the taking of evidence, this would be a major improvement compared to a VDR placed locally.

Furthermore, it will be crucial to log who is in control of the autonomous ship in relation to the placing of responsibility as well as a change of autonomy levels. This should be ensured through the use of electronic certificates by the ones responsible when changing the watch/taking over control of the ship.

3.8.5 Issues of criminal law

Traditionally, the liable parties under criminal law for compliance with regulatory requirements aimed at the shipping industry are the master and the shipowner. Society must be presumed to have an interest in the possibility of a remote operator being liable to criminal law sanctions to the extent that he assumes obligations that rest with the master under current law. Criminal enforcement vis-à-vis remote operators could present difficulties, cf. also section 4.5.8.

Considering the fundamental criminal principle that it is only possible to impose punishment for conditions the criminality of which is based in law, cf. section 1(1) of the criminal code, it will be necessary to amend the relevant current legal basis where the master is the party liable to punishment if it is to be possible to make the remote operator liable to punishment. However, in Danish law the party liable to punishment is often given in abstract terms, such as "*anyone violating(...)*". If this is the case, it will not be necessary to amend the legal basis.

3.8.6 Insurance issues

The shipowner's possibility of covering the risk and exposure to liability by insurance is decisive for commercial shipping.

In relation to the spread of autonomous ships, it is necessary to find acceptable solutions to the distribution of the changed risk resulting from the new technology. The present system with a strict liability norm for the shipowner combined with a right to liability exemptions and limitations under internationally recognized conventions has resulted in an effective insurance market.

It is our conclusion that clarity in terms of the international regulatory framework conditions will be a necessary precondition for a well-functioning and effective insurance market for autonomous ships.

A too expensive or non-transparent insurance market could present a considerable systemic barrier to autonomous ships.

The distribution of risk between P&I and Hull & Machinery insurances in case of collision will presumably also give rise to considerations. It is far from certain that the present distribution of risk can be maintained in relation to autonomous ships. However, this is a commercial rather than a regulatory issue.

Seaworthiness under insurance law

It is our conclusion that the regulation of seaworthiness under Danish insurance law (section 114 of the marine insurance convention and section 63 of the act on insurance agreements) will not present a barrier to unmanned autonomous ships as long as the ship is seaworthy without manning from an objective seamanlike assessment.

However, seaworthiness under insurance law in relation to autonomous ships will presumably give rise to uncertainty in many other jurisdictions, especially common law jurisdictions (see section 4.8.8.2). Given that the insurance terms on a large part of the global insurance market is subject to law of a common law jurisdiction, this is a great challenge in relation to insurance of autonomous ships.

Homogeneous technical standards and international regulation hereof will be important to ensure a functioning insurance market for the new risk presented by autonomous ships.

If international regulation of shipping makes autonomous ships possible, it is difficult to imagine that the insurance market will not adjust to the new market conditions.

Insurance of cyber risks

As regards cyber risks, new insurance products need to be developed since the risks and types of losses made possible by cyber attacks are not covered by traditional insurance products.

The traditional types of marine insurance, especially P&I and Hull & Machinery insurances, will for example normally not cover cyber risks since they will typically contain a so-called "*institute cyber attack exclusion clause (CL 380)*".

Cyber insurance products have been developed, but it is uncertain whether the coverage needed is available in relation to the actual risk and extent of loss since present cyber insurance products have the form of collective arrangements (pools), where one shipowner's major loss could exhaust the other insurance-covered shipowners' possibility of being covered.

Cyber insurances do not yet have an extent where there is a secure insurance market. Furthermore and according to the insurance companies, there is a large gap between the actual cyber risk and the limited insurance taken out in this field and, thus, a major non-insured risk.

3.9 Cybersecurity and anti-terror safeguards

3.9.1 Cybersecurity

In June 2017,³³ it was decided that, no later than at the annual verification of the Document of Compliance under the ISM Code after 1 January 2021, the shipowner must have addressed cyber risk management as part of its safety management system (SMS).

It is our conclusion that the goal-based approach of the ISM Code makes it suitable to constitute the regulatory framework for cyber risk management.

Given the rapid change in the threat scenario and the technology (and thus the hacking methods) as well as the large difference between the organisations of shipowners depending on type and size, it is our **recommendation** that cybersecurity regulation be based on industry guidelines that can be continuously amended and updated rather than on prescriptive, convention-based regulation. The guidelines should establish an international cybersecurity standard for shipping to be supplemented by the shipowner's own assessment of cyber risk management in its safety management system under the ISM Code. Furthermore, risk management in accordance with the ISO27000 standards could be a supplement.

The ISPS Code (mentioned below in section 4.9.5 on anti-terror safeguards as well as in section 4.9.2) contains mechanisms for exchanging information about security incidents.

In relation to the regulation of cybersecurity in shipping, it should be considered to establish special obligations for shipowners to report cybersecurity incidents to the flag State. Subsequently, the flag State could share knowledge about the type and number of cybersecurity incidents in anonymised form with other flag States as well as the shipowners and other relevant stakeholders, such as classification societies and insurance companies with a view to acquiring a better knowledge base for countering and planning a preparedness against cybersecurity incidents.

In Danish law, section 4(3) of the act on safety at sea contains the legal basis for the Minister for Industry, Business and Financial Affairs to *"lay down regulations on the obligation to report accidents and other incidents at sea to the Danish Maritime Authority as well as information about the authorities' reporting hereof to the European platform for accidents at sea"*. This legal basis could be used for issuing regulations on reporting obligations in connection with cybersecurity incidents.

3.9.2 Anti-terror safeguards

To the extent that autonomous ships do not have a crew on board (autonomy levels RU and A), it is our conclusion that it must be presumed that the investigation and safeguarding obligations stipulated in part A, regulations 7 and 9, of the ISPS Code could be met without any human interference if it is technically possible to provide the same security level without any crew being physically present on board, for example through the use of cameras, sensors and heat-sensitive or movement-sensitive scanners. Another possibility could be to include in the shipowner's ship security plan a special port manning of an autonomous ship at autonomy levels RU and A with special procedures for such port manning.

³³ Maritime Safety Committee (MSC), 98th session, 7-16 June 2017.

4. REGULATORY BARRIERS



4.1 Introduction

This section 4 analyses the regulatory barriers to autonomous ships.

Section 4.2 contains an analysis of the concepts of a "ship" and a "vessel" under current regulation in order to clarify whether an autonomous ship is to be considered a ship.

Subsequently, the regulatory barriers will be analysed in relation to the jurisdiction over ships (section 4.3 – jurisdictional issues).

Then, the regulatory barriers will be analysed thematically within the following subjects: Navigation and regulations for preventing collisions at sea (section 4.4); Manning and "seafarers" of the future (section 4.5); Protection of the marine environment (section 4.6); Construction requirements and technical conditions for ships (section 4.7); Liability, compensation and insurance issues (section 4.8); Cybersecurity and anti-terror safeguards (section 4.9).

4.2 Is an autonomous ship a ship?

4.2.1 The definitions of a "ship" and a "vessel"

The international conventions regulating shipping do not contain generally recognised definitions of a "ship" and a "vessel". To the extent that the concepts have been defined, these definitions are based on the purpose of each individual convention. International legal theory seems to generally agree that autonomous ships will also be considered ships in relation to international regulation and, consequently, be covered by this.³⁴

UNCLOS leaves it to the flag State to establish the conditions for giving ships their nationality, cf. UNCLOS, article 91 (described below in section 4.3.1 (the jurisdiction of flag States)).

Part 1 of the merchant shipping act on ships and part 2 on registration in the Register of Shipping do not contain general definitions of "ships" or "vessels".

However, section 11(2) of the merchant shipping act delimits the concept of a ship negatively: *"floating docks, cable drums, floating containers and other similar equipment are not considered ships for the purposes of this part"*, just as section 11(3) of the merchant shipping act implies that *"barges, lighters, dredging machinery, floating cranes and the like are considered ships (...)"*, but are solely covered by the obligation to be registered if they are fitted with propulsion machinery.

Section 11 of the merchant shipping act and the delimitations herein are national Danish law. Otherwise, the merchant shipping act implements the definition of a "ship" contained in a number of IMO conventions in relation to the following subjects:

1. Wreck removal (section 165 of the merchant shipping act, the Nairobi International Convention on the Removal of Wrecks, 2007)
2. Salvage (section 441 of the merchant shipping act, the International Convention on Salvage, 1989)
3. Liability and compensation for oil pollution damage (section 191 of the merchant shipping act, the 1992 Protocol to the Convention on Civil Liability for Oil Pollution Damage, 1969).

³⁴ See Carey, Veal and Tsimplis as well as Van Hooydonk.

Danish and Nordic maritime legal theory generally assumes that ships have the following characteristics³⁵:

1. A ship is a floating arrangement, with a buoyancy partly caused by the arrangement being hollow.
2. A ship must be capable of moving on or through the water.
3. The ship is not required to be able to move by its own power. Also a lighter, a barge or a floating crane without propulsion machinery are considered ships, cf. section 11(3) of the merchant shipping act.
4. The ship must have a certain size. Rowboats, kayaks, etc. fall outside the concept of a ship. Section 10(2) of the merchant shipping act stipulates that ships must have a gross tonnage of at least 5 in order to be registered as ships in the Register of Shipping.

To the extent that autonomous ships fall within the above-mentioned criteria, nothing seems to prevent autonomous ships from being considered ships under Danish law and, thus, from being covered by current national shipping regulation.

4.2.2 Manning requirements?

Neither Danish law nor international regulation contains a basis for requiring a ship to be manned in order for it to be considered a ship in the regulatory sense³⁶. Rather, what is decisive is the ship's functionality and its ability to move on and through the water.

Another issue is whether the safe manning regulations as well as the functions performed by the crew could present a barrier to autonomous ships (see section 4.5 on manning and "seafarers" of the future below).

4.2.3 Requirement for a genuine link between the ship and the flag State

The requirement for a "genuine link" between a ship and its flag State under article 91(1) of UNCLOS³⁷ gives rise to separate considerations on autonomous ships.

United Nations Convention on Conditions for Registration of Ships from 1986 (the "Ship Registration Convention") contains additional clarification of the international law understanding of the concept of a "genuine link". The convention was developed on the initiative of a number of developing countries that wanted a requirement for a clear relation between ships and their flag States with a view to protecting national interests when it comes to attracting ships to and retaining them on their registers. However, the convention has not yet entered into force and has been acceded to by only 14 states.³⁸

³⁵ Martens and Mathiesen and Falkanger, Bull and Rosenberg Overby. A ship in the wider sense means the same as a vessel, i.e. any arrangement constructed for transporting goods or persons at sea. See Brækhus, Falkanger, Bull and Rosenberg Overby, p. 42 and Herman Bruserum.

³⁶ See analysis of the definitions of a "ship" in a number of international maritime conventions by Dr. Bulent Sozer, Turkey, attached as an annex to the CMI's Working Group on Ship Nomenclature, available from the CMI website: <http://comitemaritime.org/Uploads/Work%20In%20Progress/Ship%20Nomenclature/Ltr%20to%20Presidents%20re%20IWG%20on%20Vessel%20Nomenclature%20-%20080316.pdf> as well as Serdy, Tsimplis, Veal et al.

³⁷ The UN "Convention on the High Seas" adopted in Geneva in 1958, which is the forerunner of UNCLOS, also contains in article 5(1) a requirement for a "genuine link" between the flag State and the ship. Art. 5(1) has the following wording: "Each State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship; in particular the State must effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag".

³⁸ https://treaties.un.org/pages/viewdetails.aspx?src=treaty&mtdsg_no=xii-7&kapitel=12&lang=en (accessed most recently on 30 November 2017). At least 40 states, representing at least 25 per cent of the world's tonnage, are required to accede to the convention in order for it to enter into force.

Article 10(1) of the ship registration convention stipulates that the owner of a ship must be established in the flag State and/or have its registered office in the flag State in order for the ship to be registered in the relevant flag State. If this requirement is not met, the flag State must ensure that there is a legal representative (either a physical or legal person) of the shipowner with a registered office in the flag State and with full powers to represent the shipowner in connection with *"any legal process"*.³⁹

The requirement for a genuine link between ships and their flag States does not present a barrier to autonomous ships since the central part of the requirement is the ship's relation to the flag State – either in the form of the shipowner's affiliation or in the form of a local legal representative of the shipowner. Autonomous ships will still have an owner. Under international law, the manning of a ship will not be considered a precondition for a ship's registration in a flag State. The requirement for a "genuine link" will, thus, not present a barrier to ships at autonomy levels RU and A.

4.3 Jurisdictional issues

International shipping regulation stipulates principles of states' jurisdiction over ships as a flag State, a coastal State or a port State as well as states' territorial jurisdiction over the sea. Jurisdiction entails the competence to regulate and enforce.

A flag State's jurisdiction is founded on a ship's nationality. A ship flying the Danish flag is subject to Danish jurisdiction and is, in this connection, considered Danish territory. The competence of the flag State follows the ship, irrespective of where the ship is located geographically, whereas the jurisdiction of coastal States and port States follows the geographical location of the state.

As regards jurisdiction, UNCLOS⁴⁰ is the central convention. The principles of UNCLOS on jurisdiction are, in international law, considered common international law and can, thus, also be applied to the (few) states that have not acceded to the convention.

Sections 4.3.1 and 4.3.2 analyse current regulations on the jurisdiction of flag States, coastal States and port States in terms of any barriers to autonomous shipping.

4.3.1 The jurisdiction of flag States

It follows from article 90 of UNCLOS (right of navigation) that *"Every State, whether coastal or land-locked, has the right to sail ships flying its flag on the high seas"*.

UNCLOS, art. 91(1), stipulates the following on ships' nationality: *"Every State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship."*

UNCLOS, art. 94(1), lays down the obligations held as a flag State as well as the jurisdiction of the flag State: *"Every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag"*.

UNCLOS, art. 94(2)(b), elaborates on this stipulating that the flag State must: *"assume jurisdiction under its internal law over each ship flying its flag and its master, officers and crew in respect of administrative, technical and social matters concerning the ship."*

³⁹ Order on the registration of ships that are not considered to have a Danish owner (order no. 1132 of 25 September 2013), contains a general requirement for foreign owners of Danish registered ships to be affiliated with Denmark (the establishment obligation). For legal persons it is sufficient to appoint a physical or legal person in Denmark whom it is possible to sue on behalf of the owner or the shipowner, cf. section 2(ii)(c) of the order. In addition, the ship is required to be effectively administered, controlled and directed from Denmark (the activity condition) under section 3 of the Order.

⁴⁰ United Nations Convention on the Law of the Sea, 1982, transposed into Danish law through order no. 17 of 21 July 2005. The convention has been acceded to by a total of 169 states.

Furthermore, flag States must (UNCLOS, article 94(3)) *"take such measures for ships flying its flag as are necessary to ensure safety at sea with regard, inter alia, to:*

- (a) the construction, equipment and seaworthiness of ships;*
- (b) the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments;*
- (c) the use of signals, the maintenance of communications and the prevention of collisions."*

The necessary measures are elaborated on in article 94(4) of UNCLOS:

"Such measures shall include those necessary to ensure:

- (a) that each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of ships, and has on board such charts, nautical publications and navigational equipment and instruments as are appropriate for the safe navigation of the ship;*
- (b) that each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship;*
- (c) that the master, officers and, to the extent appropriate, the crew are fully conversant with and required to observe the applicable international regulations concerning the safety of life at sea, the prevention of collisions, the prevention, reduction and control of marine pollution, and the maintenance of communications by radio."*

When taking measures under article 94(3) and (4) of UNCLOS, the flag State must *"conform to generally accepted international regulations, procedures and practices and take any steps which may be necessary to secure their observance"* (UNCLOS art. 94 (5)).

As is evident from the above provisions, UNCLOS is very wide and abstract in its formulation of the competence of flag States and actually leaves it to subsequent detailed regulation within the IMO to establish the obligations of flag States. This provides flexibility when it comes to interpreting the principles of the convention in accordance with technological and societal developments, inter alia in relation to autonomous shipping.

4.3.2 Jurisdiction as a coastal State and as a port State

Within its territorial waters, a state has some jurisdiction over ships of other nationalities due to the state's sovereignty and interest in protecting its territorial waters. Under article 3 of UNCLOS, a state's territorial waters can be extended to a maximum of 12 nautical miles from its coastline/baseline⁴¹. The degree of jurisdiction increases from the outer part of a state's territorial waters and the closer one gets to the coast. Under article 8 of UNCLOS, the waters on the shore-turned side of the baseline of a state's territorial waters constitute a state's inner waters.

Furthermore, coastal States are entitled to establish an exclusive economic zone of up to 200 nautical miles from the coastline, where the coastal State has limited jurisdiction, covering only the right to explore and utilise the resources of the sea and to enforce environmental jurisdiction⁴². The sea beyond these zones is international waters ("high seas") and is not subject

⁴¹ The definition of a "coastline" and a "baseline" as well as the principles governing the surveying of these are stipulated in chapter II, section II, of UNCLOS on the borders of territorial waters. As regards Danish territorial waters, reference is made to the delimitation of territorial waters (act no. 200 of 7 April 1999) as well as the act on exclusive economic zones (act no. 411 of 22 May 1996).

⁴² See especially UNCLOS, art. 211(5), on the restriction on a coastal State to only issue regulations that are in accordance with or that implement internationally generally accepted international rules and norms as well as article 220(3) of UNCLOS on the coastal State's right to require information from foreign ships in case of obvious violations of current international regulations and norms. The coastal State is entitled to restrict foreign vessels' passage only: *"Where there are clear grounds for believing that a vessel navigating in the exclusive economic zone or the territorial sea of a State has, in the exclusive economic zone, committed a violation referred to in paragraph 3 resulting in a substantial discharge causing or threatening significant pollution of the marine environment (...)"*, cf. UNCLOS, art. 220(5).

to the jurisdiction of any state. Everybody is entitled to navigate, fish and fly over international waters and here only the flag State does, in general, have any jurisdiction over the ship.

If a ship of foreign nationality is present in a port or in a state's inner waters, the port State or the coastal State has full jurisdiction over the ship according to article 2 of UNCLOS on the sovereignty of coastal States. Ships flying foreign flags have no general right of access to foreign ports, and port States are entitled to lay down regulations on foreign ships' port calls as well as their access to the state's inner waters (UNCLOS, art. 25(2), 211(3) and 255).

In relation to autonomous ships, states are, thus, entitled to ban autonomous ships from ports as well as from the state's inner waters to the extent that it will not be contrary to general international law principles on proportionality and non-discrimination as well as article 300 of UNCLOS on the misuse of rights under the convention and article 18 of UNCLOS on innocent passage (see section 4.3.3 below).

For this reason, it will be central to the spread of autonomous ships to acquire international agreement about the regulatory requirements so that their trade area is not restricted to national waters where the national maritime authorities have a positive attitude to autonomous ships.

As regards Danish ports, section 5 of the port act⁴³ stipulates that Danish ports have "an obligation to receive ships to the extent possible considering the space available and safety unless otherwise established by the Minister of Transport through permits issued pursuant to previous legislation."

4.3.3 Right of innocent passage

UNCLOS, art. 17, establishes the fundamental principle that all ships – irrespective of nationality – are entitled to innocent passage through the territorial waters of coastal States.

Passage is considered innocent "so long as it is not prejudicial to the peace, good order or security of the coastal State. Such passage shall take place in conformity with this Convention and with other rules of international law" (UNCLOS, art. 19(1)).

UNCLOS, art. 19(2), lists situations where a passage is considered harmful:

"Passage of a foreign ship shall be considered to be prejudicial to the peace, good order or security of the coastal State if in the territorial sea it engages in any of the following activities:

- (a) any threat or use of force against the sovereignty, territorial integrity or political independence of the coastal State, or in any other manner in violation of the principles of international law embodied in the Charter of the United Nations;*
- (b) any exercise or practice with weapons of any kind;*
- (c) any act aimed at collecting information to the prejudice of the defence or security of the coastal State;*
- (d) any act of propaganda aimed at affecting the defence or security of the coastal State;*
- (e) the launching, landing or taking on board of any aircraft;*
- (f) the launching, landing or taking on board of any military device;*
- (g) the loading or unloading of any commodity, currency or person contrary to the customs, fiscal, immigration or sanitary laws and regulations of the coastal State;*
- (h) any act of wilful and serious pollution contrary to this Convention;*
- (i) any fishing activities;*
- (j) the carrying out of research or survey activities;*
- (k) any act aimed at interfering with any systems of communication or any other facilities or installations of the coastal State;*
- (l) any other activity not having a direct bearing on passage."*

⁴³ Consolidated act no. 457 of 23 May 2012.

The exceptions listed in article 19(2) of UNCLOS are based on the ship's type rather than its technical arrangement or manning.

Coastal States' right to limit foreign ships' right of innocent passage through legal restrictions in national law is, furthermore, regulated by article 21 of UNCLOS.

The following considerations may motivate restrictions on the right of innocent passage pursuant to article 21(1) of UNCLOS):

"The coastal State may adopt laws and regulations, in conformity with the provisions of this Convention and other rules of international law, relating to innocent passage through the territorial sea, in respect of all or any of the following:

- (a) the safety of navigation and the regulation of maritime traffic;*
- (b) the protection of navigational aids and facilities and other facilities or installations;*
- (c) the protection of cables and pipelines;*
- (d) the conservation of the living resources of the sea;*
- (e) the prevention of infringement of the fisheries laws and regulations of the coastal State;*
- (f) the preservation of the environment of the coastal State and the prevention, reduction and control of pollution thereof;*
- (g) marine scientific research and hydrographic surveys;*
- (h) the prevention of infringement of the customs, fiscal, immigration or sanitary laws and regulations of the coastal State."*

UNCLOS, art. 21(1), is restricted by art. 21(2), according to which:

"Such laws and regulations shall not apply to the design, construction, manning or equipment of foreign ships unless they are giving effect to generally accepted international rules or standards."

Furthermore, article 24(1)(a) of UNCLOS restricts the right to lay down national requirements on innocent passage, according to which coastal States must not *"impose requirements on foreign ships which have the practical effect of denying or impairing the right of innocent passage"*.

The right of innocent passage also applies to nuclear-powered ships as well as to ships carrying cargoes of nuclear material or other substances that are dangerous or harmful, cf. article 23 of UNCLOS.

Straits used for international navigation within a state's territorial waters are especially protected against the coastal State's restrictions on foreign ships' passage due to their status as "traffic junctions". Articles 37 to 44 of UNCLOS contain special provisions on transit passage of such straits. Examples of such straits are, inter alia, the Little Belt and the Great Belt, which are covered by article 35(c) of UNCLOS as *"straits in which passage is regulated in whole or in part by longstanding international conventions in force specifically relating to such straits"*.

Since the right of innocent passage is a fundamental part of UNCLOS and international law in general, autonomous ships must – irrespective of their autonomy level – be presumed to be entitled to innocent passage through other states' territorial waters to the extent that the autonomous ship meets UNCLOS's perception of a "ship" and a "vessel", cf. section 4.2.

4.3.4 Port State Control

As mentioned in section 4.3.1 (the jurisdiction of flag States) above in connection with the reference to article 94(1) and (2) of UNCLOS, the flag State has the jurisdiction to exercise control and authority over ships' technical condition.

In practice, this means that the flag State (often via delegation to the classification societies) ensures compliance with current technical regulations and standards and issues the required certificates to ships flying its flag in relation to relevant international conventions which the flag State has acceded to (especially SOLAS, MARPOL and STCW).

It follows from chapter I, regulation 17, of SOLAS that the principle applies that a contracting Party to the convention must consider certificates issued in another state Party to the convention as if the certificates had been issued by the contracting Party itself (mutual recognition). A coastal State or a port State can subject a ship to additional control only if there are *“clear grounds for believing that the condition of the ship or its equipment does not correspond substantially with the particulars of that certificate”*, cf. SOLAS, chapter I, regulation 19.

In order to ensure an effective system for controlling ships’ technical condition in addition to the inspection by the flag State, 14 European shipping nations have concluded the so-called Paris MoU (Memorandum of Understanding on Port State Control) in 1982, establishing a system for Port State Control of ships from all countries calling at a port in the acceding States.⁴⁴ Today, the agreement covers all EU member States as well as Canada, Iceland, Norway and Russia. The USA is affiliated as a cooperating country.⁴⁵ Port State Control involves an extra layer of systematised control of ships’ technical condition and safety.⁴⁶ Systematised Port State Control is also motivated by the fact that a number of flags of convenience have historically proven to not effectively control ships flying their flags. The aim of the Paris MoU is that all acceding States control approx. 25 per cent of the ships calling at their ports. Annually, approx. 18,000 inspections are carried out under the Paris MoU.⁴⁷ Ships are to be subjected to detailed inspection only if there is a special reason for this because of the ship’s logbooks or certificates (or lack hereof). In addition to ships’ technical condition, Port State Control inspections under the Paris MoU also include an inspection of seafarers’ certificates of competency and qualifications according to the STCW Convention as well as compliance with SOLAS, MARPOL and MLC. Organisationally, the Paris MoU is structured around a Committee (the Port State Control Committee) and a secretariat function in the Netherlands as well as a common database in which the results of all the inspections carried out by the member States are stored and accessible to the member States.⁴⁸

Inspired by the Paris MoU, similar regional Port State Control agreements have been made in Asia/the Pacific area (Tokyo MoU⁴⁹) and Latin America (Acuerdo Latinoamericano de Viña del Mar⁵⁰).

In the EU, special regulations have been laid down on Port State Control within the territorial waters of the member States by directive 16/2009 of the European Parliament and of the Council of 23 April 2009 on Port State Control.⁵¹ Based on the Paris MoU, the directive stipulates a number of additional obligations on information exchange and reporting between the EU member States in relation to Port State Control of ships as well as on the professional qualifications of ship surveyors.

On the condition that autonomous ships are designed so that it would be physically possible to inspect them, neither SOLAS, MARPOL, STCW or the Paris MoU nor directive 16/2009 contains regulatory barriers to autonomous ships.

⁴⁴ <https://www.parismou.org/> (accessed most recently on 30 November 2017).

⁴⁵ Dyre Jespersen, p. 105.

⁴⁶ Falkanger, Bull and Rosenberg Overby pp. 81 ff.

⁴⁷ <https://www.parismou.org/about-us/organisation> (accessed most recently on 19 November 2017).

⁴⁸ Dyre Jespersen, pp. 104–105.

⁴⁹ <http://www.tokyo-mou.org/> (accessed most recently on 2 November 2017). Tokyo MoU covers 20 states in Asia/the Pacific area.

⁵⁰ <http://alvm.prefectura naval.gov.ar/cs/ciala/home?Lang=1374097586979> (accessed most recently on 3 November 2017)

⁵¹ Transposed into Danish law by order no. 1195 of 12 November 2014 on Port State Control of ships.

However, in relation to unmanned autonomous ships (autonomy levels RU and A), it will be necessary to make amendments to clarify who can act on behalf of the ship since SOLAS, MARPOL, STCW and the Paris MoU as well as directive 16/2009 on Port State Control presupposes the presence of a master on board, cf. for example Paris MoU, paragraph 3.10, and directive 16/2009, article 17. It will presumably be natural to have the shipowner, as defined in regulation 1(2) of the ISM Code, replace the master's functions and areas of responsibility in relation to Port State Control.

4.3.5 The exercise of authority vis-à-vis autonomous ships

The exercise of authority (such as maritime surveillance, customs authority, maritime authority and court authority) vis-à-vis autonomous ships gives rise to challenges in connection with unmanned ships (autonomy levels RU and A). According to current regulation, the master is the shipowner's and the ship's representative vis-à-vis the authorities and can receive guidance about navigational issues and orders on course changes, stopping, detention (including arrest) and access to the ship. Furthermore, the master is the representative vis-à-vis the authorities in relation to the presentation of certificates and other documents on board as well as any other communication purpose.

Based on an interpretation of the purpose, it is the master's function as the shipowner's and the ship's representative that is at the core of most of the provisions that impose obligations on the master vis-à-vis the authorities and not the place from where the function is performed. This is especially the case in relation to regulations on orders on navigation, stopping and detention (including arrest). In connection with these obligations of a functional nature, it must be presumed that a human being with the necessary qualifications who is in control of the ship could perform similar functions in case of authority orders given from places other than the ship and would, thus, be considered the master. Consequently, the remote operator could take over the function as the ship's and the shipowner's representative vis-à-vis the authorities in relation to ships at autonomy levels M, R, RU and A. Whether it is necessary to amend existing regulation in this connection is described in relation to each individual barrier in sections 4.4 to 4.9 below as well as in [Appendix 3](#).

Many legal acts presuppose that certificates or other documents are physically available on board. SOLAS Annex 1 contains an overview of certificates and other documents that are required to be kept on board ships pursuant to IMO regulations. The overview also contains the legal basis of the relevant legal act for each individual type of document. It is generally our recommendation that all flag States adapt their regulation to make it possible for the flag State to issue certificates and other documents digitally. In addition to promoting autonomous ships, it would also allow for simplified Port State Control if it becomes possible in the longer term to get access to a common database of all certificates.

Denmark has already adapted its regulation, and with effect from 24 June 2016 Denmark issues all new ship certificates digitally.

Furthermore, Denmark has on 24 April 2017 concluded a Memorandum of Understanding (MoU) with the maritime authorities of Singapore and Norway on the spread of the use of digital certificates internationally.

4.3.5.1 Maritime surveillance

In Denmark, the Defence is responsible for coast guard/maritime surveillance activities (the Naval Staff under Defence Command Denmark), cf. the act on protection of the marine environment, section 34⁵².

⁵² Consolidated act no. 1033 of 4 September 2017.

The Defence is also responsible for the exercise of authority vis-à-vis ships in Danish waters and has the right to intervene against ships under part 13 of the act on protection of the marine environment. Furthermore, the Naval Staff is authorized to:

- Communicate with the person who has the ultimate responsibility for the ship's navigation and who can overrule autonomous steering and manually steer the ship.
- Communicate requirements to detain and stop the ship.
- Communicate guidance about navigational conditions that may present a danger to the ship's safe navigation and ensure that action is taken (typically in VTS areas).

Of importance to the Naval Staff's exercise of authority is its ability to communicate with the one responsible for the ship's navigation as well as with the person capable of taking over the manual steering of the ship and making it stop. It is the *function* rather than the location from where the function is performed which is central. In relation to ships at autonomy levels R, RU and A, it must be presumed that these functions could also be performed by a remote operator as long as he can take over the manual steering of the ship.

4.3.5.2 Customs clearance

In connection with the exercise of authority, it must be possible for the customs and tax authorities to get access to ships and to communicate with the person who is in control of the ship and can represent it.

According to section 16(1) of the customs act,⁵³ the customs and tax authorities are entitled to examine and control all ships calling at Danish territorial waters without having any judicial authorisation beforehand. Section 16(5) of the customs act stipulates that *"ships must stop if the customs and tax authorities require this"*.

Furthermore, section 17 of the customs act stipulates that *"companies engaged in air-cushion and ship traffic or the master of the means of transport is obliged to give and document the information that may be necessary to perform the control, including information about the means of transport, the crew, passengers and their registered luggage as well as cargoes, as well as to identify and open or uncover all accessways to cargo, spaces and hiding places (...)"*. Pursuant to section 17(5) of the customs act, section 69 of the order on customs clearance⁵⁴ requires the master to confirm the information about the means of transport and the cargo, etc. that is required under section 17(1) of the customs act by presenting ship papers, voyage records or registration papers as well as shipment documents, etc.

Finally, section 18 of the customs act stipulates that *"Operators of means of transport must, upon arrival to the Danish customs area from a third country, notify the customs and tax authority. Masters of ships arriving in a Danish port from another place in the EU customs area or leaving the Danish customs area for another place in the EU customs area must also notify the customs and tax authority if the ship carries goods for which no customs or dues have been paid as cargo or stores."*

According to section 18(2), the notification can be made by an authorised person.⁵⁵

In relation to ships at autonomy levels R, RU and A, it must be presumed that a remote operator of the ship will be considered the master for the purposes of the customs act. The remote operator could give the information and present the documents needed to perform control under section 17 of the customs act and stop the ship following a request under section 16(5) of the

⁵³ Consolidated act no. 1223 of 20 September 2016, as amended. On the legal basis of the customs act, the order on customs clearance has been issued (order no. 403 of 3 May 2012), which contains in part 4 regulations on the customs clearance of means of transport, including ships.

⁵⁴ Order no. 403 of 3 May 2012.

⁵⁵ This is also stipulated in section 71(11) of the order on customs clearance.

customs act. Furthermore, the remote operator could make notifications when calling at and leaving Danish ports under section 18 of the customs act.

As regards ships at autonomy levels RU and A, the obligation to “*identify and open or uncover all accessways to cargo, spaces and hiding places*” stipulated in section 17(1) of the customs act would present a barrier. To the extent that the shipowner could authorise a local port representative or agent to perform this obligation and be available to the customs authorities while the ship is in port, this would presumably be a solution in practice.

4.4 Navigation and regulations for preventing collisions at sea

4.4.1 COLREG – Requirements for human control and simultaneous decision competence

In general, shipping regulation is founded on the fundamental principle that ships are controlled by human beings in all respects and that navigation decisions are based on a seamanlike professional assessment of the specific situation.

This general principle can be deduced from COLREG⁵⁶, especially regulation 2 on the precedence of ordinary seamanship to the detailed navigational provisions of COLREG as well as COLREG regulation 5 (on lookout), regulation 6 (on safe speed) and regulation 8 (on precautions to be taken to avoid collisions).

COLREG regulation 2 (our emphasis):

“(a). Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

“(b). In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger”

This analysis is based on the assumption that what is central in COLREG is the *simultaneous human decision competence*⁵⁷. In other words, it is decisive *who* steers the ship rather than *from where* it is being steered. Furthermore, it is decisive that decisions are taken in real time (simultaneously) and are not an expression of pre-programmed choices. It cannot be presumed that COLREG contains an inherent obligation for navigation decisions to be taken on board ships, though this was the only possibility when COLREG was developed. The functions and purpose of COLREG is to provide guidelines and common parameters for navigation decisions, recognising that decisions will always be based on an assessment of specific circumstances. As long as navigation decisions are taken by human beings, they could be made in accordance with COLREG irrespective of *where* the decisions are made, naturally on the condition that it is possible to get a sufficient decision basis (situational awareness) from the location from where the human control and decision competence are exerted. What is decisive in COLREG is the *functions* required by the various regulations, rather than the place from where the functions are performed unless they can be performed only from a specific physical place.

Regulation 5 of COLREG on lookout is of the utmost importance as regards autonomous ships. The provision has the following wording:

⁵⁶ COLREG has been transposed into Danish law through the order on regulations for preventing collisions at sea (order no. 1083 of 20 November 2009).

⁵⁷ See also the CMI Position Paper, p. 20: “(...) *the IMO Regulations, in particular SOLAS, the STCW and the COLREG, make it clear that contemporaneous human involvement in the decision-making process is essential, even if on-board attendance is not always.*”

“Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.”

Regulation 5 explicitly mentions that, in connection with lookout, both sight and hearing must be used (*“a proper look-out by sight and hearing”*). The use of the word *“appropriate”* leaves some discretion to the navigating officer of the watch.

In addition, the abstract norm *“by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision”* is added.

Especially English law contains a rather extensive legal practice related to the use of *“all available means”*, particularly in relation to the use of radar⁵⁸.

To the extent that it is technically possible to replace the human sight and hearing by cameras, sensors, radars or other technical means (electronic lookout), the first part of COLREG regulation 5 (*“a proper look-out by sight and hearing”*) could be met electronically without human involvement as long as the electronic solution corresponds, as a minimum, to the human sight and hearing and provides the same safety level. This is supported by the presupposition in regulation 5 that *“all available means”* (in addition to *“sight and hearing”*) must be used. It cannot be presumed that COLREG regulation 5 is a hindrance to the use of technological means for lookout as long as these means correspond to human sight and hearing, as a minimum. This is supported by the fact that, already today, the use of radar (including radar plotting), VTS (Vessel Traffic Service) and AIS (Automatic Identification System) are considered as using *“all available means”*.

The second part of regulation 5 presupposes, however, a simultaneous human decision competence since it refers to *“a full appraisal of the situation and of the risk of collision”*.

Should future technology make it possible for ships to communicate directly with each other and coordinate their course/speed etc., it would be a technological level that COLREG regulation 5 does not take account of. Anti-collision systems as those used in air traffic would require new international regulation.

4.4.1.1 Autonomy levels R and RU

Remotely controlled ships with or without manning (autonomy levels R and RU) could meet the fundamental principle of human control and simultaneous decision competence of COLREG to the extent that a human being is remotely controlling the ship in real time and taking navigation decisions.

If it is possible to reach international support for the above interpretation, it will not be necessary to make amendments to COLREG as regards autonomy levels R and RU.

New regulation will be needed in relation to:

(i) Technical requirements for electronic lookout, remote control and communication and network systems, including requirements for latency, redundancy and prevention as well as preparedness in case of ship communication failure (presumably as a part of SOLAS).

(ii) A special assessment of the operational risk management for remotely controlled ships should be included as a part of shipowners' Safety Management System under the ISM Code.

⁵⁸ The *Anneliese* [1970] 2 All ER 29; [1970] 1 Lloyd's Rep 355; The *Maritime Harmony* [1982] 2 Lloyd's Rep 400, The *Nordic Ferry* [1991] 2 Lloyd's Rep 591, The *Maloja II* [1993] 1 LR 48, as well as Carey p. 11.

- (iii) Educational and qualification requirements for the remote operator (using the structure of the STCW Code, if relevant).
- (iv) Principles of changes to the navigation obligation.

4.4.1.2 Autonomy level A

Fully autonomous ships, which are self-steering according to pre-programmed algorithms of choices and considerations (autonomy level A) could hardly meet the requirements for human control and simultaneous decision competence stipulated in COLREG.

As possible solution proposals, it has been considered whether autonomous ships at level A could be considered “*not under command*” or “*restricted in her ability to manoeuvre*” according to COLREG regulation 3, thereby obliging all other ships to “*keep out of her way*”⁵⁹. It is our assessment that a ship at autonomy level A that is capable of navigating cannot be considered “*not under command*” though the ship is not steered by a *simultaneous* human decision competence, but on the basis of pre-programmed choices.

The purpose of a current UK-based research project entitled “Machine executable collision regulations for Marine Autonomous systems (MAXCMAS)” is to examine, develop and implement “*real-time collision avoidance algorithms for autonomous maritime vessels*”⁶⁰. When this analysis was finalised (on 30 November 2017), no results had been published from the project yet. Several other parties have also mentioned the possibility of using artificial intelligence and machine learning to achieve algorithms that could simulate human decision making according to COLREG. However, this requires that the algorithms can reflect human intuition, common sense and seafarers’ experience if the provisions of COLREG are to be met.

Rather than to seek to develop algorithms adapted to COLREG (presupposing simultaneous human decision competence), we recommend the drafting of new international regulations for preventing collisions at sea for autonomous ships at level A. New regulations must take account of the fact that the ships are not subject to simultaneous human decision competence, but will act according to pre-programmed choices and considerations. Such regulations for preventing collisions at sea, as described under paragraph (iii) below, can have the form of an annex to COLREG applicable only to ships at autonomy level A.

Ethical considerations

Considering the ethical dilemmas related to fully autonomous ships, ethical guidelines must be laid down internationally for the programming of fully autonomous ships’ algorithms and prioritisation of protective considerations.

Steering via pre-programmed algorithms raises the overall question how much and which decision competence should be left to systems and pre-programmed choices.

The co-existence of autonomous systems and non-autonomous systems should be considered ethically.

A report was published in June 2017 by an ethical committee established by the German Federal Minister for transport and digital infrastructure which considers ethical requirements for autonomous vehicles.⁶¹ Since the issues related to autonomous vehicles are, to a wide extent, comparable to those related to autonomous ships at level A, it would be natural to seek

⁵⁹ See Carey, p. 13.

⁶⁰ The project participants are Rolls-Royce, Lloyds Register, Atlas Elektronik UK, Queen’s University Belfast and Southampton Solent University’s Warsash Maritime Academy. For more about this issue see: Wasif Naeem, George W Irwin, Aolei Yang, ‘COLREG-based collision avoidance strategies for unmanned surface vehicles’ (2012) 22 Mechatronics 669 as well as Sable Campbell, Mamun Abu-Tair and Wasif Naeem, ‘An Automatic COLREG-complaint obstacle avoidance system for an unmanned surface vehicle’, (2014) 228(2) Journal of Engineering for the Maritime Environment 108, 110 as well as Carey, Luci, pp. 13 ff.

⁶¹ Report on Automated and Connected Driving.

inspiration from this report. The report lists 20 overall ethical regulations and principles of "automated and connected vehicular traffic"⁶².

In addition to the required new regulation for autonomy levels R and RU, new regulation of the following other areas will be needed for ships at autonomy level A:

- (i) The prioritisation of protective considerations/navigation decisions when programming autonomous ships at level A on the basis of ethical considerations.
- (ii) Definition and indication of which types of decisions should be left to human beings.
- (iii) Regulations for navigation/regulations for preventing collisions at sea and regulations for signalling/communication between fully autonomous ships and ships at lower autonomy levels as well as between fully autonomous ships.

It will be necessary to regulate who has the navigation obligation at any time (and thus both the criminal and civil liability) for autonomous ships at levels R, RU and A and to lay down procedures for how to change the navigation obligation in an environment with dynamic levels of autonomy. Section 4.8 below contains an analysis of the possible changes in liability that will be the result of moving navigation decisions and control of the ship from one master locally on board the ship (autonomy level M) to a remote operator (autonomy levels R and RU) and to navigation according to pre-programmed choices/considerations without any simultaneous human decision competence (autonomy level A).

Section 4.5.8 below sheds light on the changed roles of the master and rest of the crew in relation to autonomous ships and the new job functions that are expected to arise in the wake of autonomous ships.

4.4.2 Delay and loss of communication link with autonomous ships

At the current technological stage, satellite communication with and data transfer to and from ships from ashore may be subject to delay.

Account must be taken of this before remotely controlled ships (levels R and RU) and fully autonomous ships (level A) can be in compliance with COLREG regulation 6 (on safe speed) and regulation 8 (on precautions to be taken to avoid collisions).

If the communication link is lost, autonomous ships at levels RU and A will be considered "not under command", cf. COLREG regulation 3(f), and there will be an obligation to be able to act in accordance herewith in terms of navigation under COLREG regulation 18 (on ships' obligations vis-à-vis each other) and to display light signals as a ship not under command according to COLREG regulation 27(a). In case the communication link to shore is lost, it will be possible to navigate autonomous ships at level R locally from on board the ship, and thus the ship will not be considered "not under command".⁶³

4.4.3 Periodically unmanned (physical) bridge

Periodically unmanned (physical) bridges on board ships may enhance the safety level by countering fatigue, while facilitating better use of the crew and liberating resources for tasks other than navigation. This would be of interest to more or less all types and sizes of ships.

However, constant manning of a ship's physical bridge is a cornerstone of the navigation rules applicable to ships. Below, it is analysed whether it is possible to periodically have an unmanned physical bridge within the existing international regulatory frame.

⁶² Report on Automated and Connected Driving, pp. 10-13.

⁶³ Carey pp. 14 ff.

The STCW Code, section A-VIII/2, Part 3-2, regulation 64, contains the legal basis for the machinery space on board a ship being periodically unmanned. It follows from regulation 64 that the appointed engineer officer of the watch must be immediately available for being called to the machinery space.

In relation to autonomous ships, this gives rise to considering the possibilities of having a periodically unmanned bridge under current regulations.

COLREG regulation 5 and the possibilities of electronic lookout, as described above in section 4.4.1, are central in terms of the possibilities of having a periodically unmanned bridge.

Furthermore, the STCW Code contains bridge watch principles in section A-VIII/2, Part 4-1, which require a more detailed analysis.

Especially regulations 14, 18 and 24 are of relevance in connection with periodically unmanned bridges.

Regulation 14 (our emphasis):

"A proper lookout shall be maintained at all times in compliance with rule 5 of the International Regulations for Preventing Collisions at Sea, 1972, as amended and shall serve the purpose of:

- .1 maintaining a continuous state of vigilance by sight and hearing, as well as by all other available means, with regard to any significant change in the operating environment;*
- .2 fully appraising the situation and the risk of collision, stranding and other dangers to navigation; and*
- .3 detecting ships or aircraft in distress, shipwrecked persons, wrecks, debris and other hazards to safe navigation.*

Regulation 18 (our emphasis):

"When deciding the composition of the watch on the bridge, which may include appropriately qualified ratings, the following factors, inter alia, shall be taken into account:

- .1 at no time shall the bridge be left unattended;*
- .2 weather conditions, visibility and whether there is daylight or darkness;*
- .3 proximity of navigational hazards which may make it necessary for the officer in charge of the watch to carry out additional navigational duties;*
- .4 use and operational condition of navigational aids such as ECDIS, radar or electronic position-indicating devices and any other equipment affecting the safe navigation of the ship;*
- .5 whether the ship is fitted with automatic steering;*
- .6 whether there are radio duties to be performed;*
- .7 unmanned machinery space (UMS) controls, alarms and indicators provided on the bridge, procedures for their use and their limitations; and*
- .8 any unusual demands on the navigational watch that may arise as a result of special operational circumstances."*

Regulation 24 (our emphasis):

"The officer in charge of the navigational watch shall:

- .1 keep the watch on the bridge;*
- .2 in no circumstances leave the bridge until properly relieved; and*
- .3 continue to be responsible for the safe navigation of the ship, despite the presence of the master on the bridge, until informed specifically that the master has assumed that responsibility and this is mutually understood."*

During the watch, the navigating officer is obliged to make sure that the operating state of on-board navigation equipment is tested *“as frequently as practicable and as circumstances permit, in particular before hazardous conditions affecting navigation are expected. Whenever appropriate, these tests shall be recorded. Such tests shall also be carried out prior to port arrival and departure”*, cf. the STCW Code, section A-VIII/2, Part 4-1, regulation 33.

Furthermore, the navigating officer must carry out regular controls to ensure that:

*“.1 the person steering the ship or the automatic pilot is steering the correct course;
 .2 the standard compass error is determined at least once a watch and, when possible, after any major alteration of course; the standard and gyro-compasses are frequently compared and repeaters are synchronized with their master compass;
 .3 the automatic pilot is tested manually at least once a watch;
 .4 the navigation and signal lights and other navigational equipment are functioning properly;
 .5 the radio equipment is functioning properly in accordance with paragraph 86 of this section;
 and
 .6 the UMS controls⁶⁴, alarms and indicators are functioning properly”*, cf. the STCW Code, section A-VIII/2, Part 4-1, regulation 34.

During the watch, the navigating officer of the watch must, furthermore, take consideration of:

*“.1 the need to station a person to steer the ship and to put the steering into manual control in good time to allow any potentially hazardous situation to be dealt with in a safe manner; and
 .2 that, with a ship under automatic steering, it is highly dangerous to allow a situation to develop to the point where the officer in charge of the navigational watch is without assistance and has to break the continuity of the lookout in order to take emergency action.”*, cf. the STCW Code, section A-VIII/2, Part 4-1, regulation 35.

Section A-VIII/2, Part 4-1, regulations 34 and 35, of the STCW Code implies that it is possible to use the self-steering function/automatic steering without this surrender of human steering being contrary to STCW, COLREG, SOLAS or any other international shipping regulations. It is, in a way, possible to consider a periodically unmanned bridge an extended self-steering function, with the important difference that the functions performed today by the navigating officer during the watch from the ship’s bridge (especially lookout under COLREG regulation 5 and control of navigation and navigation equipment under the STCW Code, section A-VIII/2, Part 4-1, regulation 33) will have to be performed from another place than the ship’s physical bridge when the bridge is periodically unmanned.

The requirements for the manning of a ship’s bridge under the STCW Code, section A-VIII/2, Part 4-1 (especially regulations 14, 18 and 24 cited below) imply – according to an interpretation of the purpose – that the *functions* related to the ship’s bridge must be manned and that the ship’s navigation must always be monitored by a human being capable of intervening immediately.

If it is technically possible to change the bridge watch from the ship’s physical bridge to an “electronic bridge” somewhere else with the same or better functionality, it is our conclusion that it would presumably be compatible with COLREG and the STCW Code if the ship’s physical bridge is periodically unmanned (autonomy level M). This is true in case of a change of the bridge watch to an electronic bridge ashore or below deck. The provisions on changes of the watch stipulated in the STCW Convention and the STCW Code must be met in connection with such changes. The navigating officer cannot leave the physical bridge on the ship without surrendering the bridge watch to another person with the qualifications needed to perform the same functions with simultaneous decision competence. Thus, it is not possible for the navigating officer to leave the bridge and to be “on call” from the ship’s navigation system according to current regulations.

⁶⁴ Equipment for remote operation.

If it is technically possible with an equivalent safety level and functionality to perform the functions related to the ship's bridge from a location other than the ship's physical bridge (an "electronic bridge") under human surveillance, the bridge must be presumed to be "manned" under the STCW Code and, thus, to be in compliance with current regulations.

On the other hand, it cannot be presumed to be in compliance with COLREG (especially regulation 5) that the ship's physical bridge is unmanned if there is not a person in some other place who performs the functions that the navigating officer performs on the ship's physical bridge during the watch and who is capable of intervening immediately. This will present a barrier to ships at autonomy level A.

Furthermore, the technical provisions on bridge design stipulated in SOLAS must be met when designing the electronic bridge, especially SOLAS chapter V, regulation 15, on "*Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures*" (our emphasis):

"All decisions which are made for the purpose of applying the requirements of regulations 19, 22, 24, 25, 27, and 28 of this chapter and which affect bridge design, the design and arrangement of navigational systems and equipment on the bridge and bridge procedures shall be taken with the aim of:

- .1 facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions;*
- .2 promoting effective and safe bridge resource management;*
- .3 enabling the bridge team and the pilot to have convenient and continuous access to essential information which is presented in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays;*
- .4 indicating the operational status of automated functions and integrated components, systems and/or sub-systems;*
- .5 allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot;*
- .6 preventing or minimizing excessive or unnecessary work and any conditions or distractions on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot; and*
- .7 minimizing the risk of human error and detecting such error if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action."*

SOLAS chapter V, regulation 15, will present a barrier to fully autonomous ships (level A) since it presupposes – just like COLREG – that there must be human surveillance and a possibility of taking over the steering of the ship and making a "*full appraisal of the situation*".

SOLAS chapter V, regulation 22, on the requirements for the visibility and visual field from the wheelhouse will also have to be met by an electronic bridge.

A special challenge will remain in relation to the STCW Convention, chapter VIII, regulation 2(2)(1), which contains an obligation for flag States to ensure that the master ensures that the watchkeeping navigating officer is (our emphasis) "*physically present on the navigating bridge or in a directly associated location such as the chartroom or bridge control room at all times*". If it is to be possible to have periodically unmanned bridges in international waters, this provision needs to be amended, thus enabling the watchkeeping navigating officer to periodically be located somewhere else on board the ship.

Furthermore, SOLAS chapter II-I, regulation 37, on communication between the navigation bridge and the machinery space presupposes that there are two independent means of

communication between the physical navigation bridge and the machinery space. The provision will present a barrier to all autonomy levels since it does not allow for the use of an electronic bridge. The provision will have to be amended to make it possible to use an electronic bridge. Regulations requiring several types of communication links will also be essential in relation to an electronic bridge.

4.4.3.1 Conclusions – Autonomy levels M, R and RU

Clarification of understanding and interpretation

A common understanding and interpretation of the regulatory requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) in relation to autonomous ships at levels M, R and RU must be acquired within the IMO.

Amendment of existing regulation

Chapter VIII, regulation 2(2), of the STCW Convention must be amended to make it possible for watchkeeping navigating officers to periodically be located somewhere else on board the ship.

SOLAS chapter II-I, regulation 37, must be amended to make it possible to use an electronic bridge. It will also be essential to regulate the requirements for several types of communication links in relation to an electronic bridge.

New regulation

New regulation is required in relation to:

- (i) Technical requirements for equipment making electronic lookout and an electronic bridge possible, such as cameras, sensors, communication and network systems as well as equipment making it possible to log who has the bridge watch.
- (ii) Requirements for the design and construction of electronic bridges.
- (iii) Educational, qualification and certification requirements for operators (navigating officers) of electronic bridges.
- (iv) Principles of changes of the bridge watch.

4.4.3.2 Conclusions – Autonomy level A

The regulation of requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) presupposes human control and simultaneous decision competence.

Especially COLREG regulation 5 as well as SOLAS chapter V, regulation 15, will in this connection present a barrier to fully autonomous ships (level A).

Ships at autonomy level A, which are steering according to pre-programmed algorithms as regards the prioritisation of choices and considerations, will not meet the requirement for human control and simultaneous decision competence.

New regulation

In addition to the required new regulation for autonomy levels M, R and RU in relation to periodically unmanned (physical) bridges and generally in relation to COLREG (see sections 4.4.1 and 4.4.2), new regulations of the following additional areas will be needed for ships at autonomy level A:

- (i) Technical requirements for recognition and assessment of objects/conditions at sea.
- (ii) Definition and indication of which types of decisions must be left to human beings.

4.4.4 Pilotage

To the extent that shore-based pilotage will be technically possible and give the pilot the same “situational awareness” from the electronic bridge as from the physical bridge, there are no regulatory barriers in international regulation. This presupposes that it is regulatorily possible to remotely control ships from an electronic bridge, cf. the requirements in sections 4.4.1 to 4.4.3 above.

However, pilotage is subject to varied national regulation in the individual coastal and port States. For autonomous ships, it will be important that national and local regulations on pilotage and mandatory pilotage do not prevent autonomous ships from calling at ports. For example, each US state establishes its own regulations on pilotage and mandatory pilotage.

Ships at autonomy levels M and R will presumably not present great challenges since the on-board crew could perform the navigation obligation during port calls and act according to advice from a local pilot in case of mandatory pilotage.

For ships at autonomy levels RU and A, pilotage could, however, have the form of shore-based pilotage or, alternatively, exemption from mandatory pilotage only if the national authorities in the port State that the ship calls at can accept that the ship is remotely controlled from the quay by the remote operator. To the extent that national or local regulation does not allow for shore-based pilotage or exemption from mandatory pilotage, this could limit the trade area of autonomous ships and present a regulatory barrier. Consequently, international regulations on shore-based pilotage should be laid down within the IMO, especially related to the requirements for the pilot’s access to the ship’s electronic bridge (through the use of an electronic certificate) and requirements for redundancy and safety in the communication link.

It is our recommendation that the same navigation obligation (and responsibility) as that of a traditional master be regulatorily imposed on the remote operator and that the pilot’s assistance in case of shore-based pilotage solely be in the form of consultancy, just as is the case for pilots today. The remote operator will be responsible for navigation decisions. For fully autonomous ships (level A) subject to mandatory pilotage, the operation must be presumed to change to level RU with a remote operator taking over the navigation obligation (and thus the responsibility) with the pilot as an adviser. It is difficult to imagine that the pilot alone will have control of a ship at autonomy level A and thereby assume the related responsibility.

In relation to liability, it must be presumed under Danish law that the pilot’s liability would be the same in the case of shore-based pilotage as in the case of pilotage with the pilot physically on board a ship. The basis of the liability will be professional liability subject to the ordinary compensation conditions⁶⁵ of Danish law. The shipowner will be liable for the pilot’s fault and neglect under section 151(1) of the merchant shipping act. The pilot will be entitled to limitation of liability pursuant to the Convention on Limitation of Liability from 1976 (see more on limitation of liability below in section 4.8.3).

However, shore-based pilotage will presumably give rise to liability issues in many other jurisdictions.⁶⁶

SOLAS chapter V on safety of navigation contains, in regulation 23, requirements for pilot embarkation arrangements. The provisions have been drafted for the pilot’s physical access to the ship while at sea. To the extent that it will be possible to pilot autonomous ships without the pilot being physically present on board the ship, regulation 23 will need to be interpreted in this light. It must be possible to meet the purpose of the regulation in connection with shore-based pilotage – to provide the pilot access to the ship – by giving the pilot access to the electronic

⁶⁵ Falkanger, Bull and Rosenberg Overby, p. 156.

⁶⁶ See, for example, Carey, pp. 22ff., on liability issues under English law and other common law jurisdictions.

bridge. To the extent that it is technically possible with an equivalent level of safety, the provision will not present a barrier to autonomous ships.

In Danish law, pilotage is regulated by the pilotage act⁶⁷. Section 3(viii) defines pilotage as:

"advice given to the ship's master about navigation, the voyage and manoeuvring irrespective of whether the advice is provided on board the ship or by means of communication from another ship or from ashore." The same definition is included in the order on the issue of pilot certificates and pilotage exemption certificates, section 1(vi).

Furthermore, section 15 of the pilotage act contains the legal basis for the Danish Maritime Authority's stipulation of more detailed regulations on *"tests with and any establishment of shore-based pilotage"*. Thus, it is presupposed that pilotage can take place without the pilot being physically on board the ship. The pilotage act and the associated order on the issue of pilot certificates and pilotage exemption certificates thus do not present a barrier to autonomous ships irrespective of their autonomy level. However, as autonomous ships are gaining ground, it must be assessed what could be considered *"relevant navigation"* and *"voyage frequency"* in terms of pilots' experience, including whether steering of a ship from ashore on the basis of *"situational awareness"* could be considered navigational experience under the pilotage act.

Section 14 of the pilotage act contains provisions on pilotage exemptions for *"navigating officers with extensive knowledge about both the waters and the ship or type of ship"*.

4.4.5 Special regulations for preventing collisions in Danish waters

In addition to COLREG, which also applies to Danish and Greenland inner waters and territorial waters,⁶⁸ special regulations for preventing collisions apply in certain Danish waters according to the order on regulations for navigation, etc. in certain Danish waters.⁶⁹ The order contains special requirements on signalling (light and sound signalling and flagging) as well as on the use of the propeller, speed and the obligation to keep clear in special fairways and channels. Furthermore, section 11(5) of the order contains an obligation for the master to observe the navigational instructions given by the *"local harbour master"* under icy conditions. To the extent that it would be technically possible for autonomous ships at autonomy levels R and RU to meet these obligations (including the possibility of the local harbour master to get in contact with the master of a remotely controlled ship at autonomy level RU), the special Danish regulations for preventing collisions at sea will not present a barrier to autonomous ships at autonomy levels R and RU. However, the provisions presuppose – just like COLREG – that there is simultaneous human decision competence and that a seamanlike assessment is made of the specific situation. Thus, the regulations will present a barrier to autonomy level A.

In certain Danish waters, it is furthermore prohibited to navigate, anchor and fish.⁷⁰ The regulation hereof cannot be presumed to present special barriers to autonomous ships.

4.4.6 Reporting obligations (EU regulation and Danish law)

The regulation of Danish waters contains special reporting obligations for ships passing the Sound and the Drogden Channel (SOUNDREP)⁷¹ and the Great Belt (BELTREP)⁷². The regulations require passing ships to report via VHF to calling stations when they enter the reporting areas. The reports must contain certain information, including the ship's name, call sign and IMO number, position, course, speed, destination and ETA, draught, cargo, height (if above 35 metres), size of

⁶⁷ Consolidated act no. 352 of 12 April 2016.

⁶⁸ The order on regulations for preventing collisions at sea, section 1(2) (order no. 1083 of 20 November 2009).

⁶⁹ Order no. 779 of 18 August 2000.

⁷⁰ Cf. order no. 135 of 4 March 2005 on prohibitions against navigation, anchoring and fishing, etc. in certain areas in Danish waters.

⁷¹ Cf. order no. 924 of 25 August 2011 on the ship reporting system SOUNDREP and on reporting when passing the Drogden dredged channel for ships the height of which exceeds 35 metres.

⁷² Cf. order no. 820 of 26 June 2013 on the ship reporting system BELTREP and navigation under the East Bridge and the West Bridge in the Great Belt.

manning and type and quantity of bunkers on board. This information can be reported via AIS. However, ships are required to make a VHF call to report the ship's name as well as entry of the reporting area. Furthermore, the ships are obliged to keep a continuous listening watch on the relevant work channel as well as channel 16. The provisions presuppose that there is a person who is in control of the ship who could make the necessary reports via VHF and keep a continuous listening watch. It must be presumed that these obligations can be performed by a person who is in control of the ship irrespective of whether this person is on board the ship or not. Thus, the reporting obligation will not present a barrier to autonomous ships at levels M, R and RU. The reporting obligations will present a barrier to autonomy level A. The solution will presumably be to amend regulation to allow for automatic reports in digital format.

In addition to a reporting obligation in the Sound and the Great Belt, EU regulation contains reporting obligations for ships calling at the territorial waters of the EU member States. The purpose of the EU regulation is to enhance navigational safety and the authorities' possibility of reacting in case of accidents, incidents or dangerous situations at sea. The EU regulation is stipulated in directive 2002/59/EC of the European Parliament and the Council establishing a traffic monitoring and information system for shipping in the Community, as amended by directive 2009/17/EC of the European Parliament and of the Council. The directive has been transposed into Danish law through the order on technical regulation on a traffic monitoring and information system in Danish waters and ports⁷³. The order imposes a number of reporting obligations on masters of ships flying the Danish flag and calling at a port in a member States as well as ships flying foreign flags with a gross tonnage of or above 300 tonnes calling at Danish inner and outer territorial waters, cf. sections 4 and 5 of the order.

The information concerns a. identification (name, call sign, IMO identification number or MMSI number of the ship), b. port of destination, c. estimated time of arrival at the port of destination, d. estimated time of departure for the port of destination and e. the number of persons on board. For high-risk ships that may be subjected to an expanded inspection under article 14 of directive 2009/16/EC of the European Parliament and of the Council on Port State Control, additional information is required to be reported on the nature and extent of the cargo as well as the ship's condition and planned mandatory ship surveys and maintenance and repair work to be performed during the stay in port.

Considering the purpose of the reporting obligations, it must be possible for the remote operator to meet the obligation for ships at autonomy levels R and RU though the wording only mentions the master. To the extent that ships at autonomy level A are technically capable of identifying accidents and incidents at sea so that it is possible to make reports, the regulation will not present a barrier to autonomy level A. The reporting must be presupposed to be made either directly from the fully autonomous ship in digital format or via a remote operator.

With effect from 1 June 2015, the order on technical regulation on a traffic monitoring and traffic information system in Danish waters and ports is amended⁷⁴ so that the reporting obligation under sections 4 and 5 of the order are now to be made electronically via SafeSeaNet⁷⁵ to the Admiral Danish Fleet (today the Naval Staff under Defence Command Denmark). The amendment is made on the basis of directive 2010/65/EC of the European Parliament and of the Council on the reporting obligations of ships, which stipulates in article 5 that "*Member States shall accept the fulfilment of reporting formalities in electronic format and their transmission via a single window as soon as possible and in any case no later than 1 June 2015.*" Directive 2010/65/EC of the European Parliament and of the Council on reporting formalities for ships does not contain any barriers to autonomous ships since article 4 of the directive stipulates that the reporting

⁷³ Order no. 1021 of 26 August 2010, as amended by order no. 417 of 9 May 2012.

⁷⁴ See order no. 417 of 9 May 2012, amending section 6 of the order.

⁷⁵ SafeSeaNet is the EU maritime information exchange system, which has been developed by the Commission in cooperation with the member States. The network consists of the national SafeSeaNet systems as well as a central EU SafeSeaNet system that functions as a junction.

obligation can be met by (our emphasis) *“the master or any other person duly authorised by the operator of the ship”*.

The order on technical regulation on a traffic monitoring and traffic information system in Danish waters and ports contains – with its legal basis in directive 2002/59/EC, article 17 – special obligations for ships in Danish waters to report accidents and incidents at sea that impair the safety of the ship or the voyage as well as observations of drifting objects on the sea (section 12) and to forward information – in case of accidents – on dangerous goods (section 15). Neither of these reporting obligations presupposes the master’s physical presence on board the ship. Thus, they will not present barriers to autonomous ships at autonomy levels M, R and RU as long as the obligations can be performed from somewhere else. To the extent that ships at autonomy level A are technically capable of identifying the mentioned accidents and incidents at sea so that it is possible to make reports, the regulation will not present a barrier. It must be presupposed that reports can be made either directly from the fully autonomous ship in digital format or via a remote operator.

Furthermore, the order contains – on the legal basis of article 18 of directive 2002/59/EC and respecting international law – the legal basis for the Danish Maritime Authority to prohibit navigation or to ban ships from calling at/leaving ports in case of adverse weather conditions (section 13). If a ship is involved in an accident at sea and there is an imminent risk to Denmark’s coasts or the safety of the ship or persons, the Danish Maritime Authority is also authorised to order the master to 1) use a specific route, 2) put an end to the risk to safety at sea, and 3) seek a place of refuge, or 4) form an evaluation team on board to assess the extent of the risk, assist the master in remedying the situation and keeping the authorities informed (section 16).

To the extent that there is a master or a remote operator who could receive an order from the authorities and react to it, autonomous ships at all autonomy levels must be presumed to be able to meet the obligations stipulated in the order irrespective of whether the master is physically present on board the ship.

4.5 Manning and “seafarers” of the future

4.5.1 Requirements in international regulation for the manning of ships

This section analyses the international regulation of manning levels stipulated in UNCLOS and SOLAS, respectively.

UNCLOS art. 94

Under article 94(3) of UNCLOS, the flag State is obliged to:

“take such measures for ships flying its flag as are necessary to ensure safety at sea with regard, inter alia, to:

- (a) the construction, equipment and seaworthiness of ships;*
- (b) the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments;*
- (c) the use of signals, the maintenance of communications and the prevention of collisions”.*

Article 94(4)(b) of UNCLOS stipulates that this involves, inter alia (our emphasis):

“that each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship”

Two requirements can be deducted from article 94(4)(b) of UNCLOS:

(1) All ships must be under the command of a master and officers with the appropriate qualifications.

(2) The crew must be appropriate (in terms of number and qualifications) in relation to the relevant ship's type, size, machinery and equipment.

The first requirement necessitates a more detailed analysis of the concept "*in the charge of a master and officers who possess appropriate qualifications (..)*". A fully autonomous ship (level A) without human involvement in navigation and steering could not meet the requirement to be "*in the charge of a master and officers who possess appropriate qualifications*". Article 94(4)(b) does not stipulate whether the master or the officers must be on board the ship. What is decisive, however, seems to be that one or more persons with "*appropriate qualifications*" are "*in charge*".

Ships at autonomy levels M, R and RU must still be considered to be "*in charge of a master and officers who possess appropriate qualifications*" to the extent that a human being (a master or navigating officer) holding the necessary qualifications is in control of the ship, irrespective of whether he is on board the ship or somewhere else.

A fully autonomous ship (level A) without human involvement in navigation and steering will, on the other hand, not be in compliance with article 94(4)(b) of UNCLOS. It will be necessary to amend article 94(4)(b) of UNCLOS if the provision is not to present a barrier to ships at autonomy level A.

In connection with a periodically unmanned (physical) bridge, cf. section 4.4.3 above, it must be presumed that what is decisive in terms of whether the ship is "*in the charge of a master and officers who possess appropriate qualifications*" is whether an appropriately qualified human being with simultaneous decision competence is monitoring the ship and capable of intervening immediately though there is nobody in command on the physical bridge of the ship. When using a periodically unmanned bridge, it could change who is "*in charge*", depending on who has the bridge watch and thus the possibility of exerting simultaneous decision competence. As long as a person can always be identified as the one in command of the ship, a shift in the command cannot be presumed to be contrary to the obligations of UNCLOS, article 94(4)(b).

The requirement contained in the second part of the provision that "*the crew is appropriate in qualification and numbers*" leaves much room for a specific assessment. To the extent that it can be validated that an autonomous ship is – according to its type, size, machinery, equipment and voyage plan – capable of operating without manning, nothing prevents an appropriate manning level to be zero. It cannot be presumed that the provision presupposes that there must always be a crew on board if the ship is capable of operating safely without an on-board crew.

Under article 94(5) of UNCLOS, the flag State must take account of "*generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance*" in connection with compliance with the requirements of article 94(4)(b). If other international regulation is adapted to ships at autonomy level A, it could be argued – referring to the principle of article 94(5) – that article 94(4)(b) of UNCLOS will not present a barrier since it would be contrary to "*generally accepted regulations, procedures and practices*". Considering the fundamental nature of UNCLOS, it is however our recommendation that article 94 of UNCLOS be amended to expressly allow for ships at autonomy level A.

[SOLAS chapter V, regulation 14](#)

SOLAS also contains regulations on the manning of ships. SOLAS chapter V, regulation 14(1)⁷⁶ has the following wording:

⁷⁶ Transposed into Danish law through the order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships (order no. 377 of 4 May 2009).

“Contracting Governments undertake, each for its national ships, to maintain, or, if it is necessary, to adopt, measures for the purpose of ensuring that, from the point of view of safety of life at sea, all ships shall be sufficiently and efficiently manned”.

Whether a ship is “sufficiently and efficiently manned” will naturally depend on a specific assessment by each flag State. In this connection and considering the wording of the provision and the purpose of SOLAS, what is decisive will be whether autonomous ships at autonomy levels RU and A can be unmanned from “the point of view of safety of life at sea”. Here, the overall principle of SOLAS chapter I, regulation 5, on equivalence will presumably be decisive (see section 4.7.1 below). Thus, ships at autonomy levels RU and A will have to demonstrate their ability to offer at least the same safety level when unmanned as that of manned ships to be in compliance with SOLAS chapter V, regulation 14(1). If it is safe and sound considering the type of ship and its technical equipment for the ship to operate with a little crew or without a crew at all, this is possible according to the wording of regulation 14. According to its wording, regulation 14 does not require a minimum safe manning.

According to part B, regulation 4.28,⁷⁷ of the ISPS Code, flag States must take account of any extra working load which implementation of the ship’s security plan may result in and ensure that the ship is also in this context “sufficiently and efficiently manned”. Reference is also made to section 4.9.5.1 below on the ISPS Code.

Summary

Neither UNCLOS article 94(4)(b) nor SOLAS chapter V, regulation 14(1), changes the fact that safe manning levels are subject to the flag State’s subjective assessment as regards when a ship’s manning is “appropriate in qualification and numbers” and the ship can be considered “sufficiently and efficiently manned”. The approach of flag States to safe manning levels differs much. Some flag States make a specific assessment on the basis of the shipowner’s recommendation/application, whereas other flag States define minimum manning levels for different types and sizes of ships.⁷⁸ It must be presumed that flag States’ different approach to safe manning levels could in itself present a regulatory barrier.

It will be necessary to consider whether to lay down new technical safety requirements for ships at autonomy levels RU and A in SOLAS, taking account of unmanned ships. Reference is made especially to section 4.5.2 on emergency equipment and section 4.7 in general.

Furthermore, reference is made to section 4.5.5 on MLC, regulation 2.7, which also contains regulations on safe manning levels.

4.5.2 Obligation to assist persons in distress at sea

Considering the dangers that have always been related to shipping, it is a fundamental maritime principle that seafarers are obliged to assist persons in distress at sea to the extent that it will not compromise the safety of the ship, its crew or passengers.

In relation to autonomous ships, this raises the question whether there is an obligation to maintain a certain manning level or whether there will be certain structural restrictions on the ability to meet the obligation to offer assistance to persons in distress at sea.

The obligation to assist persons in distress at sea should be considered in relation to the UN Human Rights Convention and the general obligation to assist fellow human beings in distress, which follows from the criminal law of most jurisdictions. In Danish law, section 253 of the penal code stipulates that it is a criminal act to not “according to ability, assist somebody in apparent danger or take the measures necessitated by the circumstances for rescuing somebody who

⁷⁷ See section 4.9.5.1 on the ISPS Code.

⁷⁸ Carey, pp. 8ff.

seems to be unconscious, or required to take care of persons who are shipwrecked or affected by a similar accident.”⁷⁹ The provision stipulates that it is only a criminal offence if “it is possible for him without causing any special danger or self-sacrifice for himself or others.”

Section 30 of the act on safety at sea also contains a legal basis for imposing penalty:

“If, in the event of a collision or in the event that the ship as a result of its navigation or in a similar way causes damage to another ship or persons or goods on board, and where it may be done without particular danger to the ship itself, its crew and passengers, the master of the ship fails to afford the other ship and its crew and passengers all the assistance possible and necessary to rescue it from the danger that has arisen and if he fails to give the radio call sign, name and home port of the ship as well as the place or the port from which it comes and for which it is bound, the party in question shall be punishable by fine or imprisonment for a term not exceeding 4 months.”

The obligation to assist persons in distress is at the centre of international shipping regulation.

UNCLOS art. 98(1) contains the following provision:

“ 1. Every State shall require the master of a ship flying its flag, in so far as he can do so without serious danger to the ship, the crew or the passengers;

(a) to render assistance to any person found at sea in danger of being lost;

(b) to proceed with all possible speed to the rescue of persons in distress, if informed of their need of assistance, in so far as such action may reasonably be expected of him;

(c) after a collision, to render assistance to the other ship, its crew and its passengers and, where possible, to inform the other ship of the name of his own ship, its port of registry and the nearest port at which it will call.”

SOLAS chapter V (Safety of navigation), regulation 33, regulates the obligations and procedures in case of emergencies⁸⁰.

“1. *The master of a ship at sea which is in a position to be able to provide assistance on receiving information from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so. This obligation to provide assistance applies regardless of the nationality or status of such persons or the circumstances in which they are found. If the ship receiving the distress alert is unable or, in the special circumstances of the case, considers it unreasonable or unnecessary to proceed to their assistance, the master must enter in the log-book the reason for failing to proceed to the assistance of the persons in distress, taking into account the recommendation of the Organization, to inform the appropriate search and rescue service accordingly.*

1-1

Contracting Governments shall co-ordinate and co-operate to ensure that masters of ships providing assistance by embarking persons in distress at sea are released from their obligations with minimum further deviation from the ships' intended voyage, provided that releasing the master of the ship from the obligations under the current regel does not further endanger the safety of life at sea. The Contracting Government responsible for the search and rescue region in which such assistance is rendered shall exercise primary responsibility for ensuring such co-ordination and co-operation occurs, so that survivors assisted are disembarked from the assisting ship and delivered to a place of safety, taking into account the particular circumstances of the

⁷⁹ Section 253(1) of the penal code (consolidated act no. 977 of 9 August 2017, as amended).

⁸⁰ Transposed into Danish law through the order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships (order no. 377 of 4 May 2009).

case and guidelines developed by the Organization. In these cases the relevant Contracting Governments shall arrange for such disembarkation to be effected as soon as reasonably practicable.

2 *The master of a ship in distress or the search and rescue service concerned, after consultation, so far as may be possible, with the masters of ships which answer the distress alert, has the right to requisition one or more of those ships as the master of the ship in distress or the search and rescue service considers best able to render assistance, and it shall be the duty of the master or masters of the ship or ships requisitioned to comply with the requisition by continuing to proceed with all speed to the assistance of persons in distress.*

3 *Masters of ships shall be released from the obligation imposed by paragraph 1 on learning that their ships have not been requisitioned and that one or more other ships have been requisitioned and are complying with the requisition. This decision shall, if possible be communicated to the other requisitioned ships and to the search and rescue service.*

4 *The master of a ship shall be released from the obligation imposed by paragraph 1 and, if his ship has been requisitioned, from the obligation imposed by paragraph 2 on being informed by the persons in distress or by the search and rescue service or by the master of another ship which has reached such persons that assistance is no longer necessary.*

5 *The provisions of this regulation do not prejudice the Convention for the Unification of Certain Rules of Law Relating to Assistance and Salvage at Sea, signed at Brussels on 23 September 1910, particularly the obligation to render assistance imposed by article 11 of that Convention.*

6 *Masters of ships who have embarked persons in distress at sea shall treat them with humanity, within the capabilities and limitations of the ship."*

Furthermore, the Salvage Convention⁸¹ contains in article 10(1) an obligation for the master to render assistance to persons in distress at sea:

"Every master is bound, so far as he can do so without serious danger to his vessel and persons thereon, to render assistance to any person in danger of being lost at sea."

UNCLOS, SOLAS and the Salvage Convention contain an obligation for the master to "render assistance" or "provide assistance". It has not been established in more detail how far these obligations extend.

It must be presumed that the obligation to notify search and rescue services about persons in distress at sea could be met from ashore to the extent that an autonomous ship is fitted with sufficient electronic lookout to register persons in distress. An autonomous ship could also constitute a communication hub in case of a marine accident by remaining close to the scene of the accident. The challenge for autonomous ships is the obligation to physically provide assistance to persons in distress at sea and be capable of rescuing and salvaging persons, ships and goods.

The fact that an autonomous ship is unmanned or only manned with a few persons could hardly exempt the master from the fundamental obligation to provide assistance to persons in distress at sea. There is only a legal basis for such an exception if assisting persons in distress could compromise the safety of the ship or those on board. It could be argued that the obligation for the master to physically provide assistance to those in distress at sea does not extend beyond the technical capabilities of the autonomous ship. In other words, the master (remote operator) is not obliged beyond his ability in relation to the specific ship's special design, equipment and

⁸¹ The IMO International Convention on Salvage, 1989, transposed into Danish law through part 16 of the merchant shipping act on salvage.

arrangement. This interpretation of the purpose is supported by the wording of UNCLOS, article 98(1), and SOLAS chapter V, regulation 33, which stipulates that the master is only obliged if he is *"in a position to be able to provide assistance"*, and *"in so far as such action may reasonably be expected of him"*. Such an interpretation of UNCLOS, article 98(1), and SOLAS chapter V, regulation 33, implies that the provisions will not present a barrier to autonomous ships irrespective of their autonomy level.

Considering the fundamental nature of the obligations, the contents of the provisions must be clarified within the IMO in relation to autonomous ships at levels RU and A so as to acquire a homogeneous protective level internationally. In addition, it will be necessary to introduce new regulation on the requirements for the technical arrangements on board unmanned autonomous ships needed to enable them to provide satisfactory assistance to persons in distress at sea, inter alia in the form of liferafts, emergency rations and other emergency equipment. It will be necessary to include the possibilities of providing assistance into the design of autonomous ships so that unmanned autonomous ships can provide assistance to persons in distress at sea at a satisfactory level that does not differ much from that of fully manned ships (equivalence).

4.5.3 The SAR Convention

The purpose of the SAR Convention⁸² is to lay down obligations for its contracting Parties to provide and coordinate rescue services and emergency assistance at sea. The convention recommends that contracting Parties monitor ships in their territorial waters and establish ship reporting systems for ships to the radio stations of coastal States enabling contracting Parties to quickly localize ships capable of providing assistance to persons in distress at sea. Furthermore, the convention contains obligations for contracting Parties to maintain a listening watch on the internationally recognised radio channels for emergency calls.

The convention does not contain any barriers to autonomous ships.

4.5.4 Stowaways

The FAL Convention⁸³ imposes special obligations on shipowners and masters to secure that stowaways do not get on board ships.

Security arrangements (deck watch in ports and a search of the ship) must be organised to prevent persons from embarking in ports and hiding on board and to ensure that stowaways are easily detected if they succeed in getting on board.⁸⁴

The obligations to maintain an appropriate deck watch in ports with a risk of stowaways⁸⁵ as well as to search the ship for stowaways before leaving the port⁸⁶ will, for autonomous ships at levels RU and A, imply that physical manning is needed in ports to the extent that an appropriate deck watch and search of the ship is not technically possible by means of cameras and sensors.

The provisions of the FAL Convention on human treatment of stowaways at sea, including the master's obligation to secure stowaways *"security, general health, welfare and safety of the stowaway while he/she is on board, including providing him/her with adequate provisioning, accommodation, proper medical attention and sanitary facilities"*⁸⁷ will, according to the wording, present a barrier to autonomous ships to the extent that autonomous ships cannot meet the manning level requirements (autonomy levels RU and A). Furthermore, the requirements will result in restrictions on the possibilities of designing autonomous ships since, in terms of

⁸² International Convention on Maritime Search and Rescue, 1979, as amended.

⁸³ Convention On Facilitation of International Maritime Traffic, 1965, as amended. The provisions of the convention on stowaways have been transposed into Danish law through the order on technical regulation on stowaways in ships (order no. 9269 of 19 May 2003).

⁸⁴ The FAL Convention, Annex, paragraph 4.3, and the order on technical regulation on stowaways in ships, section 4.

⁸⁵ The FAL Convention, Annex, paragraph 4.3.2.2, and the order on technical regulation on stowaways in ships, section 5(1)(iv).

⁸⁶ The FAL Convention, Annex, paragraph 4.3.2.3, and the order on technical regulation on stowaways in ships, section 6.

⁸⁷ The FAL Convention, Annex, paragraph 4.4.2, and the order on technical regulation on stowaways in ships, section 9.

structure, account must be taken of the ability to provide *“provisioning, accommodation, proper medical attention and sanitary facilities”*.

Though the wording of the Annex to the FAL Convention, paragraph 4.4.2, does not provide the legal basis for being exempted from the obligation, it cannot be presumed that the intention has been to extend the obligation beyond what is technically possible for the specific ship. When the provision was developed, it was inconceivable that ships could in the longer term be unmanned (autonomy levels RU and A) and that ships would thus not always be arranged with a possibility to provide *“provisioning, accommodation, proper medical attention and sanitary facilities”* on board. It could be argued that the provision should be interpreted in the light of the possibilities and technical arrangements of the specific ship.

Since the obligations are of a fundamental humanitarian nature, the FAL Convention should be amended to include requirements for the technical arrangement of unmanned autonomous ships (levels RU and A) in order to detect and avoid stowaways on board as well as requirements for which facilities and equipment must be available on board in terms of the provisioning, accommodation, medical attention and sanitary facilities of stowaways who have succeeded in getting on board.

Stowaways covered by the concept of a refugee in the UN Refugee Convention⁸⁸ enjoy special legal protection. When establishing the obligation of unmanned autonomous ships to take care of stowaways under the FAL Convention, consideration must be taken of this, cf. the Annex of the FAL Convention, paragraphs 4.1 and 4.4.

4.5.5 STCW and MLC

The STCW Convention contains (minimum) qualification requirements and standards for masters, officers and other seafarers in terms of education and training, certification (certificates of competency) as well as regulations on watchkeeping schemes and principles. Article 3 of the STCW stipulates that the convention applies only to *“seafarers serving onboard seagoing ships entitled to fly the flag of a Party (...)”*. Thus, according to its wording, the STCW does not apply to remote operators of remotely controlled ships (autonomy level R) and unmanned ships (autonomy levels RU and A).

When the STCW was developed (1978) and subsequently revised, account was not taken of the possibility of ships becoming unmanned in the longer term. However, the obligations imposed on seafarers by the STCW must be presumed to be analogously applied to the persons who will perform similar work functions for autonomous ships as those prescribed in the STCW though these functions will be performed from places other than on board the ship. This assumption is based on the wider purpose of the STCW (*“to promote safety of life and property at sea and the protection of the marine environment”*) and the legal basis laid down in article IX of the Convention for flag States to establish special:

“educational and training arrangements, including those involving sea-going service and shipboard organization especially adapted to technical developments and to special types of ships and trades, provided that the level of sea-going service, knowledge and efficiency as regards navigational and technical handling of ship and cargo ensures a degree of safety at sea and has a preventive effect as regards pollution at least equivalent to the requirements of the Convention”.

The purpose of the MLC is to *“secure the right of all seafarers to decent employment”*, cf. the MLC, art. 1(1). The MLC contains regulations on seafarers’ rights and occupational health as well as the arrangement and quality of the accommodation. According to article 2(2) of the MLC, the

⁸⁸ The UN Convention relating to the Status of Refugees, 1951, as amended (derives from article 14 of the UN World Declaration on Human Rights, 1948), transposed into Danish law through the order on Denmark’s ratification of the convention on the status of refugees signed in Geneva on 28 July 1951 (order no. 55 of 24 November 1954), as amended by the order on the Protocol of 31 January 1967 concerning the legal status of refugees (order no. 21 of 12 February 1968).

convention applies only to “seafarers”. Article 2(1)(f) of the MLC defines a seafarer as “any person who is employed or engaged or works in any capacity on board a ship to which this Convention applies”. On the basis of the definition of a “seafarer”, it must be presumed that the MLC will not apply to autonomous ships at autonomy levels RU and A, but only to ships at autonomy levels M and R. The MLC does not contain any barriers to ships at autonomy levels M and R.

Regulation 2.7 of the MLC contains provisions on safe manning levels (our emphasis):

“Each Member shall require that all ships that fly its flag have a sufficient number of seafarers employed on board to ensure that ships are operated safely, efficiently and with due regard to security under all conditions, taking into account concerns about seafarer fatigue and the particular nature and conditions of the voyage.”

To the extent that unmanned autonomous ships (autonomy levels RU and A) are safe without any manning on board in relation to the other international regulations on safe manning levels (see section 4.5.1), regulation 2.7 of the MLC will not present a barrier to ships at autonomy levels RU and A. The intention behind regulation 2.7 of the MLC is not to lay down special regulations on safe manning levels, but to ensure that the overall purpose of the MLC: “to secure the right of all seafarers to decent employment”⁸⁹ (MLC Art 1(1)) is reflected in the flag States’ safe manning documents. In other words, the protective consideration consists in securing seafarers acceptable conditions of employment if they are on board a ship, and not to regulate whether seafarers are required on board ships. This is supported by MLC standard A.2.7(2) and (3).

4.5.6 The Polar Code

The Polar Code⁹⁰ contains stricter requirements for ships operating in polar areas. They are special structural requirements, protective measures against pollution of the marine environment and special requirements for the manning of ships. The Polar Code is to be considered an extra “layer” of requirements for ships operating in polar region, which are added to the requirements of especially SOLAS, MARPOL and STCW.

Chapter 12 of the Polar Code on “Manning and training” presupposes that ships operating in polar areas are manned. Consequently, the Polar Code will present a barrier to autonomous ships at levels RU and A. Chapter 12 of the Polar Code will need to be amended if it is to be possible to operate unmanned autonomous ships (levels RU and A) in polar areas. Any new regulation must establish which technical solutions can replace the functions of the crew and the safety preparedness.

4.5.7 The concept of a master

Under current international regulation, the master is – together with the shipowner – the central obligated and liable party. This is also the case in terms of civil and criminal law. Criminal law is a national matter. However, all states will have criminal jurisdiction to prosecute masters for breaches of the law committed in their territorial waters. Furthermore, flag States have criminal jurisdiction over masters on ships flying their flag.

Besides having the overall responsibility for the ship’s navigation and seaworthiness, the master is also the flag State’s representative and is entitled to enforce the acts and regulations of the flag State on board the ship. Considering that ships in international trade are often far from the shore, the master’s exercise of authority on board the ship also includes – besides aspects of a purely maritime safety related nature and his managerial function vis-à-vis the crew – authority in relation to, for example, shipwrecked persons, refugees, stowaways and, not least, in relation to the carriage of goods and passengers. Furthermore, the master is the ship’s and the

⁸⁹ MLC art. 1(1).

⁹⁰ The IMO International Code for Ships Operating in Polar Waters, 2015.

shipowner's representative vis-à-vis the authorities of coastal States and port States as well as international authorities.⁹¹

A common denominator across jurisdictions seems to be that a master is:

| | |
|----|---|
| 1. | A physical person |
| 2. | who is responsible for a ship (and any person or thing on board the ship) as well as for the enforcement of the flag State's acts and regulations⁹² |

A number of the master's rights and obligations are related to the fact that ships are manned and that it is practical to always have a person on board the ship who is capable of representing and "signing for" the ship and the shipowner with legally binding effect.

In practice, the master's tasks have already, to a wide extent, been moved to land, and the organisation and operation of most shipowners are taken care of in a cross field between the shore-based organisation and the seafarers. The approach to shipowner activities applied by the ISM Code with the involvement of the entire shipowner organisation and requirements to appoint a "designated person"⁹³ as a link between the seafarers and the shipowner's shore-based organisation is a recognition of this (see section 4.7.8 below).

Autonomous ships will result in further changes of the master's role, especially in relation to ships at autonomy levels R, RU and A.

It must be presumed that a large part of the rights and obligations resting with the master under current regulations could be performed by a remote operator *mutadis mutandis*. This is especially true of the navigation obligation as well as the role as the ship's/shipowner's representative vis-à-vis the authorities and, to some extent, the obligation to take care of the cargo after it has been loaded. However, in connection with a number of obligations, it must be established which requirements will be made on ships at autonomy levels RU and A, considering that the master is not physically present on board the ship. These obligations are mentioned in the individual sub-sections of this section 4 where they belong thematically. Especially the obligations to provide assistance to persons in distress at sea (section 4.5.2) and stowaways (section 4.5.4) deserve to be mentioned here.

With unmanned ships (autonomy levels RU and A), the exercise of authority on behalf of the flag State on board the ship and the managerial authority vis-à-vis the crew (see hereon under Danish law in section 4.5.)) will hardly be of relevance any longer.

In relation to autonomous ships at levels R, RU and A, the responsibility for the ship's seaworthiness should be imposed upon the shipowner rather than on the remote operator. The responsibility must follow the legal entity for which it is possible to ensure compliance with the obligation and to arrange for the company's activities. The remote operator will be responsible for the operation, but does not have any possibility of ensuring the ship's seaworthiness since it will require technical insight that will be embedded with the shipowner as an organisation.

Especially in relation to the carriage of goods, current regulation and the standard documents used (especially bills of lading and charter parties) presuppose that the master acts as the shipowner's representative vis-à-vis the cargo owners. Naturally, it will be necessary for the shipowner to delegate these obligations/functions to others (such as local port agents). It will, for example, not be possible for the remote operator to check the quantity and quality of goods during loading and unloading in different ports. As a consequence of the changed roles, the

⁹¹ Carey pp. 16-22.

⁹² Cartner, Fiske and Leitner, p. 86.

⁹³ Part A, regulation 4, of the ISM Code.

remote operator will hardly have the same right of representation vis-à-vis third parties as that of the master today. The right to represent the shipowner and to conclude agreements on behalf of the shipowner must be presumed to be regulated by the contract concluded between the remote operator and the shipowner. To the extent that a new business area arises for remote operators as independent legal entities, separate from the shipowners and holding the responsibility for a number of ships from various shipowners, it will give rise to separate considerations of liability issues (see section 4.8.3 below on remote operators' liability).

It must be presumed that the obligations and rights resting with the master under current regulation in relation to ships at autonomy levels R, RU and A will presumably be distributed between the remote operator, the shipowner's shore-based organisation (where a "*designated person*" will probably be the key person) as well as local representatives/agents of the shipowner. This will necessitate amendments of existing regulation to the extent that the wording is not so abstract that the delegation of rights and obligations from the master can be included in the existing regulatory frame.

4.5.8 Remote operators

Remote operators will assume a central role in connection with autonomous ships at autonomy levels R, RU and A. At autonomy levels R and RU, the remote operator will exercise simultaneous decision competence, while the remote operator at autonomy level A must be presumed to supervise and be "on call" only in cases where the ship's steering system is requesting human decision-making.

On the basis of COLREG, regulation 2, on good seamanship (section 4.4.1 above), it must be presumed that remote operators will, as a minimum, be required to complete the usual training programme for navigating officers and meet the requirements for this under the STCW Convention.

To this should be added the other competences necessary to steer an autonomous ship, especially education and qualifications within operational technology ("OT") and other relevant technology of importance to the steering of autonomous ships.

An annex should be drawn up to the STCW Convention, regulating the special conditions applicable in relation to qualifications, education, certification as well as watchkeeping schemes and principles for remote operators of ships at autonomy levels R, RU and A so as to acquire international standards. The regulations should be based on an equivalence approach. A special issue to be taken into account is how to replace practical seagoing experience by virtual simulator experience.

Furthermore, it should be considered to make an amendment to the ISM Code that establishes the principles for remote operators. Such regulation could cover organisational and decision structures, means of communication and emergency procedures and should be based on the principles and requirements made in relation to the "*Master's Responsibility and Authority*" in part A, regulation 5, of the ISM Code.

It must be presumed that remote operators will be considered "*masters*" under UNCLOS, article 94(2)(b). Thus, the flag State will have jurisdiction over the remote operator and be able to lay down regulations applicable to the remote operator. The flag State's enforcement vis-à-vis remote operators could, however, give rise to problems to the extent that remote operators are operating from a jurisdiction other than the flag State.

Remote operators will presumably be specialised as either operators with navigating tasks and operators with engineering tasks. In the long term, the operator's role will presumably include both elements of the navigating officer's and the engineer officer's functions. In this connection,

the Danish educational approach with the concept of a “dual officer”⁹⁴ will presumably become more common.

The status of the remote operator under employment law gives rise to considerations. The act on seafarers’ conditions of employment, etc. does not contain a definition of the concept of a “master”. Considering the definition of a “seafarer” in section 1(1): “*all persons, apart from the master, employed, engaged or working on board a Danish ship who does not exclusively work on board while the ship is in port,*” it must be presumed that a purely shore-based remote operator under employment law will not be considered a “seafarer” and thus not be covered by the act and its regulation of the employment relationship. Under Danish employment law, a shore-based remote operator will – considering the nature of the work – presumably be considered a salaried employee according to section 1(1)(b) and (c) of the salaried employees act.⁹⁵

Another consequence is that, under Danish law, shore-based remote operators will not be entitled to be covered by the net wages scheme pursuant to the act on the taxation of seafarers.⁹⁶ Naturally, this is of commercial importance when considering whether autonomous ships are interesting and where shore-based operational centres will be located geographically, if decided on.

4.5.9 The concept of the master under Danish law

In Danish law, the master’s obligations are regulated in part 6, sections 131-143, of the merchant shipping act.

Many of the provisions presuppose that the master is physically present on board the ship (sections 131, 133, 134, 135, 136, 138, 142 and 143).

These provisions present barriers to autonomous ships at levels RU and A.

Furthermore, several of the provisions stipulated in part 6 of the merchant shipping act concern the master’s right to represent the ship and the shipowner, which is also motivated by the master’s physical presence on board the ship (sections 137, 138, 139 and 141).

It is possible to remove the regulatory barriers of the merchant shipping act by inserting a new part 6a in the merchant shipping act stipulating the rights and obligations of remote operators.

This part should contain a definition of “remote operators” as well as a definition of “autonomous ships”. The concept of a “remote operator” should be used rather than a “shore-based operator” in order to also be able to include operators who are physically located on another ship or somewhere else.

On the basis of this analysis, we will recommend the following definitions:

“autonomous ships”: “ships capable of providing – via automatic processes or systems – decision support or making it possible to take over parts of or the entire human control and steering of the ship, irrespective of whether the exercise of control/steering is done from the ship or from somewhere else.”

“remote operator”: “a person with the necessary qualifications who performs or monitors the navigation of one or more autonomous ships without being physically present on board the ship and who is entitled to represent the ship vis-à-vis the authorities.”

As a general principle, the remote operator should be considered equal to the master in the merchant shipping act and have the same rights and obligations with the amendments deriving

⁹⁴ <http://www.simac.dk/education/study-ships-officer/> (accessed most recently on 30 November 2017).

⁹⁵ Consolidated act no. 1002 of 24 August 2017, as amended.

⁹⁶ Act no. 386 of 27 May 2005, as amended.

from the nature of the issue. In terms of navigation, the remote operator should be subjected to the principles of section 132 of the merchant shipping act.

The most important amendments following from the special role of the remote operator are described in general below.

First and foremost, it will be necessary to consider the provisions in part 6 of the merchant shipping act that presuppose that the master is physically present on board the ship (sections 131, 133, 134, 135, 136, 138, 142 and 143).

In relation to ships at autonomy levels R, RU and A, the right to represent and sign for the ship and the shipowner should not be placed with the remote operator, cf. section 4.5.6 above. It should be left to the shipowner to decide to whom they want to delegate the right of representation. These deviations from sections 137, 138, 139 and 141 of the merchant shipping act will need to be included in the regulations applicable to the remote operator.

In terms of seaworthiness (section 131 of the merchant shipping act), the obligation to ensure that ships are seaworthy and fit for the cargo to be carried should rest solely with the shipowner of autonomous ships at autonomy levels R, RU and A. However, any new regulations applicable to the remote operator should establish which obligations rest with the remote operator when it comes to the handling of goods after they have been loaded.

Furthermore, the obligations of the remote operator in relation to incidents at sea and marine accidents should be regulated.

Finally, it should be considered whether to establish requirements on the basis of liability and mandatory liability insurance for remote operators.

4.5.9.1 Act on safety at sea

In addition to the merchant shipping act, the act on safety at sea⁹⁷ also contains regulation applicable to the master.

According to section 10 of the act on safety at sea, the master is responsible that:

(i) the ship is in an appropriate condition in terms of health and safety; (ii) that it is possible to perform the work on board in a fully appropriate manner in terms of health and safety; (iii) that the ship's structural and technical arrangements are in an appropriate condition with a view to preventing pollution.

The provision will present a barrier to ships at autonomy levels R, RU and A and should be amended so that the obligations rest with the shipowner, for example by inserting a new subsection 2 in section 10, as follows:

"As regards autonomous ships without a master on board, where the navigation is performed by a remote operator, the obligations stipulated under section 10(1) shall only rest with the shipowner."

4.5.9.2 The act on seafarers' conditions of employment, etc. (the seamen's act)

The act on seafarers' conditions of employment⁹⁸ contains provisions on the master's managerial authority and decision competence on board a ship. Section 51 stipulates that the master has the managerial authority and the responsibility for this ("*the highest authority on board*"). The master's authority over the ship and the seafarers means that the master is entitled to "*take the*

⁹⁷ Consolidated act no. 72 of 17 January 2014, as amended.

⁹⁸ Consolidated act no. 73 of 17 January 2014, as amended.

precautions necessary to maintain order on board" (section 62). The master is considered the representative of the flag State and has the police authority on board the ship when it is not in a Danish port.

The master's right to exercise authority is based on the fact that the master is considered a representative of the flag State and its territorial authority. The exercise of authority is extended to investigations of crimes on board as well as the taking of evidence for the ship's log (section 63(1)), any other taking of evidence (section 63(4)), detention/arrest of suspects (section 63(2), and the surrender of suspects for prosecution (section 63(2) and (3)).

For ships at autonomy levels RU and A, the master's managerial authority and tasks related to the exercise of authority vis-à-vis the crew will not be necessary since the ships will be unmanned.

There will still be a master on board ships at autonomy level M, who could exercise the managerial authority and general authority.

In relation to external parties in open seas (persons who are shipwrecked or in distress), the remote operator should take over the exercise of authority in relation to ships at autonomy levels R, RU and A. For more details on this, reference is made to section 4.5.6 and, especially in relation to Danish law, to section 4.5.9.

4.5.10 The act on the manning of ships

The act on the manning of ships⁹⁹ transposes parts of the STCW Convention into Danish law and contains regulations on manning levels and requirements for seafarers' qualifications.

Section 3 of the act stipulates that *"there shall be a master on every ship, and in addition there shall be the safe manning required for the purpose of safety of life at sea."*

The provision will present a barrier to ships at autonomy levels R, RU and A and should be amended, for example by inserting a new subsection 2 in section 3, as follows:

"Nothing shall prevent the master from not being physically on board a ship if the master or a remote operator is capable of meeting the obligations and functions from somewhere else that rest with the master under this act or regulations issued with their legal basis in this act."

In relation to safe manning levels, the act on the manning of ships also contains – in addition to the second part of section 3: *"there shall be the safe manning required for the purpose of safety of life at sea"* – provisions in section 5 (our emphasis):

"For passenger ships (irrespective of size), for cargo ships of 20 gross tonnage or more and for cargo ships of less than 20 gross tonnage in international trade, the safe manning shall be fixed by the Danish Maritime Authority. For cargo ships of less than 20 gross tonnage in domestic trade the Danish Maritime Authority may fix the safe manning if warranted for the purpose of safety of life at sea.

Subsection 2. The safe manning shall be fixed for each individual ship taking into consideration the type of ship, design, equipment, use and area of operation so that the size and composition of the crew will make it possible to cover all tasks of importance to the safety of the ship and those on board, including

- 1) maintenance of safe watchkeeping on the bridge and in the engine room;*
- 2) operation and maintenance of live-saving appliances;*
- 3) operation and maintenance of damage control equipment, fire-fighting equipment and communication equipment;*

⁹⁹ Consolidated Act no. 74 of 17 January 2014.

- 4) other safety-related maintenance and cleaning activities;
- 5) mooring operations;
- 6) food provisioning and sanitary conditions.

Subsection 3. When determining the safe manning, account shall also be taken of the watch arrangements on board, shift work, the actual working hours of the individual categories of crew, applicable rules on rest periods and the use of general purpose crew.

Subsection 4. The safe manning may include persons with a different training background if the training is comparable with the training prescribed by or under the provisions of this act."

Safe manning levels are established by the Danish Maritime Authority following an individual assessment for each individual ship. Danish law does not use safe manning forms for individual types or sizes of ships, which is the case in a number of countries, including Singapore¹⁰⁰. As mentioned in section 4.4.3 in relation to a periodically unmanned (physical) bridge, it must be presumed – also in relation to the act on the safe manning of ships – that what is essential in the provisions are the functions that the master and the crew are to perform, rather than from where they specifically perform the functions, though the wording of section 3 of the act on the manning of ships uses the term "on each individual ship".

The term "the safe manning required for the purpose of safety of life at sea" stipulated in section 3 of the act on the manning of ships should, however, be clarified in relation to unmanned ships, for example by inserting a new subsection 3 in section 3 of the act on the manning of ships, as follows:

"When establishing the safe manning required for the purpose of safety of life at sea stipulated in section 3(1), account shall be taken of the technical arrangements and equipment of the ship. To the extent that such technical arrangements and equipment by themselves provide the necessary safety of human life at sea, these could replace the crew pursuant to section 3(1)."

Finally, the act on the manning of ships should contain a legal basis for the Danish Maritime Authority to establish training and certification requirements for remote operators, for example by adding a new subsection 4 to section 3 of the act on the manning of ships, as follows:

"The Danish Maritime Authority may, taking account of binding internationally adopted provisions and following consultation with the shipowner and seafarer organisations, lay down regulations on the training, qualification and certification requirements for masters of remote operators covered by section 3(2)."

4.5.11 Ships' logs and radio logs

The order on ships' logs and radio logs¹⁰¹ has been issued pursuant to section 471(1) of the merchant shipping act. Sections 1 and 2 of the order establishes obligations to keep a ship's log and radio log. As regards ships' logs, the obligation rests with the master or a mate under the supervision and co-responsibility of the master (section 4(1)). Section 133(1) of the merchant shipping act also imposes an obligation on the master to "ensure that log books are kept as directed". The radio log must be kept by the radio operator under the supervision and co-responsibility of the master (section 4(2)).

It is evident from section 3(2) of the order that there is a legal basis for the Danish Maritime Authority to approve the electronic keeping of a ship's log.

However, the order does not contain any legal basis for keeping the radio log electronically.

¹⁰⁰ Carey p.8 ff.

¹⁰¹ Order no. 978 of 20 July 2007.

Besides requirements for keeping a ship's log and a radio log, the order also contains requirements for the master to check that the logs are kept accurately and as prescribed (section 4(4) and to go through the logs at least once a month.

The logs must be kept for at least three years from the date of the last entry (section 10(2)) or, in case of ongoing court cases, until the case has been finally settled.

Previously, section 11 of the order contained an obligation for all ships to keep a physical annex file on board containing the ship's survey reports. Section 11 was repealed with effect from 1 July 2017¹⁰².

Section 2 of the order present a barrier to autonomous ships (autonomy levels RU and A) since there is no legal basis for keeping a radio log electronically from ashore.

Section 3(2) of the order on ships' logs and radio logs could, for example, be amended as follows (amendments are underscored):

"The Danish Maritime Authority may approve electronic ship's log books and radio log books, and permit that entries in the ship's log book or radio log book in full or in part may be replaced by records made by electronic means."

4.6 Protection of the marine environment

4.6.1 Autonomous ships and protection of the marine environment

One of the main purposes of autonomous ships is a reduced impact on the environment. A large part of the current environmental impact on the sea is caused by garbage from ships (food, packaging and sewage¹⁰³). This impact will be eliminated with unmanned ships (levels RU and A) and reduced considerably with lower manning levels at autonomy levels M and R. In an environmental context, autonomous ships will, however, need to prove that they do not present an increased risk of pollution damage, especially from the ship's own oil tanks and from its cargo, and that the preparedness of the crew today in case of pollution accidents (prevention and risk minimization in case of damage) can be replaced by technical means.

4.6.2 MARPOL

MARPOL¹⁰⁴ contains provisions the purpose of which is to protect the sea against ship pollution. MARPOL replaced the International Convention for the Prevention of Pollution of the Sea by Oil, 1954, which only concerned measures against oil pollution. MARPOL has a wider scope since it concerns measures against "*harmful substances*", which are defined as "*any substance which, if introduced into the sea, is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea, and includes any substance subject to control by the present Convention*"¹⁰⁵. MARPOL contains structural and equipment requirements for ships, including special requirements for tankers (also survey and inspection requirements), as well as regulations on discharge, ship-to-ship transfers (STS) and a number of reporting obligations in relation to oil spillage and pollution as well as obligations on the part of the contracting Parties to share information on pollution of the sea and to establish sanctions in case of violations of the provisions of the Convention as well as to enforce them. In addition to the merchant shipping act, MARPOL has been transposed into Danish law through the act on protection of the marine environment¹⁰⁶ and the act on safety at sea¹⁰⁷ and a number of order issued by authority laid down in these acts.

¹⁰² See order no. 579 of 30 May 2017.

¹⁰³ See MARPOL Annex IV, Regulations for the Prevention of Pollution by Sewage from Ships, and Annex V, Regulations for the Control of Pollution by Garbage from Ships.

¹⁰⁴ International Convention for the Prevention of Pollution from Ships, 1973, as amended.

¹⁰⁵ MARPOL Art. 2(2).

¹⁰⁶ Consolidated act no. 1033 of 4 September 2017.

¹⁰⁷ Consolidated act no. 72 of 17 January 2014.

4.6.3 Masters' reporting obligations under MARPOL Protocol I and the act on protection of the marine environment

The act on protection of the marine environment falls under the responsibility of the Ministry of Environment and Food of Denmark.

Pursuant to section 37(1) of the act, the Minister for Environment and Food of Denmark is authorised to lay down regulations on places of refuge for ships at risk of causing pollution of the marine environment. This authority has been used through the issue of the order on places of refuge and plans hereon¹⁰⁸. Annex 2 of the order stipulates that the operational part of the place of refuge plan is performed by the Maritime Assistance Service ("MAS") under Defence Command Denmark in cooperation with the master of the ship in need of assistance. A number of reporting obligations are imposed on the master in relation to the ship and its conditions as well as any identified oil pollution. Furthermore, the master is obliged to make a risk assessment of the elements forming part of a potential plan on places of refuge. The master is entitled to take another decision than the one prescribed by the MAS, cf. SOLAS chapter V on safety of navigation, regulation 34-1, on the basis of the master's professional assessment of safety of navigation and the risk of pollution of the marine environment.

Pursuant to part 12 (section 39) of the act on the marine environment, an order has been issued on reporting under the act on protection of the marine environment.¹⁰⁹ Section 2 of the order imposes reporting obligations on the master in case of pollution of the sea or a risk hereof. The reporting requirements concern the implementation of MARPOL Protocol 1 as well as article 4 of the OPRC Convention.¹¹⁰

There is an obligation to report any kind of collision, contact with the ground or grounding as well as in case of any risk of discharge caused by fire, explosion, defective machinery or equipment that may affect the manoeuvrability of the ship or for other reasons. Furthermore, reports must be made about any identified pollution of the sea or drifting goods. The reporting must be made immediately to Defence Command Denmark via the fastest possible means of communication.¹¹¹

It must be presumed that the obligations resting with the master under MARPOL Protocol I and article 4 of the OPRC Convention, as implemented in the act on the marine environment and orders issued in pursuance hereof, could be met by a remote operator for ships at autonomy levels R, RU and A to the extent that it is technically possible to collect the information about pollution of the sea stipulated in the act/order.

This is supported by MARPOL Protocol 1, article 1, as well as article 4 of the OPRC Convention which imposes the reporting obligation on "*The master or other person having charge of any ship involved in an incident*". Thus, MARPOL Protocol 1, article 1, and the implementation hereof in the act on the marine environment will not present a barrier to autonomous ships as long as "*a person having charge*" is able to make the reporting.

It should be considered amending section 2 of the order on reporting pursuant to the act on protection of the marine environment to clarify that a remote operator could also make the reports in relation to autonomous ships with reference to the future definitions of a "remote operator" and "autonomous ships" in the merchant shipping act, cf. section 4.5.9.

¹⁰⁸ Order no. 875 of 27 June 2016.

¹⁰⁹ Order no. 874 of 27 June 2016.

¹¹⁰ International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990.

¹¹¹ Sections 5 and 6 of the order.

4.6.4 Requirements for local pollution preparedness on board ships

MARPOL contains requirements for special emergency preparedness plans in relation to pollution of the marine environment by oil¹¹² and other hazardous/noxious liquid substances.¹¹³ The OPRC Convention, which has been transposed into Danish law by the order on technical regulation on ship emergency preparedness plans in case of pollution accidents caused by hazardous or noxious substances,¹¹⁴ also contains requirements for emergency preparedness plans in relation to hazardous and noxious substances.

These emergency preparedness plans presuppose that there is a crew on board ships in the form of a local emergency preparedness in case of unintentional incidents.

The same is true of other special measures and procedures mentioned in the order on the transfer of bunker oil between ships in Danish territorial waters¹¹⁵ as well as the order on the transfer of liquid cargoes between ships in Danish and Greenland territorial waters.¹¹⁶ Both orders makes the masters on the transferring and the receiving ship, respectively, responsible for planning and performing these operations without any risk of damage to the ships involved as well as the crew, shipping in the area and the marine environment.¹¹⁷

In Danish law,¹¹⁸ the requirements for special emergency preparedness plans on board ships also apply to ships carrying hazardous and noxious substances classified as polluting under the IMDG Code¹¹⁹, the BC Code¹²⁰ or the ICG Code¹²¹.

The above-mentioned requirements will present barriers to ships at autonomy levels RU and A.

It will be necessary to introduce new regulation for ships at autonomy levels RU and A in MARPOL, the OPRC Convention and Danish law. Such new regulation must list the technical requirements that could, in terms of safety, provide a preparedness capable of replacing the manning on board the ships involved.

4.6.5 SOLAS chapter VI – Carriage of cargo and fuel

SOLAS chapter VI contains provisions on the handling of cargo on board ships.

Regulation 2(1) contains the following reporting obligation for the shipper vis-à-vis the master:

“shipper shall provide the master or his representative with appropriate information on the cargo sufficiently in advance of loading to enable the precautions which may be necessary for proper stowage and safe carriage of the cargo to be put into effect. Such information shall be confirmed in writing and by appropriate shipping documents prior to loading the cargo on the ship.”

The purpose of the provision is to make the master or the one responsible for the ship’s operation aware of the properties of the cargo. This purpose could be met by providing a remote

¹¹² MARPOL Annex 1, chapter V, regulation 37, requires a “Shipboard Oil Pollution Emergency Plan” and MARPOL Annex 1, chapter VIII, regulation 41, requires a “STS Operations Plan”.

¹¹³ MARPOL Annex II, chapter VII, regulation 17, requires a “Shipboard marine pollution emergency plan for Noxious Liquid Substances” in case of pollution accidents from tankers carrying hazardous cargoes other than oil classified as polluting under the IBC Code (the IMO International Bulk Chemical Code (IBC Code). The code contains regulations on the design, construction and equipment of new-built or converted chemical tankers).

¹¹⁴ Order no. 765 of 22 July 2009.

¹¹⁵ Order no. 733 of 25 June 2007.

¹¹⁶ Order no. 570 of 4 June 2014.

¹¹⁷ The order on the transfer of bunker oil between ships in Danish territorial waters, section 8, and the order on the transfer of liquid cargoes between ships in Danish and Greenland territorial waters (STS operations), section 5.

¹¹⁸ The order on technical regulation on ship emergency preparedness plans in case of pollution accidents caused by hazardous or noxious substances, section 1(1) (order no. 765 of 22 July 2009).

¹¹⁹ The IMO International Maritime Dangerous Goods Code.

¹²⁰ The IMO Code of Safe Practice for Solid Bulk Cargo (BC Code). The Code is included in chapter VI of SOLAS.

¹²¹ The IMO International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

operator or the shipowner with similar information. The provision cannot be considered to present a barrier to autonomous ships since it opens up for providing a representative of the master with the information.

4.6.6 SOLAS chapter VII – Carriage of dangerous goods

SOLAS chapter VII implements the IMDG Code¹²² and contains, in regulations 6 and 7(4), reporting obligations for *“the master, or other person having charge of the ship”* in case of incidents *“involving the loss or likely loss overboard of dangerous goods in packaged form into the sea”*.

It must be presumed that the obligation could also be met by a remote operator for ships at autonomy levels R, RU and A to the extent that it is technically possible to monitor the loss of goods via cameras/sensors on board since remote operators will fall under the category of *“other person having charge of the ship”*. Thus, the provision will presumably not present a barrier to autonomous ships.

4.7 Construction requirements and technical conditions for ships

4.7.1 SOLAS and its scope of application

SOLAS contains central IMO regulations on the design and construction requirements for various types of commercial ships and their equipment. Apart from SOLAS, especially the Load Line Convention, MARPOL and the MLC also contain design and construction requirements.

The scope of application of SOLAS is commercial ships engaged on international voyages with a gross tonnage of or above 500 as well as passenger ships (defined as *“a ship which carries more than twelve passengers”*).

Chapter I, part A, regulation 4(b), of SOLAS contains the following general exemption provision (our emphasis):

“The Administration may exempt any ship which embodies features of a novel kind from any of the provisions of Chapters II-1, II-2, III and IV of these Regulations the application of which might seriously impede research into the development of such features and their incorporation in ships engaged on international voyages. Any such ship shall, however, comply with safety requirements which, in the opinion of that Administration, are adequate for the service for which it is intended and are such as to ensure the overall safety of the ship and which are acceptable to the Governments of the States to be visited by the ship. The Administration which allows any such exemption shall communicate to the Organization particulars of same and the reasons therefor which the Organization shall circulate to the Contracting Governments for their information.”

The provision leaves much discretion to each individual flag State.

Depending on their autonomy level, autonomous ships will presumably be covered by the provision on *“features of a novel kind”*, and it could be argued that it will present a serious hindrance to the development not to allow tests/trials with autonomous ships’ *“features of a novel kind”*.

The provision is supplemented by a Danish special regulation applicable to ships below 24 metres in the order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships, chapter I, part A, regulation 4(c), according to which the Danish Maritime Authority can grant exemptions from one or more provisions of SOLAS, in addition to the chapters referred to in SOLAS, chapter I, part A, regulation 4(b), above:

¹²² The IMO International Maritime Dangerous Goods Code.

“In connection with drawing approval and the first survey of ships with a length of less than 24 metres, the Danish Maritime Authority may, after a concrete assessment, exempt ships from one or more of the provisions of this set of regulations. The precondition is that the ship complies with similar safety requirements which may, at the discretion of the Administration, suffice for ships of this size and engaged in the service area for which the ship is intended.”

The limitation in connection with both exemption provisions is the safety level.

However, it will hardly be a navigable way for flag States to use the exemption provision of SOLAS, chapter I, part A, regulation 4(b), since the challenge with lacking international recognition of standards for autonomous ships will continue to be a hindrance to autonomous ships’ international voyages, cf. section 4.3.2 above on the jurisdiction of coastal States and port States.

SOLAS contains a general principle on equivalence in chapter I, regulation 5(a):

“Where the present Regulations require that a particular fitting, material, appliance or apparatus, or type thereof, shall be fitted or carried in a ship, or that any particular provision shall be made, the Administration may allow any other fitting, material, appliance or apparatus, or type thereof, to be fitted or carried, or any other provision to be made in that ship, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus, or type thereof, or provision, is at least as effective as that required by the present Regulations.”

The provisions leave some flexibility for the flag State to allow the testing of new technical solutions, but the requirement for it to be demonstrated that the solution is at least as effective (equivalence) as that prescribed requires a considerable test phase in practice before it becomes possible to put new products to use.

Apart from the exemption provision of SOLAS, chapter I, part A, regulation 4(b), and the principle of equivalence in chapter I, regulation 5(a), SOLAS contains a number of exemption provisions, which are all based on the principle of a similar safety level. These exemption provisions will not be described in any more detail in this analysis.

This analysis concludes that flag States should not generally use the exemption provisions in relation to autonomous ships since they are intended for individual exemptions.

Considering the drastic regulatory amendments that autonomous ships will necessitate, international regulations and standards should instead be established for the structural and technical conditions of autonomous ships within the IMO in order to secure international agreement and recognition and to make autonomous ships’ international voyages possible.

4.7.2 SOLAS chapter II-I – Construction – construction, subdivision and stability, machinery and electrical installations

According to SOLAS chapter II-I, regulation 5(1), the master must be provided with reliable information on the ship’s stability that is necessary to enable him to get exact guidance in a fast and simple manner about the ship’s stability under various operating conditions.

If the master is not on board the ship (autonomy levels R, RU and A), it must be presumed that the obligation can still be met. What is important must be that the stability information is available to the one steering/monitoring the ship as the basis for his decision competence when it comes to operating the ship.

SOLAS chapter II-I, regulation 19, requires damage control plans to always be available to the officer of the watch on the bridge. This provision will present a barrier to ships at autonomy levels R, RU and A. It will be necessary to amend the provision, possibly by establishing that

damage control plans must be available to the one in control of the ship and that this can be in electronic form.

SOLAS chapter II-I, regulation 38, on the engineer officer alarm must be interpreted in accordance with the purpose of the provision: that the engineer officer must be warned in case decisions or actions are required. Consequently, the alarm must, for autonomous ships at autonomy levels R, RU and A, be arranged such that the person performing/monitoring the engineer officer function ashore (presumably the remote operator) is warned so that this person has a possibility of acting as required.

It is a precondition for autonomous ships' compliance with the provision that it is technically possible for the person performing/monitoring the engineer officer ashore to carry out remotely controlled monitoring and control of central parts of the machinery space functions, thereby enabling the person to react to the alarm. The same must apply to the special requirements applicable to alarm systems, safety systems and machinery and boiler installations as well as electrical installations pursuant to SOLAS chapter II-I, regulations 51-53.

If this is not the case, the regulations will present barriers to autonomous ships at levels R, RU and A.

SOLAS chapter II-I, regulation 49, contains detailed provisions on the steering of the propulsion machinery from the navigation bridge.

An electronic bridge must meet the functional requirements of the provision. However, the provision cannot be presumed to present a barrier to autonomous ships if it is technically possible for an electronic bridge to meet the functional requirements.

4.7.3 SOLAS chapter II-II – Construction – fire safety, detection fire extinction

The overall consideration of the provisions of SOLAS chapter II-II is fire safety, especially the safety of crew and passengers. SOLAS chapter II-II has undergone continuous revisions on the basis of technical developments as well as costly experiences from fire accidents involving ships.

On the basis of SOLAS chapter II-II, an International Fire Safety Systems (FSS) Code has been adopted, containing detailed technical requirements for fire safety and fire fighting equipment, as well as an International Code for Application of Fire Test Procedures (FTP Code), establishing homogeneous international requirements for lab tests and type approval as well as the test procedure for fire safety and fire fighting equipment so that the flag States use the same basis when approving products.¹²³

SOLAS chapter II-II, regulation 7, contains detailed requirements for alarm systems, regulation 12 regulates the warning of crew and passengers, regulation 13 establishes requirements for escape routes/exits, regulations 15 and 16 contain requirements for on-board instruction and training as well as fire drills.

On the basis of a scrutiny of the above-mentioned regulations, it can be concluded that the crew plays a central role in terms of fire preparedness (safety, detection, fighting) and evacuation preparedness on board. Naturally, this is especially so on board passenger ships. The provisions of SOLAS chapter II-II will present a barrier to autonomous ships at autonomy levels RU and A.

In relation to passenger ships, it will – given the technical possibilities – need to be considered whether acceptable solutions can be found capable of replacing, partly or in full, the crew's role as a fire preparedness team and whether it will be possible to establish new regulations in SOLAS on the fire safety of ships at autonomy levels RU and A. It must be presumed that alternative fire

¹²³ See <http://www.imo.org/en/OurWork/Safety/FireProtection/Pages/History-of-fire-protection-requirements.aspx> (accessed most recently on 30 November 2017) for an extensive description of the historical development of SOLAS provisions on fire safety.

safety measures must result in the same minimum safety level as that of a manned passenger ship in case of fire and that any technical solutions must demonstrate that this is the case. It will be necessary to have fire safety measures in accordance with SOLAS chapter II-II, including sufficient manning levels on board ships, until sufficient experience has been gained with the safety level of alternative technical fire safety measures. Another possibility could be to upgrade any on-board personnel without a background as professional seamen, thus enabling the personnel to perform the fire safety tasks that rest with the crew today – apart from servicing the passengers on board.

As regards ships that do not carry passengers, the risk of personal injury and loss of human life will, of course, be different, but considerations related to cargo protection, the risk of danger to other ships as well as the risk of pollution of the marine environment will presumably result in a conclusion similar to that of ships carrying passengers. The current provisions of SOLAS chapter II-II are based on the fundamental principle that efforts must always be made to save the ship in case of fire. However, it should be carefully considered within the IMO whether this is also to be the fundamental principle for unmanned autonomous ships or whether one should apply a principle that the essential is a ship's technical capability of evacuating everybody on board quickly in case of fire, and that thus the same considerations of protection do not apply to the ship's cargo and the ship as such. This consideration will presumably vary on the basis of the ship's type and size as well as the type of cargo carried.

Regulation 4(1) of chapter II-II contains an exemption provision according to which a flag State can – if it assesses that the voyage takes place under conditions that are so safe that the use of one or more provisions of chapter II-II would be unreasonable or unnecessary – exempt specific ships or classes of ships flying its flag from meeting these requirements provided that these ships do not move more than 20 nautical miles away from the nearest land during their voyage. It follows from regulation 4(2) that *“the structural fire safety provisions required for the ship shall continue to be met”* if exemption is granted.

Considering the remarks above, it will presumably be difficult for autonomous ships at autonomy levels RU and A to get an exemption from having a crew on board under regulation 4(1).

4.7.4 SOLAS chapter III – Life-saving appliances and arrangements

Chapter III lays down requirements for the life-saving equipment that must be on board different types of ships and requirements for the emergency preparedness, maintenance and inspection.

Regulation 10(3) contains the following manning requirements for ships:

“There shall be a sufficient number of crew members, who may be deck officers or certificated persons, on board for operating the survival craft and launching arrangements required for abandonment by the total number of persons on board.”

Regulation 10(3) will present a barrier to unmanned ships (levels RU and A). The same is true of regulation 19 on emergency training and drills for the crew as well as regulation 20 on emergency preparedness, maintenance and inspection, which requires a crew on board ships.

SOLAS chapter III, regulation 2(1), contains an exemption possibility for the flag State similar to that stipulated in regulation 4(c) of chapter II-2 on fire safety, detection and extinction:

“The Administration may, if it considers that the sheltered nature and conditions of the voyage are such as to render the application of any specific requirements of this chapter unreasonable or unnecessary, exempt from those requirements individual ships or classes of ships which, in the course of their voyage, do not proceed more than 20 miles from the nearest land.”

The above remarks in section 4.7.3 concerning SOLAS chapter II-2, regulation 4(c), apply analogously in relation to SOLAS chapter III, regulation 2(1).

4.7.5 SOLAS chapter IV – Radiocommunications GMDSS

SOLAS chapter IV establishes the functional requirements for ships' radiocommunication.

Contrary to the other regulations of SOLAS, the provisions of chapter IV also apply to ships with a gross tonnage below 500, down to ships with a gross tonnage below 300, but with a length (L) of or above 15 metres with scantlings of or above 100.¹²⁴

Regulation 12 lays down requirements for a continuous radio watch on specific channels/frequencies when the ship is at sea.

Regulation 16 requires all ships to have personnel on board qualified to carry out distress and safety radiocommunication.

The exemption provisions of chapter IV, regulation 3, do not make it possible to grant exemptions from the requirements of regulations 12 and 16.

In relation to autonomous ships, it will presumably be technically possible to ensure a continuous radio watch from a shore-based control centre, cf. regulation 12, but the requirement of regulation 16 for radio-trained personnel to be on board the ship will present a barrier to ships at autonomy levels RU and A.

However, exemptions pursuant to chapter I, part A, regulation 4(b), will presumably be a possibility to the extent that it is technically possible to ensure satisfactory safety for the functionality of distress and safety communication though there are no radio-trained personnel on board. The central purpose of the provisions seems to be that there must always be human surveillance of the radio communication and, thus, a possibility of reacting and not from where the surveillance takes place.

4.7.6 SOLAS chapter V – safety of navigation

Pursuant to SOLAS chapter V, regulation 24(1), it must be possible to immediately take over manual steering of the ship from self-steering and/or track control systems in densely trafficked waters under conditions of reduced visibility and in all other situations jeopardising safety of navigation.

The purpose of the provision is to ensure that manual steering can be introduced immediately in situations jeopardising safety of navigation. In relation to ships at autonomy level A, regulation 24 implies that – irrespective of whether the ship is fully autonomous – there must always be simultaneous monitoring by remote operators in situations that must be characterised as dangerous from a navigational safety perspective. The monitoring remote operator must be capable of intervening and using manual steering immediately.

SOLAS chapter V, regulation 31, imposes an obligation on the master to report situations that may present a danger to navigation, especially dangerous weather, to all ships in the vicinity and to the relevant competent authorities. This reporting does not have to be in any specific form.

The provision will not present a barrier to autonomous ships to the extent that they are technically capable of detecting the dangerous situations and notifying ships in the vicinity. Considering the purpose of the provision, the obligation could be met by the remote operator for ships at autonomy levels R, RU and A.

¹²⁴ SOLAS chapter IV, regulation 1.

4.7.7 Chapter VIII – Nuclear ships

SOLAS chapter VIII on nuclear ships stipulates in regulation 3(1) that a nuclear ship cannot be exempted from compliance with the provisions of SOLAS.

Consequently, any exemptions granted from the requirements of the individual chapters of SOLAS will not apply to *nuclear* autonomous ships.

Regulatorily, nuclear autonomous ships will thus require entirely new regulation under SOLAS in order for them to be a possibility.

4.7.8 Chapter IX – Safe ship operation

SOLAS chapter IX implements the ISM Code.¹²⁵ Chapter IX, regulation 3(1), requires all ships and shipowners to meet the provisions of the ISM Code.

In regulation 1(2), a shipowner is defined as:

“The owner of the ship or any other organization or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the owner of the ship and who on assuming such responsibility has agreed to take over all the duties and responsibilities imposed by the International Safety Management Code.”

The ISM Code requires all shipowners to have a safety management system. The purpose is that the shipowner must make specific considerations on the safety of its own organisation/type of operations and seek to integrate the shore-based organisation with the seafarers in one common system for safe ship operation. The ISM Code has been drawn up as goal-based framework regulations, requiring shipowners to document that they have an administrative safety management system that ensures that the operation of ships has the greatest possible degree of safety with focus on the human element.

The ISM Code contains requirements for policies and procedures that the shipowner must draw up, use for training their employees and establish control and reporting mechanisms for. The shipowner is subject to certification requirements and control by the flag State. The goal-based approach of the ISM Code makes it suitable for constituting the regulatory framework for the increased shore-based steering of ships brought about by autonomous ships.

Regulation (EC) No 336/2006 of the European Parliament and of the Council of 15 February 2006 on the implementation of the International Safety Management Code within the Community extends the scope of application of the ISM Code to all cargo ships (with a gross tonnage of or above 500) and passenger ships engaged on domestic voyages or on regular voyages to or from ports in the member States, irrespective of flag.¹²⁶

4.7.9 Chapter XI – Special measures to enhance maritime security

SOLAS chapter XI contains special maritime security requirements.

It follows from chapter XI, regulation 6, that all ships must have a security alarm system capable of transmitting an alarm from the ship to a competent authority ashore, giving details about the ship and its position and information that the ship’s security is threatened or has been brought in danger. It must be possible to activate the alarm system from the ship’s bridge and from at least one other place on board.

In relation to ships at autonomy levels R, RU and A, it must be presumed that the ship is technically capable of alarming the remote operator in case the autonomous ship is threatened

¹²⁵ International Safety Management Code.

¹²⁶ Regulation (EC) no. 336/2006, art. 3(b) and (c).

by a physical attack, a cyber attack or a failure of the communication link to meet the purpose of regulation 6.

If this is not the case, regulation 6 will present a barrier.

Chapter XI, regulation 8, establishes the fundamental principle that the master's professional discretion in relation to the ship's safety must not be limited by the shipowner, the charterer or any other person. This applies to refusal of access to the ship for both persons and goods.

In relation to ships at autonomy levels R, RU and A, the master must be considered the remote operator. If the purpose of the provision is to be met, the remote operator must have the same independent decision competence, irrespective of the authority to give instructions had from the shipowner.

Regulation 11(1) of chapter XI contains an exemption provision according to which the flag State can conclude bilateral or multilateral agreements with other flag States about alternative security arrangements. The exemption possibility applies only to ship traffic with short crossings on regular routes within the territorial waters of contracting Parties.

Furthermore, regulation 12(1) of chapter XI entitles a flag State to allow equivalent security arrangements for a specific ship or group of ships.

4.7.10 Requirements for sound and light signals under COLREG

COLREG contains detailed regulations on the use of ships' lights and shapes (chapter C, regulations 20-31) and sound and light signals (chapter D, regulations 32-37), which are elaborated on in appendices I-IV to COLREG.

In order to meet the regulations, autonomous ships must be able to give correct signals in all navigational situations, also if the communication link from a control centre to autonomous ships at levels R, RU and A is lost, cf. section 4.4.2 above.

In addition, the regulations have the other important consequence that autonomous ships must be technically capable of detecting sound and light signals from other ships in order to meet the provisions of COLREG.

If the conditions above are met, the provisions on sound and light signals will not present a barrier to autonomous ships.

Exemptions

COLREG contains in regulation 1(e) the legal basis for the flag State's granting of exemptions from the provisions on sound and light signals in relation to *"number, position, range or arc of visibility of lights or shapes as well as to the disposition and characteristics of sound-signalling appliances"*.

This legal basis applies to the extent that the flag State finds that *"a vessel of special construction or purpose cannot comply fully with the provisions of any of these Rules"*.

If an exemption is granted, the ship must however still ensure the *"closest possible compliance"* with the rules.

It will depend on a specific assessment made by the specific flag State whether an autonomous ship could be considered a *"vessel of special construction"* and whether an exemption can be granted.

4.7.11 Transposition of SOLAS into Danish law

In Danish law, design and construction requirements for ships are stipulated in the order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships.¹²⁷, which implements parts of SOLAS and MARPOL, and the order on Notice D from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of passenger ships engaged in domestic voyages.¹²⁸ The orders contain all regulation of the design and construction requirements for ships; IMO regulations and EU regulations as well as special Danish regulations.

In Danish law, a number of the SOLAS chapters have a wider scope of application than is the case for Denmark's international obligations under SOLAS.

This is, for example, the case with SOLAS chapter I – General Provisions, which according to chapter I, part A, regulation 1(a), of the order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships applies to *“passenger ships, irrespective of size, engaged on international voyages and cargo ships with a length (L) of 15 m and above or with a scantling number of 100 or above, irrespective of whether they are engaged on domestic or international voyages.”*

It is also the case with SOLAS chapter II-I, Construction – Structure, subdivision and stability, machinery and electrical installations, which also applies to *“passenger ships, regardless of size, and cargo ships with a gross tonnage of 500 or more, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 as well as to cargo ships with a gross tonnage below 500 the keels of which are laid on or after 1 January 2002.”*

Other extensions of the scope of application of SOLAS have not been extensively reproduced in this analysis.

4.7.12 The concept of technical seaworthiness

The concept of seaworthiness has its origin in common law where it has been developed through several centuries' case law. Seaworthiness is of importance in many respects within maritime law, for example in connection with safety (this section 4.7), manning (section 4.5), insurance (section 4.8.8.2), chartering of ships and the carriage of goods (section 4.8.5) and pollution (section 4.6).

Seaworthiness is a core concept within both international and national regulation. Especially in common law jurisdictions, the concept of seaworthiness is considered a challenge for autonomous ships.¹²⁹

This section focuses on the concept of technical seaworthiness that covers a ship's construction, equipment and operation.

4.7.12.1 The concept of technical seaworthiness in Danish law

The act on safety at sea¹³⁰ transposes large parts of SOLAS and MARPOL into Danish law.

The act on safety at sea is a framework act that contains the main principles and main purposes. Detailed regulation of the technical conditions of ships as well as navigational conditions are stipulated in orders and technical regulations issued by the Danish Maritime Authority, as described in section 4.7.1.1 above.

Section 2(1) of the act on safety at sea contains the act's definition of seaworthiness:

¹²⁷ Order no. 377 of 4 May 2009.

¹²⁸ Order no. 556 of 26 May 2011, as amended.

¹²⁹ Carey, pp. 8ff.

¹³⁰ Promulgation of the act on safety at sea (Consolidated act no. 72 of 17 January 2014, as amended).

“Every ship shall be constructed, equipped and operated in such a way as to adequately protect human life at sea and in such a way that it is fit for the nature of the service for which it is intended at any time. As much regard as possible shall be paid to pollution protection.”

As is evident from the wording, it is a relative concept which takes account of the specific trade area, the cargo as well as wind and weather.

The definition of technical seaworthiness contains considerable flexibility, which must be presumed to allow for autonomous ships to the extent that “*human life at sea is adequately protected*” and the ship is “*fit for the nature of service for which it is intended at any time*”. Thus, the concept of technical seaworthiness stipulated in section 2(1) of the act on safety at sea cannot be considered to present a barrier to autonomous ships, irrespective of the level of autonomy.

The general concept of seaworthiness stipulated in section 2(1) of the act on safety at sea is, for ships in international trade,¹³¹ elaborated through the many detailed special requirements stipulated primarily in SOLAS, depending on the type of ship.

The concept of technical seaworthiness and the concept of loading capacity stipulated in section 262(2) of the merchant shipping act, as described in section 4.8.5 below, are two separate concepts. That a ship is seaworthy according to one of the concepts does not mean that it will be so according to the other concept.¹³² See furthermore section 4.8.8.2 on the independent concept of seaworthiness pursuant to insurance law.

4.7.13 Seaworthiness – certificates (Documentary Seaworthiness)

Ships’ possession of the certificates needed to be engaged in international trade is designated as Documentary Seaworthiness.

Since there is no international regulation and technical standards for autonomous ships, it will not be possible for classification societies to classify autonomous ships and issue certificates that are internationally recognised.

A lack of classification means that it will be difficult for autonomous ships to be insured and, thus, to be put to commercial use.

This will present a barrier to autonomous ships in international trade until international regulations have been implemented.

4.7.14 The marine equipment directive

SOLAS leaves a discretionary margin in connection with the certification of ship’s equipment.

In order to ensure a homogeneous application of the design and construction requirements of SOLAS for ships flying the flags of EU member States (including technical test standards and requirements for certification) and to ensure the free movement of marine equipment in the EU, the European Parliament and the Council have adopted the marine equipment directive.¹³³ The marine equipment directive has been transposed into Danish law through the order on equipment

¹³¹ The basis of SOLAS is that the convention applies only to ships in international trade, cf. SOLAS chapter I, regulation 1(a). However, contracting Parties may choose also to apply SOLAS (or parts hereof) in international trade.

¹³² Falkanger, Bull and Rosenberg Overby, pp. 76ff.

¹³³ Directive 96/98/EC of the European Parliament and of the Council, as amended by directive 2014/90/EU of the European Parliament and of the Council of 23 July 2014.

in ships.¹³⁴ Ship equipment meeting the requirements of the marine equipment directive must be fitted with a wheel-mark, which is a kind of CE-marking of marine equipment.¹³⁵

Equipment for autonomous ships the flag State of which is an EU member State would have to meet the requirements of the marine equipment directive. This implies that it is possible to sell and buy the equipment in all EU member States once it has been type approved. Article 30 of the marine equipment directive contains an exemption provision for equipment presenting *technical innovation*, according to which a flag State can allow the fitting on board a ship flying the flag of an EU member State of marine equipment not compliant with the procedures under the marine equipment directive if it has been found, through testing or in some other manner to the satisfaction of the flag State, that such equipment meets the purpose of the marine equipment directive.

4.7.15 EU regulation containing design and construction requirements for passenger ships

In order to enhance the safety of passenger transport within the EU, EU has adopted stability requirements for ro-ro passenger ships stipulating special stability requirements for ro-ro passenger ships engaged in regular international voyages to and from a port in a member State, irrespective of flag.¹³⁶ Each individual member State is, in its capacity as a port State, obliged to ensure that ro-ro passenger ships flying the flag of a non-member State also meet the special stability requirements of the directive.¹³⁷

Furthermore, directive 2009/45/EC of 6 May 2009¹³⁸ of the European Parliament and of the Council stipulates special safety regulations and standards for passenger ships engaged in domestic trade within the EU member States with a view to introducing a homogeneous safety level for human life and property on new and existing passenger ships and high-speed passenger craft. According to article 3 of the directive, the member States are, in their capacity as port States, obliged to ensure that passenger ships and high-speed passenger craft not flying the flag of a member State fully meet the requirements of the directive before they can engage in domestic service in the member States.

The directive contains regulations on (i) communication between the machinery space and the navigating bridge, (ii) fire safety and detection and extinction, and (iii) life-saving appliances, all of which require a trained crew on board the ship as well as a manned machinery space and navigating bridge.¹³⁹ Thus, the directive presents a barrier to autonomous passenger ships at autonomy levels RU and A. Considering the scope of application of the directive, the barrier will encompass all passenger ships in domestic trade within the EU.

4.8 Liability, compensation and insurance issues

4.8.1 General remarks about liability

The liability issues of shipping have traditionally been based on placing the navigation of ships in the hands of competent seafarers, whose competences and qualifications a shipowner can benchmark against internationally established standards and certifications, especially under the STCW.

¹³⁴ Order no. 422 of 17 May 2016.

¹³⁵ Cf. regulation (EC) no. 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products.

¹³⁶ Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 on special stability requirements for ro-ro passenger ships.

¹³⁷ Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 on special stability requirements for ro-ro passenger ships, art. 3(2).

¹³⁸ Amended by directive 2010/36/EU of the Commission of 1 June 2010.

¹³⁹ Directive 2009/45/EC of the European Parliament, chapter I, part C, 9 and 10 (regulations 37 and 38), chapter II-2 – Fire safety, detection and extinction, and chapter III – Live-saving appliances.

There is reason to presume that the introduction of autonomous ships will delegate the navigation obligation (or parts hereof) for ships at autonomy levels R, RU and A to remote operators.

Furthermore, manufacturers and programmers of autonomous ships' navigation systems as well as suppliers of communication and network solutions used by autonomous ships will have direct influence on ships' navigation and the possibility of controlling the ships. This gives rise to consider whether the liability will be placed with somebody else.

Programmers of autonomous ships' navigation systems play a special role. Contrary to remote operators, the programmer will not exercise simultaneous decision competence, but choose/decide on the programming of the navigation system at another point in time than when he takes a specific navigation decision. Naturally, this may be of importance to the placing of liability.

In general, the civil liability of shipping is regulated nationally and varies from one jurisdiction to another.

This results in complicated issues related to the choice of law and jurisdiction where it will be necessary to take account of (i) which waters the ship is in, (ii) the nature of the incident, (iii) the flag State(s) of the involved ships, as well as (iv) the nationality of the involved physical or legal persons.

However, gradually extensive international regulation has been developed on the civil liability of shipping in relation to collisions between ships, liability for pollution, liability for wreck removal and damage to goods (see section 4.8.2 below).

In most jurisdictions, the civil liability is based on a fault standard, where fault/negligence, including breaches of legal rules, causes liability. In addition, there will often be a requirement for causality and adequacy (foreseeability). In some jurisdictions, the causality between the causation of damage and the damage is, however, sufficient to cause liability without requiring fault/negligence (strict liability).

In general when clarifying liability issues, distinction must be made between contractual liability (for example damage to cargo) and non-contractual liability (for example collisions with other ships, installations at sea or port installations or other damage to third parties).

4.8.2 Shipowner's liability

The liability norm for the shipowner under Danish law is a fault standard for the shipowner's own negligent acts or omissions.

In addition, the shipowner has secondary liability for the shipowner's employees and those performing tasks in the service of the ship (employer liability) under section 151(1) of the merchant shipping act, which has the following wording:

"The shipowner shall be liable for damage caused through fault or negligence in their service by the master, crew members, pilot or others who carry out work in the service of the ship."

The employer liability within maritime law is rooted in the general legal provision on employer liability stipulated in the Danish Law of King Christian V 3-19-2 and was separately enacted in the merchant shipping act in 1892 (as the then section 8). The employer liability of the shipowner is reasoned by the fact that the shipowner has an economic interest in the ship being in operating and should, thus, be liable vis-à-vis third parties for his employees' actions/omissions giving rise to liability.¹⁴⁰

¹⁴⁰ See generally on the shipowner's liability, Falkanger, Bull and Rosenberg Overby, pp. 161ff.

The liability in connection with collisions with other ships is regulated internationally in the Collision Convention,¹⁴¹ which distributes the liability according to the degree of fault displayed by the ships involved. The ship's degree of fault covers that of both the crew and the shipowner.

However, the trend has been towards strict liability coupled with mandatory liability insurance for the shipowner in more recent international conventions related to civil liability.¹⁴²

For fully autonomous ships (autonomy level A), there is reason to presume that it makes no sense to talk about liability based on fault to the extent that navigation and decisions of importance to the ship's course and speed are taken by an autonomous system without human interference. It must be presumed that this could, in the longer term, change the liability norm, at least in connection with collisions, to the shipowner's strict liability.

If the liability norm of future regulation of ships at autonomy level A becomes strict liability, this gives rise to considerations of the distribution principles in case of collisions or the causing of damage to a third party by one or more ships with strict liability. Such principles are, for example, found in the regulation of collisions between motor vehicles in section 103 of the road traffic act.¹⁴³

Until such a strict liability is established by international or national regulation, the shipowner will still have a fault-based liability, where the arrangement of the shipowner's operation, including appropriate maintenance and updating of the navigation system as well as compliance with the guidelines/standards according to which the system has been designed, will presumably be the most important liability parameters in relation to fully autonomous ships.

Though the liability norm may change over time, there is reason to presume that the overall liability for ships' causing of damage will still rest with the shipowner in its capacity as the largest stakeholder in the operation of the ship and the primary party capable of including the risk in its business and acquiring insurance coverage.

The shipowner will presumably remain the overall liable party in commercial civil shipping and will, vis-à-vis third parties, be liable for the persons or legal entities performing work in his service, including the remote operator (see section 4.5) or the representatives to whom the shipowner may delegate competence, such as local representatives/agents of the shipowner in relation to the cargo owner or the shipowner's "designated persons", cf. section 4.5.7 above.

4.8.3 The right to limitation of liability¹⁴⁴

Considering the risky nature of shipping, which is subject to the weather and forces of nature, there has been a historical, distinct tendency to spread and allocate risk. Because of this, the shipowner has been entitled for long to exempt from and limit liability, both in relation to types of damage and faults as well as in the form of limitations in terms of value.

In addition to special regulations on limitation of liability in relation to damage to cargo (part 13 of the merchant shipping act on the carriage of general cargo, implementing the Hague-Visby Convention¹⁴⁵) part 9 of the merchant shipping act also contains provisions on global limitation of

¹⁴¹ Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels, 1910. The regulations have been implemented in part 8 of the merchant shipping act on damage in case of collisions.

¹⁴² See for example Art. 10 of The Nairobi International Convention on the Removal of Wrecks, 2007, transposed into Danish law through part 8a of the merchant shipping act and art. III of the International Convention on Civil Liability for Oil Pollution Damage, 1992, transposed into Danish law through part 10 of the merchant shipping act.

¹⁴³ Consolidated act no. 38 of 5 January 2017.

¹⁴⁴ See on limitation of liability in Danish law: Falkanger, Bull and Rosenberg Overby, pp. 183-202 as well as Bredholt, Martins, Mathiasen and Philip, pp. 252-286.

¹⁴⁵ The Hague-Visby Rules – The Hague Rules as Amended by the Brussels Protocol, 1968.

shipowner liability in connection with a number of claim types that implement the 1976 liability limitation convention, as amended by the protocol of 1996 on increased liability limits.¹⁴⁶

Considering the conclusion that an autonomous ship, cf. section 4.2 above, will in a regulatory context be considered a ship, nothing prevents the shipowner from continuously having the right to limit liability in connection with autonomous ships as is the case with conventional ships. The risks that the shipowner is faced with will be the same, including especially collision, grounding, damage to goods and injury to persons as well as environmental pollution.

The question is whether the right to limitation of liability can be extended to remote operators and manufacturers and programmers of autonomous ships' navigation systems. The group of persons entitled to limitation of liability follows from section 171 of the merchant shipping act (article 1 of the liability limitation convention) and includes – apart from the shipowner – “*an owner of a ship who is not a shipowner, a user, charterer, manager and anyone who provides services in direct connection with salvage operations*”. Furthermore, insurance companies and P&I clubs are covered to the extent that they insure the “*liability for claims subject to limitation*”, cf. section 171(3) of the merchant shipping act.

Section 171(2) extends the group to also cover “*persons for whose acts the shipowner or the others mentioned in subsection 1 is responsible*”. The extension covers the on-board crew. The provision covers the employer's employees as well as independent third parties (such as pilots) performing work for the shipowner.

Remote operators of autonomous ships must also be presumed to be covered by the right to limitation of liability under section 171(2) since he is performing a work function on behalf of the shipowner. It cannot be decisive for the application of the provision whether the work function is performed from ashore rather than at sea. However, a remote operator's right to limitation of liability is connected with uncertainty, especially if the remote operator has not been hired by the shipowner, but is an independent company acting as several shipowners' operator. It is recommended to reach international agreement about a remote operator's right to limitation of liability under the liability limitation convention since it would be central to the spread of autonomous ships.

On the other hand, the provisions on limitation of liability could hardly be extended to providing access to limitation of liability for manufacturers and programmers of autonomous ships' navigation systems since they would not be considered persons for whom the shipowner is liable.

4.8.4 The liability of manufacturers and programmers of navigation and communication equipment (hardware og software)

The liability of manufacturers and programmers of autonomous ships' navigation systems can occur for various reasons.

Vis-à-vis the buyer (the shipyard or the shipowner), the product supplied will under Danish law be subject to the defect concept and compensation principles of the law of sales, which will not allow for limitation of liability unless an express agreement has been made hereon. Defects in supplies under the law of obligations, which do not impose damage on other things or persons, can normally not be covered through insurance, but will be considered the manufacturer's or programmer's business risk.

According to general principles of the law of obligations, the shipowner will have an examination- and inspection- and maintenance obligation in relation to the equipment supplied.

¹⁴⁶ Convention on Limitation of Liability for Maritime Claims, London 1976, as amended by the Protocol of 1996.

Furthermore, manufacturers and programmers could be liable pursuant to the regulations on product liability to the extent that their products and services cause injuries to persons or damage to objects.

The regulation of product liability is a national issue and varies from one jurisdiction to another. For the EU member States, the product liability directive¹⁴⁷ and the associated legal practice does, however, ensure some harmonisation.

In addition to the product liability directive and the product liability act, the non-statutory product liability developed within legal practice¹⁴⁸ applies in Danish law. The principles hereof must be presumed to also apply to the placing of the liability of manufacturers and programmers of autonomous ships' navigation systems.

Finally, manufacturers and programmers could be subject to the professional liability of advisers based on strict culpa liability¹⁴⁹ to the extent that they must be assumed to have provided independent advice in addition to their product or service.

In Danish law, manufacturers and programmers' contractual liability will, to a wide extent (*vis-à-vis* for example shipyards and shipowners), be subject to negotiations on the basis of the principle of freedom of contract. The extent of liability, including any limitation of liability for categories of loss and in terms of value, will thus be reflected in the negotiation position.

Limitation of liability for manufacturers and programmers' of autonomous ships' navigation systems could only occur contractually with the restrictions on the right to limitation of liability and agreement requirements applicable to the choice of law of relevance to the contract. Non-contractually, manufacturers and programmers of autonomous ships' navigation systems will not be entitled to limitation of liability unless something else follows from the relevant choice of law, which is not the case in Danish law.¹⁵⁰

There is hardly reason to presume that changes will be made to the liability norm of manufacturers and programmers, but they will presumably be exposed to more liability. Against this background, central maritime suppliers to autonomous ships will assume a part of the shipowner's operational risk and, to a higher degree, risk being met directly with claims from third parties or be met with recourse claims from shipyards or shipowners (and their insurance companies) to the extent that their supplies must be considered to have caused damage resulting in claims against the shipowner and his insurance companies from third parties. In relation to non-contractual claims, risk management will be difficult.

The increased exposure to liability, both in terms of direct claims from the injured party and recourse claims from shipyards or shipowners, combined with an unknown damage record for autonomous ships could be of importance to manufacturers and programmers' possibilities of being covered by insurance and to the size of their insurance rates. Lacking possibilities of insurance coverage (or too high insurance rates) could present a commercial barrier to the development of autonomous ships.

¹⁴⁷ Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products, transposed into Danish law through the product liability act (consolidated act no. 261 of 20 March 2007).

¹⁴⁸ Dahl, B as well as Schönbeck.

¹⁴⁹ See on professional liability, Von Eyben, Bo and Isager, pp. 119ff.

¹⁵⁰ However, Danish law contains a legal basis for exemption of or limitation of liability due to special circumstances in section 24 of the liability in damages act (consolidated act no. 266 of 21 March 2014, as amended). Section 24 of the liability in damages act covers both contractual and non-contractual liability, but the legal basis has seldom been used in business. See on the liability in damages act, Von Eyben, Bo and Isager, Helle, pp. 489ff. In addition to the liability in damages act, the exemption of or limitation of liability could, in special contractual cases, take place with its legal basis in section 36 of the law of contracts.

All in all, the distribution and convergence of liability between equipment manufacturers, software suppliers, shipyards and shipowners in relation to autonomous ships will presumably give rise to new contractual problems.

Increased focus must be expected on the extent of liability and guarantees in contracts between designers, manufacturers, shipyards and shipowners. Great focus must be expected to be on the fact that manufacturers will only guarantee that their own supply is free of defects and will not vouch for the integration with other on-board equipment (interface risk) or give a "fit for purpose" guarantee.

Until standards as such are established for machine learning, liability regulation must be expected to be based on general principles of compensation law.

To the sparse extent that legal theory has dealt with liability in connection with machine learning and autonomous systems, especially in relation to autonomous cars, the recommendation is that liability regulation should await a larger degree of technological maturity and that focus should be on the regulation of the *"training and testing of machine learning technologies"*.¹⁵¹ Furthermore, the liability regulation of machine learning raises a number of ethical issues in relation to safety and "accountability", where the technology suppliers will presumably have to take account of (i) requirements for data storing and exchange when it comes to establishing the reason for unintended incidents, (ii) requirements for the design, development and tests of autonomous systems as well as documentation requirements in this connection, and (iii) the prioritisation of ethical considerations related to the programming of algorithms.¹⁵²

There is reason to presume that the new players in autonomous shipping, such as remote operators and software programmers/manufacturers of navigation systems, will give rise to regulatory introduction of new standards for good operation of autonomous ships, which are imposed on shipowners/operators as well as new certification requirements for component manufacturers/software developers of navigation systems for remotely controlled as well as fully autonomous ships. The extent and contents of standards and certification requirements may be of importance to the placing of liability.

4.8.5 Carriage of goods – seaworthiness and liability

General cargo

Both the Hague¹⁵³ and the Hague-Visby rules¹⁵⁴ (transposed into Danish law through part 13 of the merchant shipping act on the carriage of general cargo) contain obligations for the shipowner as regards seaworthiness:

"Art. 3.

1. The carrier shall be bound before and at the beginning of the voyage to exercise due diligence to:

(a) Make the ship seaworthy.

(b) Properly man, equip and supply the ship.

(c) Make the holds, refrigerating and cool chambers, and all other parts of the ship in which goods are carried, fit and safe for their reception, carriage and preservation."¹⁵⁵

Section 262(2) of the merchant shipping act, which transposes article 3 of the Hague and the Hague-Visby rules into Danish law, has the following wording:

¹⁵¹ Reed, Kennedy and Sliva, pp. 26ff.

¹⁵² Ibid.

¹⁵³ International Convention for the Unification of Certain Rules of Law relating to Bills of Lading, Brussels, 25 August 1924 (the "Hague Rules"), art. 3(1)(a).

¹⁵⁴ The Hague Rules as amended by the 1968 Protocol (the "Hague-Visby Rules") art. 3(1)(a).

¹⁵⁵ Section 262(2) of the merchant shipping act.

"The carrier shall ensure that the ship to be used for the carriage is seaworthy, including that it is properly manned and equipped and that the holds, refrigerating and freezer chambers and all other parts of the ship in which goods are loaded, are in good condition for their reception, carriage and preservation."

Section 262(2) of the merchant shipping act extends the seaworthiness obligation to the entire carriage and not only *"before and at the beginning of the voyage"*, as stipulated in article 3(1) of the Hague and Hague-Visby rules.

In relation to autonomous ships, it must be presumed that ships at autonomy levels RU and A will, as regards article 3 of the Hague and Hague-Visby rules, be considered seaworthy to the extent that they are, technically and in terms of safety, capable of operating without a crew, cf. also section 4.5.1.

However, seaworthiness challenges will arise if the ship encounters any challenges the handling of which require human presence on board the ship, despite the seaworthiness obligation under article 3(1) of the Hague and Hague-Visby rules.

Furthermore, the Hague and Hague-Visby rules, article 3(2), contains an obligation on the part of the shipowner to *"care for the cargo"*:

"Art. 3

(2) Subject to the provisions of Article 4, the carrier shall properly and carefully load, handle, stow, carry, keep, care for, and discharge the goods carried."

In Danish law, the carrier's obligation to care for the goods has been implemented in section 262(1) of the merchant shipping act with the following wording:

"The carrier shall perform the carriage with appropriate care and dispatch, take care of the goods and otherwise safeguard the interests of the owner from receipt to delivery of the goods."

Today, these obligations are to a wide extent undertaken by the master and the crew as the shipowner's representatives. The obligations could present a barrier to unmanned autonomous ships (levels RU and A) to the extent that it is not technically possible to arrange/equip the ships with technical functions capable of monitoring and handling the goods and thus of performing the same function as that performed by the crew today on board ships depending on the type of goods.

A special problem may arise for unmanned autonomous ships in relation to the handling/disposal of dangerous goods during the ship's voyage, both in the form of goods that have been declared non-hazardous, but that turn out to be hazardous, and goods that have been declared hazardous and a threat to the seaworthiness of the ship and the other goods on board.

The scope of application of the Hague and Hague-Visby rules, article 4(2)(a) (transposed into Danish law through section 276(1)(i) of the merchant shipping act), on exemption from liability for *"Act, neglect, or default of the master, mariner, pilot, or the servants of the carrier in the navigation or in the management of the ship"* will need to be clarified in relation to autonomous ships. For ships at autonomy levels R and RU, the remote operator will presumably be considered the *"pilot"* in relation to the ship's navigation, but fault committed in *"the management of the ship"* by other shore-based persons in the shipowner's organisation or by partners will not necessarily fall within the scope of application of the provision.

In relation to ships at autonomy level A, it is hardly possible to claim exemption from liability for navigation errors considering that it is a question of pre-programmed algorithms and not navigation errors due to a simultaneous decision.

Chartering of ship and charter parties

The concept of seaworthiness has also been defined in relation to the other types of chartering covered by the merchant shipping act.

Section 327 of the merchant shipping act contains a definition of the concept of seaworthiness in relation to voyage charters:

"The voyage owner shall ensure that the ship is seaworthy, including that it is properly manned and equipped and that the holds, refrigerating and freezer chambers and all other parts of the ship in which goods are loaded are in good condition for their reception, carriage and preservation."

In relation to time chartering, section 372(2) of the merchant shipping act contains the following requirements for seaworthiness:

"On delivery, the time owner shall ensure that the condition of the ship, the required certificates, manning, provisioning and other equipping of the ship fulfil the requirements for ordinary carriage trade within the trading limits stipulated in the chartering agreement."

When concluding charter parties, the provisions of the merchant shipping act will only have a judicial nature (non-mandatory) since the specific terms agreed in the charter party will take precedence considering the general principle of freedom of contract under the law of obligations.

Though both the "standard forms" typically used for charter parties and part 14 of the merchant shipping act contain requirements for ships' seaworthiness, equipment and manning, this will not present a barrier to autonomous ships under Danish law since the parties to the transport agreement are free to agree on terms adjusted to the specific ship.

On the other hand, seaworthiness will presumably give rise to problems in relation to charter parties subject to the choice of law in jurisdictions where seaworthiness in the form of manning is a mandatory condition. This is especially relevant in connection with the widespread use of English law in international freight transport.

4.8.6 The taking and securing of evidence

Traditionally, evidence from the master and the crew as well as the contents of ship logs, engine logs and radio logs have been central to the elucidation of the civil liability of ships as well as in relation to the authorities' accident investigations.¹⁵⁶

Furthermore, SOLAS, chapter V, regulation 20 (as well as Annex 10 to chapter V), requires ships (depending on type, date of construction and gross tonnage) to be equipped with a Voice Data Recorder (VDR), which continuously records on-board communication.

For autonomous ships, it must be expected that satisfactory technical solutions will need to be found in relation to the securing of evidence. In this connection, international requirements should be made within the IMO for electronic logging of data on ships' operation (including course, speed, planned voyage, etc.). Considering the fact that autonomous ships are continuously connected with land in relation to communication and data exchange, provisions should be laid down stipulating that operating data should be stored in more than one place in

¹⁵⁶ See, for example, part 18 of the merchant shipping act on ship logs, marine enquiries, etc.

order to ensure access to them in case of incidents. In connection with the taking of evidence, this will be a major improvement compared to a locally placed VDR.

In addition, it will be central to log who is in control of autonomous ships in relation to the placing of liability as well as changes to the autonomy level. This should be done on the basis of the use of electronic certificates by those responsible when changing the watch/taking over control of the ship.

In Danish law, the Danish Maritime Accident Investigation Board has been established in pursuance of section 4(3) of the act on safety at sea. The act on safety investigations of accidents at sea¹⁵⁷ contains the regulation of the Danish Maritime Accident Investigation Board and contains the Danish implementation of directive 2009/18/EC of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector.

Section 8 of the act contains regulations of relevance to the taking of evidence since it requires the shipowner, the master and the chief engineer and anyone acting on behalf of these:

“to ensure that all information that may be considered relevant to the investigative work is made available to the accident investigation board, including that information from charts, log books, electronic and magnetic recording and video tapes, VDRs and other electronic devices relating to the period preceding, during and after an accident are saved and that such information is not overwritten, altered or interfered with by other equipment.”

The obligation is also extended to *“others affected by a marine casualty or incident and who have in their possession charts, log books, electronic and magnetic recording and video tapes, VDRs or other electronic devices of relevance to the investigative work.”*

4.8.7 Liable parties under criminal law

Criminal law constitutes a central part of States' sovereignty and is, consequently, a purely national issue. For this reason, the criminal conditions applicable to shipping differ from one jurisdiction to another.

Each individual jurisdiction lists different requirements for the required degree of mental capacity to be liable to punishment, ranging from intent to various degrees of negligence. Furthermore, not all jurisdictions justify liability to punishment for legal persons as is the case in Danish law.

The parties liable for compliance with regulatory requirements for shipping are traditionally the master and the shipowner. It must be presumed that society will have an interest in a remote operator being liable to punishment to the extent that he assumes the obligations imposed on the master under current law. Criminal enforcement vis-à-vis remote operators could be connected with difficulties, cf. also section 4.5.8.

Considering the fundamental criminal principle that punishment can be imposed only for conditions the criminality of which is based in law, cf. section 1(1) of the penal code, amendments will have to be made to the acts containing the legal basis for making the master the party liable to punishment in order to impose liability to punishment on the remote operator. In Danish law, the legal basis for which person to charge will, however, often be given in abstract terms, such as *“anyone violating”*. If this is the case, it will not be necessary to amend the legal basis for punishment.

¹⁵⁷ Act no. 457 of 18 May 2011. The act implements directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 on the basic principles of investigations of accidents in the maritime transport sector and amending Council directive 1999/35/EC and directive 2000/59/EC of the European Parliament and of the Council.

4.8.8 Insurance issues

4.8.8.1 General issues

The shipowner's possibility of covering his risk and exposure to liability through insurance is decisive for commercial shipping.

In relation to the spread of autonomous ships, it is necessary to find acceptable solutions to the distribution of the changed risk that the new technology will imply. The current system with a strict liability norm for the shipowner, combined with the right to exemption from liability and limitation of liability pursuant to internationally recognised conventions, has resulted in an effective insurance market.

Major changes of the risk scenario of an industry, including especially the introduction of new and unknown risks without any precedents and claims record, will result in uncertainty as regards the extent of coverage and the size of the insurance premium. A too expensive or non-transparent insurance market could present a considerable systemic barrier to autonomous ships.¹⁵⁸

In this connection, P&I and Hull & Machinery insurance companies will need to take a stance on the actual value of recourse claims against manufacturers and programmers of navigation and communication equipment (hardware and software) in case of major damage. In this connection, the extent of the coverage and the limit of cover in the manufacturers' and programmers' liability insurance and product liability insurance will be central so that the P&I and Hull & Machinery insurance companies are not left with the recourse claims that are not covered by insurance and cannot be collected from the liable injurious manufacturers and programmers.

The distribution of risk between P&I and Hull & Machinery insurances in case of collision will presumably also give rise to considerations. It is not certain that the current distribution of risk can be continued in relation to autonomous ships. However, this is a commercial rather than a regulatory issue.

Clarity about the international regulatory framework conditions must be presumed to be a necessary precondition for a well-functioning and effective insurance market for autonomous ships.

4.8.8.2 The concept of seaworthiness under insurance law

The concept of seaworthiness in insurance law is not the same as that in chartering law (section 4.8.5) or the concept of technical seaworthiness (section 4.7.12), but it contains similar elements.

The concept is central to marine insurance. Roughly speaking, a ship will be considered not seaworthy under insurance law if it is not in such a condition – in terms of manning and equipment – as it should be according to a seamanlike assessment for the voyage to be undertaken. It must be especially assessed whether any defects identified will result in a greater risk than normally of total loss or damage to the ship, considering its voyage.

Section 114 of the marine insurance convention and section 63 of the act on insurance agreements¹⁵⁹ require a ship to be "*seaworthy, properly outfitted and manned*".

The word "*properly*" opens up for an interpretation of which equipment and manning would be appropriate for each individual ship considering the specific type and voyage. It is a flexible concept, where it is decisive whether the ship is seaworthy from a seamanlike objective assessment. As regards manning, both low manning and no manning could be presumed to be appropriate if the ship is considered seaworthy in terms of safety. It cannot be presumed that the wording "*properly outfitted and manned*" requires ships to be manned.

¹⁵⁸ Global Marine Technology Trends.

¹⁵⁹ Consolidated act no. 1237 of 9 November 2015.

According to section 114 of the Danish marine insurance convention, the insurer will be exempted from covering losses only if the loss is a consequence of the ship not being seaworthy and *"neither the ship's master nor the insured person (shipowner) knew or should realise that the ship was not seaworthy."*¹⁶⁰ In relation to ships at autonomy levels R, RU and A, the remote operator must be considered the master.

The concept of seaworthiness was removed from the Nordic Marine Insurance Plan in 2007. According to the remarks to clause 3-22, which previously referred to the concept of seaworthiness, the amendment was made when the Norwegian act on seaworthiness was replaced by the act on ship safety, which contains extensive requirements for ships' safety. Considering the abundant amount of detailed regulation of ships by flag States and classification societies, it was considered to create a more homogeneous legal position if the concept of seaworthiness was removed.¹⁶¹

The English Marine Insurance Act 1906 stipulates the insurance terms for a large part of the marine insurance market. Section 39 of the Marine Insurance Act contains a so-called "implied warranty" that *"the vessel is reasonably seaworthy in all respects"*.

Uncertainty must be presumed to arise about the seaworthiness of autonomous ships under insurance law, which will affect the insurance market. Homogeneous technical standards and regulation will be important to ensure a functioning insurance market for the new risk presented by autonomous ship until a representative claims record is available.

4.8.8.3 Insurance of cyber risks

Especially in relation to cyber risks, there is a need to develop new insurance products.

Cyber risks cover a wide array of risks and types of loss, such as damage to objects, operating loss, theft, loss of immaterial rights, data loss and costs for data recovery, costs for court cases and investigations carried out by the authorities. In reality, the risks and types of loss that may arise from cyber attacks are not covered by traditional insurance products.

For example, the traditional types of insurance in shipping, especially P&I and Hull & Machinery insurances, normally do not cover cyber risks since they will typically contain a so-called *"institute cyber attack exclusion clause (CL 380)"*, which implies that there is no insurance cover for damage *"caused by or contributed to by or arising from the use or operation, as a means for inflicting harm, of any computer, computer system, computer software programme, malicious code, computer virus or process or any other electronic system"*.¹⁶² It is possible to take out a *cyber attack exclusion clause* against an extra premium.

Cyber insurance products have been developed, but it is uncertain whether the necessary cover is available in relation to the actual risks and extent of loss since the present cyber insurance products are collective arrangements (pools), where a major loss by one individual shipowner could in reality exhaust the other insured shipowners' possibility of being covered. Cyber insurances have not yet reached a level with a safe insurance market. In addition, there is,

¹⁶⁰ Falkanger, Bull and Rosenberg Overby, p. 556.

¹⁶¹ <http://www.nordicplan.org/Commentary/Part-One/Kapitel-3/Section-3/General/>.

¹⁶² Institute Cyber Attack Exclusion Clause CL 380 has the following wording:

"1.1 Subject only to clause 1.2 below, in no case shall this insurance cover loss, damage, liability or expense directly or indirectly caused by or contributed to by or arising from the use or operation, as a means for inflicting harm, of any computer, computer system, computer software programme, malicious code, computer virus or process or any other electronic system.

1.2 Where this clause is endorsed on policies covering risks of war, civil war, revolution, rebellion, insurrection, or civil strife arising therefrom, or any hostile act by or against a belligerent power, or terrorism or any person acting from a political motive, Clause 1.1 shall not operate to exclude losses (which would otherwise be covered) arising from the use of any computer, computer system or computer software programme or any other electronic system in the launch and/or guidance system and/or firing mechanism of any weapon or missile."

according to the insurance companies, a large gap between the actual cyber risk and the limited number of insurances taken out in the area and, thus, a large non-insured risk.

4.8.9 Regulation of liability and insurance within parallel regulatory areas

In connection with cars, the owner/user is strictly liable for any damage caused by the car under sections 101-104¹⁶³ of the road traffic act. This is combined with mandatory liability insurance, cf. sections 105-107 of the road traffic act.

The act amending the road traffic act, which stipulates the conditions for permits to test self-driving cars,¹⁶⁴ shows that the system with strict liability and mandatory liability insurance also applies to tests with self-driving cars. However, the liable party and the party insured has been amended from the "owner/user" to the "permit holder" during the test phase, cf. section 104(3) and section 106(3) of the road traffic act. It must be presumed that this applies only during the test phase and that, in the future when autonomous cars have been fully approved, the "owner/user" will still be the liable party and the one obliged to take out liability insurance.

In connection with trains, the railroad company is strictly liable for damage to passengers and luggage as well as property or persons not transported by the railroad company, just as railroad companies or infrastructure managers are required to take out mandatory liability insurance, cf. section 10 of the railway act¹⁶⁵ on compensation, insurance and dangerous goods.

The liability for damage to goods carried by railroad in international traffic is subject to international regulation in the CIM Convention.¹⁶⁶ The provisions of the CIM Convention cover the liability norm, reasons for exemption from liability as well as liability limitations amounts. The provisions of the CIM Convention also apply to national transport of goods by railroad, cf. section 53(3) of the railway act.

In connection with drones, mandatory liability insurance is also required, cf. the order on the flying of drones in urban areas, section 5,¹⁶⁷ as well as article 7 of regulation (EC) no. 785/2004 of the European Parliament and of the Council of 21 April 2004. However, the insurance sum is limited to SDR 0.75 million.

4.9 Cybersecurity and anti-terror safeguards

4.9.1 In general about cybersecurity

Cybersecurity and the handling hereof have been debated for years in the IMO Maritime Safety Committee. The IMO has drawn up an overall guideline for shipowners and the authorities on how to best address cyber threats in the maritime industry¹⁶⁸. There is general agreement in the IMO Maritime Safety Committee that precautions and procedures for countering cyber threats is a natural part of the ISM Code. In June 2017¹⁶⁹, it was decided that, no later than in connection with the annual verification of a ship's Document of Compliance after 1 January 2021, shipowners must have addressed cyber risk management as part of their safety management system (SMS).

Overall, weaknesses and threats in connection with increased autonomy relate to the following system areas:

- a) 'Bridge systems': Navigation systems communicating with shore-based networks for updates.
- b) 'Cargo management systems': Digital cargo systems communicating with shore-based networks.

¹⁶³ Consolidated act no. 38 of 5 January 2017.

¹⁶⁴ Act no. 696 of 8 June 2017.

¹⁶⁵ Act no. 686 of 27 May 2015. Detailed requirements for the mandatory liability insurance are stipulated in the order on liability insurance for railroad companies and railroad infrastructure managers (order no. 1461 of 15 December 2009).

¹⁶⁶ Uniform Rules Concerning the Contract of Carriage of Goods by Rail, as amended by the Protocol of 3 June 1999 (CIM – Appendix B to the COTIF Convention).

¹⁶⁷ Order no. 1119 of 22 August 2016.

¹⁶⁸ MSC-FAL.1/Circ.3 Guidelines on Maritime Cyber Risk Management, which replaced Interim Guideline (MSC.1/Circ.1526).

¹⁶⁹ Maritime Safety Committee (MSC), 98th session, 7-16 June 2017.

- c) 'Access & control systems': Digital systems monitoring the ship's condition.
- d) 'Communication systems': Internet access via satellite or wireless communication.
- e) 'Shore interface': Ships become more dependent on communication with land.
- f) Propulsion & machinery management, and power control systems': Digital systems monitoring and controlling machinery on board the ship.

In addition to the IMO Guidelines on Maritime Cyber Risk Management, guidelines have been developed on ships' cybersecurity by a number of industry organisations. The most widespread guidelines are "Guidelines on Cyber Security Onboard Ships", which have been drawn up and supported by the industry organisations BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI.

IMO – 'Guidelines on Maritime Cyber Risk Management'

BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF & IUMI – 'The Guidelines on Cyber Security Onboard Ships'

NIST, US – 'Framework for Improving Critical Infrastructure Cyber Security'

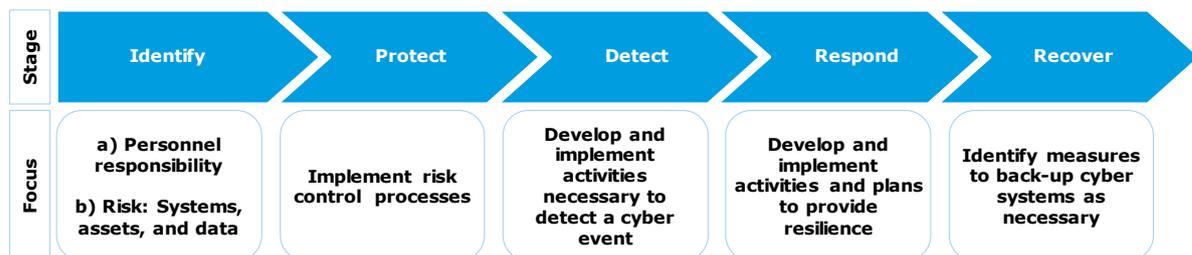
Department for Transport, UK – 'Code of Practice Cyber Security for Ships'

DNV-GL, 'Cyber security resilience management for ships and mobile offshore units in operation'

In addition, an ISO standard for cybersecurity has been drawn up (ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements. Published jointly by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC)).

The common denominators of these guidelines can be illustrated by [figure 8](#) below.

Figure 8: Common denominators for guidelines as well as weaknesses and threats of increased autonomy



In relation to cybersecurity, there generally seems to have been a change from risk avoidance to risk resilience and risk management as it has become widely recognised that it is a permanent threat under constant change. In this report, cyber risk management covers – in addition to security against hacker attacks and cyber piracy – quality assurance of communication equipment and data exchange with a view to reducing the risk of breakdown and unintended incidents.

Individual flag States have also, to a wide extent, published guidelines on cybersecurity. An example of a general guidelines is "United States National Institute of Standards and Technology's Framework for Improving Critical Infrastructure Cybersecurity (the NIST Framework)" as well as most recently from September 2017 an example of a guidelines

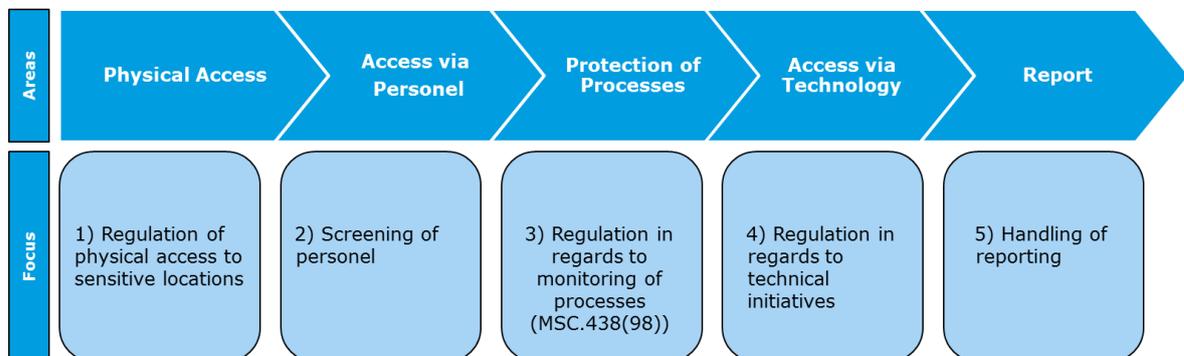
specifically aimed at shipping – “Code of Practise – Cyber Security for Ships” published by the Department for Transport, UK Government¹⁷⁰.

The Centre for Cybersecurity has developed the report *Threat Assessment: The cyber threat against the maritime sector (2007)*, which provides an overview of the risk level in the Danish maritime sector. It establishes that the cyber threat in the Danish maritime sector is aimed at the commercial level and that the level of threat from cyber criminals is considered ‘very high’. Sector-specific threats are especially aimed at theft and smuggling. However, the report characterises the level of threat in connection with destructive cyber attacks, cyber activism and cyber terror as ‘low’¹⁷¹.

Considering the fast change of the threat scenario and technologies (and hence the hacker methods) and the great difference between the organisation of shipowners depending on their type and size, it is our recommendation that cybersecurity be regulated via industry-established guidelines, which could be continuously amended and updated rather than via prescriptive convention-based regulation. The guidelines will establish an international standard of cybersecurity for shipping to be supplemented by the shipowner’s own assessment of its cyber risk management in its safety management system.

Figure 9 below presents potential areas of regulation.

Figure 9: Potential areas of regulation



4.9.2 Reporting of cybersecurity incidents

A major challenge in connection with cybersecurity is that the level of threat as well as the type and number of incidents are unknown.

The regulation of cybersecurity in shipping should establish an obligation for shipowners to report cybersecurity incidents to the flag State. Subsequently, the flag States could share knowledge about the type and number of cybersecurity incidents in anonymised form with other flag States as well as with shipowners and other relevant stakeholders, such as classification societies and insurance companies, in order to acquire an improved knowledge base for countering and planning a preparedness against cybersecurity incidents.

This attitude is supported by the Danish IT and the Danish Defence Intelligence Service, which expresses a wish to allow the Centre for Cybersecurity to share more of its otherwise secret knowledge about cyber threats with other authorities and companies in an appropriate manner.¹⁷²

The ISPS Code (mentioned below in section 4.9.5 on anti-terror safeguards) already contains mechanisms for exchanging information about security incidents. The ISPS Code defines security

¹⁷⁰ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/642598/cyber-security-code-of-practice-for-ships.pdf.

¹⁷¹ https://fe-ddis.dk/cfcs/CFCSDocuments/The_Cyber_Threat_to_the_Maritime_Sector_march.pdf.

¹⁷² <https://www.version2.dk/artikel/fe-chef-cybertrussel-mod-signalsystem-mit-indtryk-at-man-meget-opmaerksom-paa>.

incidents as “*any suspicious act or circumstance threatening the security of a ship, including a mobile offshore drilling unit and a high speed craft, or of a port facility or of any ship/port interface or any ship to ship activity.*”¹⁷³

The ISPS Code stipulates that its aim is to ensure early and effective collection and exchange of security-related information¹⁷⁴ and that it is a functional requirement for shipowners, ships and port facilities to collect and assess information related to security threats and the exchange of this information with the relevant contracting Parties.¹⁷⁵

Furthermore, the ISPS Code requires the ship security plan to contain procedures for the reporting of security-related incidents (Part A, regulation 9.4, item 12, of the ISPS Code) and regulation 12.2, item 8, imposes the obligation on the security officer of each individual ship to report security-related incidents to the relevant authority.

SOLAS chapter XI-2 on special measures to enhance maritime safety, from which the ISPS Code derives, contains in regulation 13 obligations on the part of Convention Parties to pass on to the IMO information about contact persons in the State for use in connection with ships’ reporting of security-related incidents and receipt of advice as well as to make contact details available to shipowners and ships. Thus, Convention Parties are intended to have a role to play as the contact point for the collection and sharing of security-related information.¹⁷⁶ It would be reasonable to use this system for collecting knowledge about cybersecurity incidents. In this connection, the ISPS Code should be supplemented by requirements for the degree of detail in the information on cybersecurity incidents that shipowners, ships and ports are obliged to report to a Convention Party.

In Danish law, section 4(3) of the act on safety at sea also contains a legal basis for the Minister for Industry, Business and Financial Affairs to “*lay down regulations on the obligation to notify the Danish Maritime Authority about accidents and other incidents at sea and on the authorities’ notification hereof to the European information platform for accidents at sea.*” This legal basis could be used to issue provisions on reporting obligations related to cybersecurity incidents in Danish law.

4.9.3 The NIS directive

In order to enhance the safety and reliability of net- and information services within the EU and to strengthen the movement of goods, services and persons across the borders of the internal market through the establishment of a high common cybersecurity level, the European Parliament and the Council have adopted the NIS directive.¹⁷⁷ The NIS directive requires member States to appoint public and private “operators of essential services” (OES) within a number of sectors, including the transport sector. In relation to shipping, the following have been defined as operators of essential services:

- *Inland, sea and coastal passenger and freight water transport companies, as defined for maritime transport in Annex I to Regulation (EC) No 725/2004 of the European Parliament and of the Council, not including the individual vessels operated by those companies*

- *Managing bodies of ports as defined in point (1) of Article 3 of Directive 2005/65/EC of the European Parliament and of the Council, including their port facilities as defined in point (11) of Article 2 of Regulation (EC) No 725/2004, and entities operating works and equipment contained within ports*

¹⁷³ SOLAS chapter XI-2 on special measures to enhance maritime safety, regulation 1(1)(13).

¹⁷⁴ ISPS Code, Part A, regulation 1.2, item 3.

¹⁷⁵ ISPS Code, Part A, regulation 1.3, item 1.

¹⁷⁶ Cf. also SOLAS chapter XI-2 on special measures to enhance maritime safety in regulation 7.

¹⁷⁷ Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union.

— *Operators of vessel traffic services as defined in point (o) of Article 3 of Directive 2002/59/EC of the European Parliament and of the Council*

Furthermore, the NIS directive covers digital service providers (DSPs) which are defined as “online marketplaces, online search engines and cloud computing services” in annex III to the directive pursuant to article 4(5) of the directive. Companies covered by the definition of micro-companies and small companies in Commission recommendation 2003/361/EC of 6 May 2003 on the definition of micro-companies, small and medium-sized companies are not obliged as DSPs under the NIS directive.

The OESs and DSPs appointed are obliged to introduce organised information security work – both technically and organisationally – in order to manage the risks related to their systems. More specifically, operators are required to take precautions to prevent and minimize the consequences of incidents so as to secure the continuity of the service and to document their security policies.

In addition, the NIS directive imposes obligations on both OESs and DSPs to notify the national competent authority as soon as possible about security incidents with essential (OES) or important (DSP) consequences to the continuity of the services.

In certain circumstances, the authorities can choose to inform the general public about a specific security incident. This takes place after having consulted the reporting OES or DSP that has experienced the security incident. There is a wider possibility of publishing specific incidents at DSPs than at OESs.

Considering that Denmark has not yet appointed OESs and that the wording of Danish implementation law is not yet known (the directive must be transposed into the law of the member States by 9 May 2018 at the latest), it is uncertain which importance the NIS directive will have.

However, the obligations of the NIS directive will presumably not present barriers to autonomous ships, but must rather be considered a step towards promoting cybersecurity within the transport sector, which will support the digitalisation of shipping and the spread of autonomous ship technologies.

The implementation council recommends making the specific implementation of the provisions on risk assessments, security precautions and the reporting obligation homogeneous in the member States and that Denmark does not go beyond the requirements stipulated in the directive¹⁷⁸ from the political side.

4.9.4 Risk management according to the ISO27000 standards

The ISO27000 series consists of a number of inter-related standards. The purpose is to establish international standards for the management of information security in organisations.

Some of these standards are normative and, thus, contain requirements (such as ISO27001 and ISO27006), while others are guiding in relation to various aspects of the implementation of a management system for information security.¹⁷⁹

ISO27001 contains requirements for the implementation and maintenance of an information security management system. In Denmark, ISO27001 has been chosen as a State security standard according to DS484 and compliance with it has been mandatory for Government

¹⁷⁸ See recommendations adopted at an Implementation Council meeting held on 29 September 2016 at <http://star.dk/da/Om-STAR/Nyt-fra-STAR/Nyheder/2017/06/Implementeringsraadet-sender-8-anbefalinger-og-en-liste-over-byrdefulde-eu-retsakter.aspx> (accessed most recently on 30 November 2017).

¹⁷⁹ <https://www.digst.dk/informationssikkerhed/Implementering-af-ISO27001/Implementering-af-ISO27001/Hvad-er-ISO27001>.

institutions since January 2014. The standard must have been implemented by the authorities by early 2016. Below is an overview of the most important standards of the 27000 family (some of these standards are still being drafted).¹⁸⁰

Figure 10: The ISO27000 series

| ISO Standard | Area | Description |
|--------------|------------|--|
| ISO27000 | Guidelines | Contains an overview of the 27000 family as well as the definitions and preconditions used in the rest of the standards. |
| ISO27001 | Normative | Contains requirements for the implementation and maintenance of an information security management system. |
| ISO27002 | Guidelines | Contains a list of generally recognised controls to be used as help when choosing and implementing the controls required to acquire suitable information security in a given organisation. |
| ISO27003 | Guidelines | Contains guidelines on the implementation of ISO/IEC 27001. |
| ISO27004 | Guidelines | Contains guidelines on how to measure the efficiency of an information security management system. |
| ISO27005 | Guidelines | Contains guidelines on risk assessments and management. |
| ISO27006 | Normative | Contains requirements for organisations that are to certify other organisations according to ISO/IEC 27001. |
| ISO27007 | Guidelines | Contains guidelines on how to carry out a revision of an information security management system. |

In all organisations, risks are, to a higher or lower degree, related to the use of systems, information and data. Not all risks can be removed completely, but they can be managed through a systematic approach.¹⁸¹

As is evident from the table above, ISO27005 concerns guidelines on risk assessments and management. ISO27005 consists of three parts: 1) risk identification, 2) risk analysis and 3) risk evaluation.

The purpose of risk management is to enable the organisation's management to prioritise their resources in terms of added value. Risk assessments make the management aware of current risks so that the organisation is not exposed to risk beyond the acceptable. The below model from the report (2015) published by the Danish Agency for Digitisation, 'Guidelines on IT risk management and assessment' (Vejledning i it-risikostyring og vurdering – in Danish) illustrates the risk management process¹⁸².

¹⁸⁰ <https://www.digst.dk/informationssikkerhed/Implementering-af-ISO27001/Implementering-af-ISO27001/Hvad-er-ISO27001>

¹⁸¹ Report from the Danish Agency on Digitisation, 2015: 'Guidelines on IT risk management and assessment' (Vejledning i it-risikostyring og vurdering – in Danish).

¹⁸² Report from the Danish Agency on Digitisation, 2015: 'Guidelines on IT risk management and assessment' (Vejledning i it-risikostyring og vurdering – in Danish).

Figure 11: The risk management process

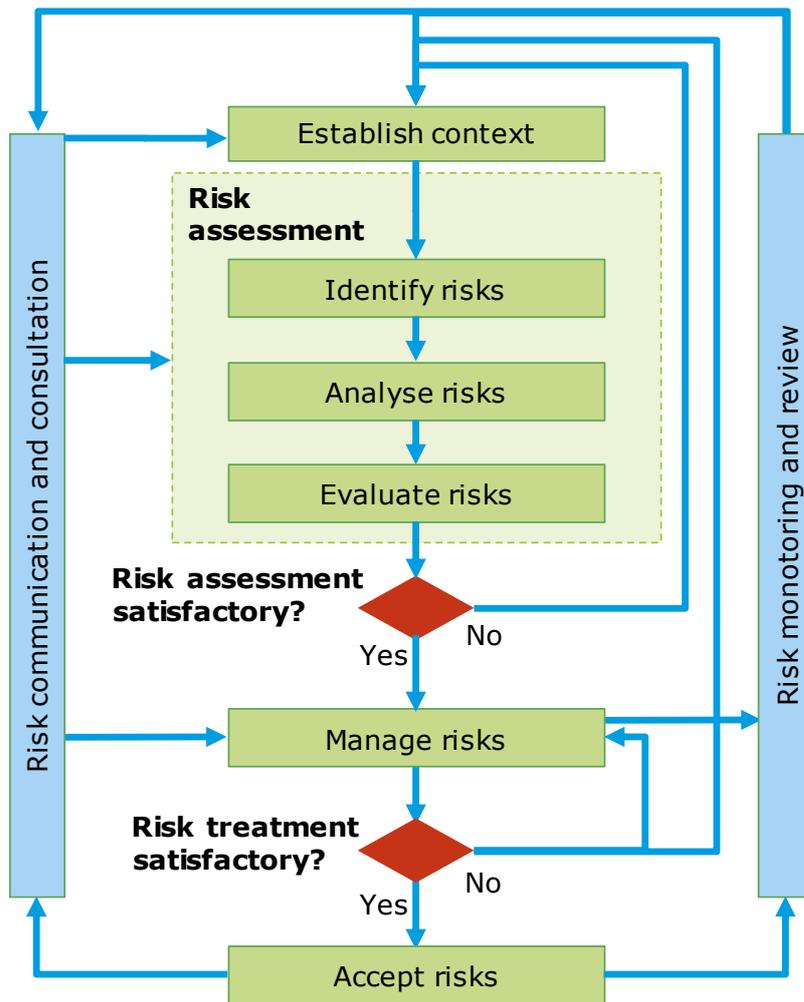


Illustration of the risk management process

Source: ISO27005

The risk management process illustrated in the above figure consists of six main activities: context establishment, risk identification, risk analysis, risk evaluation, risk management and risk acceptance. Three of the above-mentioned main activities concern a risk assessment (risk identification, risk analysis and risk evaluation). Reference is made to ISO27005 for a more detailed description.

In Denmark, it is only mandatory for Government institutions to observe ISO27001. As the autonomy level of ships is increasing, the need for ISO certification will also increase. In terms of regulation, it should be considered whether to require ISO27001- and ISO27005 certification of shipowners operating ships at autonomy levels R, RU and A.

4.9.5 Anti-terror safeguards

4.9.5.1 SOLAS chapter XI-2 and the ISPS Code

The ISPS Code¹⁸³, which is an appendix to SOLAS,¹⁸⁴ contains requirements for the security arrangements of ships, ports and Government authorities. Regulation no. 725/2004 of the European Parliament and of the Council of 31 March 2004 on enhanced security of ships and port facilities extends the ISPS regulations, which were actually intended to apply only to ships on international voyages so that they also apply to ship traffic within the European Union and its member States.

¹⁸³ International Ship and Port Facility Security Code (adopted on 12 December 2002 with entry into force on 1 July 2004). The ISPS Code was adopted following the terror attacks on 11 September 2001. The ISPS Code has been transposed into Danish law through the order on the security of port facilities (order no. 1462 of 30 November 2016).

¹⁸⁴ SOLAS chapter XI-2 on special measures to enhance maritime security.

In relation to autonomous ships, it is necessary to scrutinise the obligations imposed by the ISPS Code on shipowners and crews in terms of the attentiveness to security threats and the taking of preventive steps against episodes and threats affecting port facilities and international trade.

The ISPS Code is divided into Part A, which contains the mandatory requirements, and Part B, which contains guidelines on compliance with the mandatory requirements.

Regulation 7.2 of Part A of the ISPS Code contains obligations on ship security and requires controls and preventive measures to ensure (i) the access to ships, (ii) the embarkation of persons and goods, (iii) monitoring of deck areas and areas surrounding the ship, (iv) ongoing inspection of the cargo as well as (v) access to security-related communication.

Especially the requirement for preventive measures to secure access to security-related communication stipulated in regulation 7.2(7) is of relevance in connection with autonomous ships since the requirement will concern ships' protection against cyber attacks in relation to their communication link with land. Thus, already now assessments of the security risks related to ships' communication systems and links are required to form part of ships' security plan, cf. Part A, regulation 9, of the ISPS Code as well as Part B, regulation 8.10(5), of the ISPS Code.

This is supplemented by minimum requirements stipulated in Part A, regulation 9, of the ISPS Code for ships' mandatory security plans to contain procedures for countering security threats and breaches of security, including measures to be taken to maintain critical on-board or ship-to-port functions as well as procedures for securing inspection, testing, calibration and maintenance of all on-board security equipment (including the security alarm).

To the extent that autonomous ships do not have a crew on board (autonomy levels RU and A), it must be presumed that the obligations stipulated in regulations 7 and 9 could be met without any human interference if it is technically possible to bring about the same security level without any crew being physically present on board the ship, for example through the use of cameras, sensors and heat-sensitive or movement-sensitive scanners. It will presumably also be a possibility to operate in shipowner's ship security plan with a special port manning of an autonomous ship at autonomy levels RU and A with, including special procedures for such a port manning.

In addition to shipowners' obligation to appoint a general *company* security officer stipulated in Part A, regulation 11, of the ISPS Code, Part A, regulation 12, of the ISPS Code establishes an obligation for the shipowner to designate a security officer "*on board each individual ship*". The security officer is the central obligated party under the ISPS Code. To the extent that a security officer could perform his ship security functions without being physically on board by means of technical aids, the provision must be presumed – based on an interpretation of the purpose – to not present a barrier to autonomous ships at autonomy levels RU and A.

Pursuant to SOLAS chapter XI-2 on special measures to enhance maritime security, regulation 5(2), shipowners must ensure that the master has information on board about who is responsible for taking decisions about the use of the ship so that the master can pass on this information to the relevant authorities. It must be presumed that this function could be performed from land in relation to autonomous ships at autonomy levels RU and A by the one in control of the ship. This is supported by the wider definition of the master stipulated in the order on port facility security:¹⁸⁵ "*The master or any other person whom the shipowner has authorized to perform the master's obligations*".

SOLAS chapter XI-2, regulation 8, establishes the principle that the master's discretion in connection with the ship's safety and security cannot be set aside by instructions from the

¹⁸⁵ Section 2(xii) of the order on port facility security (order no. 1462 of 30 November 2016).

shipowner, others with decision competence over the ship (charterer or any other carrier), or any other person. The provision presupposes simultaneous human decision competence and a professional assessment, but it cannot be presumed to presuppose that the decision competence be exercised on board the ship if there is a person in some other place who could fill the same function. Thus, the provision will presumably present a barrier only to autonomous ships at autonomy level A that are not monitored by a human being with simultaneous decision competence.

APPENDIX 1 BIBLIOGRAPHY

Articles and reports, etc.

"AAWA White paper": White paper on Remote and Autonomous Ships of 21 June 2016 of the Advanced Autonomous Waterborne Applications Initiative (AAWA).

"Campbell, Abu-Tair and Naeem": 'An Automatic COLREGs-compliant obstacle avoidance system for an unmanned surface vehicle', (2014) 228(2), Journal of Engineering for the Maritime Environment.

"Carey": All hands off deck? The legal barriers to autonomous ships, Ms Luci Carey, Research Associate, Centre for Maritime Law, Faculty of Law, National University of Singapore ("NUS"), NUS Centre for Maritime Law Working Paper 17/06, NUS Law Working Paper 2017/011.

"Cartner, Fiske and Leiter": Cartner, John A.C., Fiske, Richard P., Leiter, Tara L, The international Law of the Shipmaster, Informa 2009.

"CMI Position Paper": CMI International Working Group Position Paper on Unmanned Ships and the International Regulatory Framework, Birch Reynardson et al., 29 March 2017.

"Report of the Danish Agency for Digitisation", 2015: 'Guidelines on IT risk management and assessment' (in Danish).

"Global Marine Technology Trends": Global Marine Technology Trends 2030 published by Lloyds Register, QinetiQ and University of Southampton, August 2017.

"Herman Bruserum": The carrier's responsibility for the physical properties of the ship: Liability basis. Marjus 294 (Oslo 2002) (in Norwegian).

"IMarEST": Institute of Marine Engineering, Science & Technology (IMarEST) – Written evidence (AUV0064) of 26 October 2016 on Autonomous Vessels.

"Lloyd's Register Foundation": Foresight Review of Robotics and Autonomous Systems, LLOYD's Register Foundation, October 2016.

"Reed, Kennedy and Sliva": 'Responsibility, Autonomy and Accountability: legal liability for machine learning' Queen Mary University of London, School of Law, Legal Studies Research, Paper No 243/2016.

"Report on Automated and Connected Driving": Report on Automated and Connected Driving by the Ethics Commission appointed by the German Federal Minister for Transport and Digital Infrastructure – June 2017.

"Serdy, Tsimplis, Veal et al.": A Serdy, M Tsimplis, R Veal et al., Liability for Operation in Unmanned Maritime Vehicles with Differing Levels of Autonomy (European Defence Agency, Brussels, 2016).

"Sozer": Analysis of the definitions of a "ship" in a number of international maritime conventions by Dr. Bulent Sozer, Turkey, enclosed as an annex to the CMI Working Group on Ship Nomenclature, available from the CMI website:

<http://comitemaritime.org/Uploads/Work%20In%20Progress/Ship%20Nomenclature/Ltr%20to%20Presidents%20re%20IWG%20on%20Vessel%20Nomenclature%20-%20080316.pdf>

"Threat Assessment": The cyber threat against the maritime sector, Threat Assessment by the Danish Defence Intelligence Service's Centre for Cyber Security (CFCS) – March 2017.

"Van Hooydonk": E Van Hooydonk: "The law of unmanned merchant shipping – an exploration", [2014], *Journal of International Maritime Law* 403.

"Veal and Tsimplis": R. Veal and M Tsimplis: "The integration of unmanned ships into the lex maritima", [2017]. *Lloyd's Maritime and Commercial Law Quarterly* 303.

Codes of Conduct, Guidelines, etc.

"Code of Practice Cyber Security for Ships", Department for Transport, UK, September 2017.

"Design Code": Design Code for Unmanned Marine Systems – Lloyd's Register, February 2017.

"Framework for Improving Critical Infrastructure Cyber Security", NIST, US, January 2017.

"Guidelines on Maritime Cyber Risk Management", IMO, July 2017.

"Maritime UK Industry Code of Practice", version 1.0, November 2017.

"MASS Code of Conduct": The Maritime Autonomous Systems Surface, MAS(S) Industry Code of Conduct made by the UK Marine Industries Alliance, March 2016.

"ShipRight Procedure": Cyber-enabled Ships – ShipRight procedure – autonomous ships, Lloyd's Register, first edition, July 2016.

"The Guidelines on Cyber Security Onboard Ships", BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF & IUMI, July 2017.

Legal literature

"Blume": P. Blume, *The legal system and legal methodology*, 3rd ed., 2016 (in Danish).

"Bredholt, Martens, Mathiasen and Philip": J. Bredholt, J. Martens, J. V. Mathiasen and A. Philip, *The merchant shipping act with comments*, 4th ed., 2012 (in Danish).

"Brækhus": S. Brækhus, *The concept of a ship*, Marjus 5 (Oslo 1975) (in Danish).

"Dahl, B:" B. Dahl, *Product liability*, Juristforbundets Forlag, 1973 (in Danish).

"Dyre Jespersen": J. Dyre Jespersen, *Shipping regulations I & II*, 3rd ed., 2012 (in Danish).

"Evald": J. Evald, *Legal theory, methodology and science*, 1st ed., 2016 (in Danish).

"Falkanger, Bull and Rosenberg Overby": T. Falkanger, H.J. Bull and L. Rosenberg Overby, *Maritime law*, 4th ed., 2013 (in Danish).

"Hansen and Werlauff": J. Hansen and E. Werlauff, *The legal methodology – an introduction*, 2nd ed., 2016 (in Danish).

"Herman Bruserum": H. Bruserum, *The carrier's liability for the physical properties of the ship: The liability basis*. Marjus 294 (Oslo 2002) (in Norwegian).

"Pedersen": P.V. Pedersen, *Transport law*, 1st ed., 2008 (in Danish).

"Schønbeck": A. Schønbeck, Product liability: overview and contractual handling, 1st ed., 2015 (in Danish).

"Von Eyben, Bo and Isager, Helle": B. Von Eyben and H. Isager, Textbook on the law of torts, 8th ed., Jurist- og Økonomforbundets Forlag, 2015 (in Danish).

APPENDIX 2

OVERVIEW – MAPPING OF REGULATION

| 1. Jurisdictional issues |
|---|
| A. IMO regulation |
| UNCLOS (United Nations Convention on the Law of the Sea, 1982) |
| United Nations Convention on Conditions for Registration of Ships (1986) |
| B. International regulation |
| Vienna Convention on the Law of Treaties of 23 May 1969 |
| Paris Memorandum of Understanding (Paris MoU), 1982 |
| Directive 2009/16/EC of the European Parliament and the Council of 23 April 2009 on Port State Control |
| Memorandum of Understanding on Port State Control in the Asia-Pacific Region (Tokyo MOU), December 1993 |
| The Latin American Agreement on Port State Control of Vessels, November 1992 |
| C. Danish regulation |
| Customs act (consolidated act no. 1223 of 20 September 2016, as amended) |
| Order on customs clearance (order no. 403 of 3 May 2012) |
| Act on the Danish International Register of Shipping (consolidated act no. 68 of 17 January 2014) |
| Order on the Danish International Register of Shipping (order no. 1157 of 1 October 2013) |
| Order on the registration of ships that are not considered to have a Danish owner (order no. 1132 of 25 September 2013) |

| 2. Navigation and regulations for preventing collisions at sea |
|--|
| A. IMO regulation |
| COLREG (IMO Convention on the International Regulations for Preventing Collisions at Sea, 1972) |
| UNCLOS (United Nations' Convention on the Law of the Sea, 1982) |
| STCW (IMO International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978) |
| Polar Code (International Code for Ships Operating in Polar Waters, 2015) |
| Convention on Limitation of Liability for Maritime Claims, 1976 |
| B. EU regulation |
| Directive 2002/59/EC of the European Parliament and of the Council establishing a Community vessel traffic monitoring and information system, as amended by directive 2009/17/EC of the European Parliament and of the Council |
| Directive 2010/65/EU of the European Parliament and of the Council on reporting formalities for ships arriving in and/or departing from ports of the Member States and repealing directive 2002/6/EC |
| C. Danish regulation |
| Danish pilotage act (act no. 352/2016) |
| Act delimiting territorial waters (act no. 200 of 7 April 1999) |
| Act on exclusive economic zones (act no. 411 of 22 May 1996) |
| Act on ports (consolidated act no. 457 of 23 May 2012) |
| Merchant shipping act (consolidated act no. 75 of 17 January 2014, as amended) |
| Order on the issue of pilot certificates and pilotage exemption certificates (order no. 1077/2012) |
| Order on watchkeeping in ships (order no. 1758/2006) |
| Order on the regulations for preventing collisions at sea (order no. 1083/2009) |
| Order on navigation, etc. in Danish waters (order no. 779/2000) |
| Order on prohibition against navigation, anchoring and fishing, etc. in certain areas in Danish waters (order no. 135/2005) |
| Order on the ship reporting system BELTREP and navigation under the East Bridge and the West Bridge in the Great Belt (order no. 820/2013) |
| Order on the ship reporting system SOUNDREP and on reports when passing the Drogden dredged channel for ships whose height exceeds 35 metres (order no. 924/2011) |
| Order on United Nations Convention on the Law of the Sea of 10 December 1982 and the associated agreement of 28 July 1994 on the application of chapter XI of the convention (order no. 17 of 21 July 2005) |
| Order on technical regulation on a vessel traffic monitoring and information system in Danish waters and ports (order no. 1021 of 26 August 2010) |

| 3. Manning and “seafarers” of the future |
|--|
| A. IMO regulation |
| MLC (International Labour Conference (ILO)’s Maritime Labour Convention, 2006) |
| FAL (Convention on the Facilitation of International Maritime Traffic, 1965) |
| SAR (International Convention on Maritime Search and Rescue 1979) |
| The International Convention on Salvage, 1989 |
| B. International regulation |
| Directive 2005/36/EC of the European Parliament and of the Council of 7 September 2005 on the recognition of professional qualifications |
| United Nations Refugee Convention, 1958 |
| C. Danish regulation |
| Act on the manning of ships (consolidated act no. 74 of 17 January 2014) |
| Act on seafarers’ conditions of employment, etc. (consolidated act no. 73 of 17 January 2014) |
| Act on the Danish Government’s Seamen’s Service (consolidated act no. 70 of 17 January 2014) |
| Order on ships’ logs and radio logs (order no. 978 of 20 July 2007) |
| Order on insurance or other guarantee for covering the shipowner’s liability to the seafarers and the master in case of breach of the employment contract (order no. 1346 of 21 November 2016) |
| Act on the taxation of seafarers (act no. 386 of 27 May 2005) |
| The salaried employees act (consolidated act no. 81 of 3 February 2009) |

| 4. Protection of the marine environment |
|---|
| A. IMO regulation |
| MARPOL (IMO International Convention for the Prevention of Pollution from Ships, 1973) |
| Bunker Convention (IMO International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001) |
| HNS Convention (IMO Hazardous and Noxious Substances by Sea Convention, 1996) |
| CLC Convention (IMO International Convention on Civil Liability for Oil Pollution Damage, 1969) |
| International Maritime Dangerous Goods (IMDG) Code |
| OPRC (International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990) |
| B. Danish regulation |
| Act on protection of the marine environment (consolidated act no. 1033 of 4 September 2017) |
| Order on places of refuge and plans hereon (order no. 875 of 27 June 2016) |
| Order on reporting pursuant to the act on protection of the marine environment (order no. 874 of 27 June 2016) |
| Order on technical regulation on ship emergency preparedness plans in case of pollution accidents caused by hazardous or noxious substances (order no. 765 of 22 July 2009) |
| Order on the transfer of liquid cargoes between ships in Danish and Greenland territorial waters (STS operations) (order no. 570 of 4 June 2014) |
| Order on the reporting obligation of recipients of HNS substances carried in bulk by ship (order no. 1451 of 15 December 2014) |
| Order on the transfer of bunker oil between ships in Danish territorial waters (order no. 733 of 25 June 2007) |

| 5. Construction requirements and technical conditions for ships |
|---|
| A. IMO regulation |
| SOLAS (International Convention for the Safety of Life at Sea, 1974) |
| Load Line Convention (IMO International Convention on Load Lines (CLL), 1966) |
| B. EU regulation |
| Directive 96/98/EC of the European Parliament and of the Council on marine equipment, as amended by directive 2014/90/EU of the European Parliament and of the Council of 23 July 2014 |
| Directive 2009/16/EC of the European Parliament and of the Council of 23 April 2009 on Port State Control |
| Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 on special stability requirements for ro-ro passenger ships |
| Directive 2009/45/EC of the European Parliament and of the Council of 6 May 2009 on safety rules and standards for passenger ships, as amended by Commission directive 2016/844/EU of 27 May 2016 |
| C. Danish regulation |
| Act on safety at sea (consolidated act no. 72 of 17 January 2014) |
| Act on tonnage measurements of ships (consolidated act no. 71 of 17 January 2014) |
| Order on marine equipment (order no. 422 of 17 May 2016) |
| Order on Port State Control of ships (order no. 1195 of 12 November 2014) |
| Order on Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships (order no. 377 of 4 May 2009) |
| Order on Notice B from the Danish Maritime Authority, the construction and equipment, etc. of ships (order 1866/2015) |
| Order on Notice D from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of passenger ships in domestic trade (order no. 556 of 26 May 2011), as amended by order no. 516 of 22 May 2017. |

| 6. Liability, compensation and insurance issues |
|--|
| A. IMO regulation |
| Collision Convention (Convention for the Unification of Certain Rules of Law with respect to collisions between Vessels, 1910) |
| B. International regulation |
| Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council |
| Regulation (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004 on insurance requirements for air carriers and aircraft operators |
| International Convention for the Unification of Certain Rules of Law relating to Bills of Lading ("Hague Rules"), 1924 |
| The Hague-Visby Rules – The Hague Rules, as amended by the Brussels Protocol 1968 |
| Convention concerning International Carriage by Rail (COTIF), 1980 |
| C. Danish regulation |
| Danish Marine Insurance Convention of 2 April 1934 |
| Act on insurance agreements (consolidated act no. 1237 of 9 November 2015) |
| Order on insurance certificates as proof of coverage for maritime claims (order no. 1259 of 16 December 2011) |
| Order on certificates for confirmation of insurance or other guarantee for coverage of compensation liability in case of accidents during the carriage of passengers by sea (order no. 9 of 10 January 2013) |
| Order on insurance or other guarantee for coverage of the owner's liability in connection with wreck removal, etc. (order no. 27 of 20 January 2015) |
| Nordic Marine Insurance Plan of 2013, Version 2016 |
| Act on safety investigations of marine accidents (act no. 457 of 18 May 2011) |
| Road traffic act (consolidated act no. 1386 of 11 December 2013) |
| Penal code (consolidated act no. 1052 of 4 July 2016) |
| Railway act (consolidated act no. 686 of 27 May 2015) |
| Order on the flying of drones in urban areas (order no. 1119 of 22 August 2016) |

| 7. Cybersecurity and anti-terror safeguards |
|---|
| A. IMO regulation |
| ISPS CODE (International Ship and Port Facility Security Code) |
| International Safety Management Code (ISM Code) |
| B. EU regulation |
| Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 March 2004 on enhancing ship and port facility security |
| Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union |
| C. Guidelines |
| Guidelines on Cyber Security Onboard Ships, drawn up by the industry organisations BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI |
| MSC-FAL.1/Circ.3, IMO Guidelines on Maritime Cyber Security Management |
| ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements |
| United States National Institute of Standards and Technology's Framework for Improving Critical Infrastructure Cybersecurity (the NIST Framework) |
| Code of Practice – Cyber Security for Ships published by the Department for Transport, UK Government |
| D. Danish regulation |
| Order on port facility security (order no. 1462 of 30 November 2016) |

APPENDIX 3 OVERVIEW – REGULATORY BARRIERS

A: International regulation

| No. | Regulatory theme | Legal act and provision | Autonomy level | Conclusion | Recommendation |
|-----|-----------------------|--|----------------|---|---|
| 1 | Jurisdictional issues | UNCLOS Art. 25(2), 211(3) and 255 | All | States' right to ban ships from their ports and inner waters and to lay down special regulations for foreign ships' calls pursuant to UNCLOS art. 25(2), 211(3) and 255 will present a general barrier to autonomous ships to the extent that port and coastal States do not want autonomous ships in their waters, cf. section 4.3.2 (jurisdiction as a coastal State and port State). This could restrict the trade area of autonomous ships to the national waters of States whose national maritime authorities have a positive attitude to autonomous ships. | New regulation Autonomous ships should be regulated within the IMO so as to acquire a generally recognised international set of regulations which will result in coastal States and port States not banning autonomous ships from their inner waters and ports. |
| 2 | Port State Control | SOLAS, MARPOL, STCW Paris MoU Directive 16/2009 of the European Parliament and of the Council of 23 April 2009 | RU and A | Presuming that autonomous ships are designed to make it physically possible to inspect them and subject them to Port State Control inspections, there are no regulatory barriers to autonomous ships in SOLAS, MARPOL, STCW, Paris MoU or directive 16/2009. In relation to unmanned autonomous ships (autonomy levels RU and A), it will, however, be necessary to make amendments to clarify who can act on behalf of the ship since SOLAS, MARPOL, STCW, Paris MoU and directive 16/2009 on Port State Control presuppose the | Amendment of regulation Amendments will need to be introduced in relation to Port State Control of unmanned ships (RU and A). It will presumably be natural to have the shipowner – as defined in regulation 1(2) of the ISM Code – replace the master's functions and responsibilities in relation to Port State Control. |

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| | | | | presence of a master on board, cf. for example Paris MoU, paragraph 3.10, and directive 16/2009, article 17. | |
| 3 | Navigation and regulations for preventing collisions at sea (in general) | COLREG, regulations 2, 5, 6, 7 and 8 | R, RU and A | <p>COLREG is based on the fundamental principle of human control and simultaneous decision competence as well as the taking of navigational decisions on the basis of seamanlike professional assessments of the specific situation.</p> <p>Autonomy levels R and RU: Remotely controlled ships with or without manning (autonomy levels R and RU) could meet the fundamental principle of human control and simultaneous decision competence stipulated in COLREG to the extent that a person is remotely controlling the ship in real time and taking navigational decisions.</p> | <p>Autonomy levels R and RU:</p> <p>Clarification of understanding and interpretation A common understanding and interpretation of COLREG in relation to autonomous ships at levels R and RU should be reached within the IMO.</p> <p>New regulation New regulation is required in relation to:</p> <p>(i) Technical requirements for electronic lookout, remote control and communication and network systems, including latency, redundancy and prevention requirements as well as emergency readiness in case of defective communication with the ship (presumably as part of SOLAS);</p> |

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| | | | | <p>(ii) A special assessment of operational risk management for remotely controlled ships should be included as a part of shipowners' Safety Management System under the ISM Code;</p> <p>(iii) Training and qualification requirements for remote operators (using the structure of the STCW Code, if relevant);</p> <p>(iv) Principles of changes in the navigation obligation.</p> <p>Autonomy level A: Fully autonomous ships that are self-steering according to pre-programmed algorithms of choices and considerations (autonomy level A) could hardly meet the requirements for human control and simultaneous decision competence stipulated in COLREG.</p> | <p>(ii) A special assessment of operational risk management for remotely controlled ships should be included as a part of shipowners' Safety Management System under the ISM Code;</p> <p>(iii) Training and qualification requirements for remote operators (using the structure of the STCW Code, if relevant);</p> <p>(iv) Principles of changes in the navigation obligation.</p> <p>Autonomy level A:</p> <p>New regulation In addition to the required new regulation for autonomy levels R and RU, new regulation of the following additional areas will be necessary for ships at autonomy level A:</p> <p>(i) Prioritisation of protective considerations when programming autonomous ships at level A on the basis of ethical considerations;</p> <p>(ii) Definition and indication of the type of decisions that could be left to human beings;</p> |
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| | | | | | (iii) Provisions on navigation/regulations for preventing collisions at sea and provisions on signalling/communication between fully autonomous ships and ships at lower autonomy levels as well as between fully autonomous ships. |
| 4 | Navigation and regulations for preventing collisions at sea (periodically unmanned (physical) bridge) | COLREG, regulation 5 STCW Code, section A-VIII/2, part 4-1, Principles to be observed in keeping a navigational watch (especially regulations 14, 18 and 24) SOLAS chapter V, regulation 15, on bridge design and chapter V, regulation 22, on requirements for lookout and the field of vision from the wheelhouse | All | <p>Autonomy levels M, R and RU: If it is technically possible to change the bridge watch from the physical bridge on board to an “electronic bridge” somewhere else with the same or improved functionality, it is our conclusion that a periodically unmanned physical bridge (autonomy level M) will presumably be compatible with the provisions of COLREG and the STCW Code.</p> <p>This is so in connection with a change of the bridge watch to either an electronic bridge ashore or below deck. During such changes of the watch, the provisions of the STCW Convention and the STCW Code hereon must be met. The navigating officer cannot leave the physical bridge on board without having left the bridge watch to another person with the competences needed to perform the same functions with simultaneous decision competence. Thus, the navigating officer cannot leave the bridge and be “on call” from the ship’s navigation system pursuant to current regulation.</p> | <p>Autonomy levels M, R and RU:</p> <p>Clarification of understanding and interpretation It is our conclusion that a common understanding and interpretation of the regulatory requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) should be acquired within the IMO in relation to autonomous ships at levels M, R and RU.</p> <p>Amendment of existing regulation Chapter VIII, regulation 2(2)(1), of the STCW Convention needs to be amended so as to make it possible for watchkeeping navigating officers to</p> |

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| | | | | <p>If it is technically possible to perform the functions related to the ship's bridge – at an equivalent safety level and functionality – from another location than the ship's physical bridge (an "electronic bridge") under human surveillance, it must be presumed that the bridge will still be manned pursuant to the STCW Coe and is, thus, in compliance with current regulations.</p> <p>However, it cannot be presumed to be in accordance with COLREG (especially regulation 5) that the ship's bridge is physically unmanned if there is not a human being somewhere else who performs the functions carried out by the navigating officer on the ship's physical bridge during his watch and who is capable of intervening immediately. This will present a barrier to ships at autonomy level A.</p> <p>Furthermore, the technical regulations on bridge design stipulated in SOLAS must be kept when designing the electronic bridge, especially SOLAS chapter V, regulation 15, on bridge design and regulation 22 on requirements for lookout and field of vision from the wheelhouse.</p> | <p>periodically be somewhere else than on board the ship.</p> <p>SOLAS chapter II-I, regulation 37, needs to be amended to allow for an electronic bridge. It will also be essential in relation to an electronic bridge to regulate the requirements for several types of communication links.</p> <p>New regulation New regulation is required in relation to:</p> <p>(i) Technical requirements for equipment making electronic lookout and an electronic bridge possible, such as cameras, sensors, communication and network systems as well as equipment making it possible to log who has the bridge watch;</p> <p>(ii) Requirements for the design and construction of electronic bridges;</p> <p>(iii) Training, qualification and certification requirements for operators (navigating officers) of electronic bridges; and</p> |
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| | | | | <p>Autonomy level A: The requirements for lookout, bridge watch and bridge design (especially COLREG, the STCW Code and SOLAS) presuppose human control and simultaneous decision competence.</p> <p>Especially COLREG, regulation 5, and SOLAS chapter V, regulation 15, will in this connection present a barrier to fully autonomous ships (level A).</p> <p>Ships at autonomy level A, steering by themselves according to pre-programmed algorithms as regards the prioritisation of choices and consideration will not meet the requirement for human control and simultaneous decision competence.</p> | <p>(iv) Principles for changes of the bridge watch.</p> <p>Autonomy level A:</p> <p>New regulation In addition to the regulatory measures required to allow for autonomy levels M, R and RU, new regulation of the following additional areas will be needed for ships at autonomy level A:</p> <p>(i) Technical requirements for recognition and assessment of objects/conditions at sea; and</p> <p>(ii) Definition and indication of which types of decisions should be left to human beings.</p> |
| 5 | Navigation regulations for preventing collisions at sea (pilotage) | National and local regulations on mandatory pilotage | RU and A | To the extent that national or local regulation does not allow for shore-based pilotage or exemption from mandatory pilotage, this will restrict the trade area of ships at autonomy levels RU and A. | New regulation The IMO should adopt international regulation on shore-based pilotage, especially as regards the requirements for the pilot's access to the ship's electronic bridge (through the use of an electronic certificate) and redundancy and security requirements for the communication link. |
| 6 | Navigation and regulations for | SOLAS chapter V, regulation 23 | RU and A | To the extent that pilotage of autonomous ships could technically performed without the pilot having to embark the ship, | Clarification of understanding and interpretation |

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| | preventing collisions at sea (pilotage) | | | <p>regulation 23 will need to be interpreted in the light of this.</p> <p>It must be possible to meet the purpose of the regulation – to give the pilot access to the ship – in case of shore-based pilotage by giving the pilot access to the electronic bridge. To the extent that this is technically possible at an equivalent safety level, the provision will not present a barrier to autonomous ships.</p> | The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to autonomous ships. |
| 7 | Navigation and regulations for preventing collisions at sea (reporting obligations) | Directive 2002/59/EC of the European Parliament and of the Council (especially articles 17 and 18), as amended by directive 2009/17/EC of the European Parliament and of the Council | R, RU and A | <p>Autonomy levels R and RU: Considering the purpose of the reporting obligations, it must be possible for the remote operator to meet the obligation for ships at autonomy levels R and RU though the wording refers to the master.</p> <p>Autonomy levels R and RU: To the extent that ships at autonomy level A are technically capable of identifying accidents and incidents to allow for reporting, the regulation will not present a barrier. It must be presumed that reporting can be made either directly from the fully autonomous ship in digital format or via a remote operator.</p> | <p>Clarification of understanding and interpretation A common understanding and interpretation of the scope of the directives must be reached in relation to autonomous ships.</p> |
| 8 | Manning and “seafarers” of the future | UNCLOS art. 94(4)(b) | | <p>Autonomy levels M, R and RU: Ships at autonomy levels M, R and RU must still be considered to be “<i>in charge of a master and officers who possess appropriate qualifications</i>” to the extent that a person (master or navigating officer) holding the necessary qualifications is in control of the ship</p> | <p>Autonomy levels M, R and RU: The interpretation given in the conclusion must be clarified within the UN so as to reach agreement about a common understanding of the provision in relation to autonomous ships.</p> |

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| | | | | <p>irrespective of whether he is on board the ship or somewhere else.</p> <p>Autonomy level A: A fully autonomous ship (level A) without human involvement in navigation and steering will, on the other hand, not be in accordance with UNCLOS art. 94 (4) (b).</p> | <p>Autonomy level A:</p> <p>Amendment of regulation It is necessary to amend UNCLOS article 94(4)(b) if the provision is not to present a barrier to ships at autonomy level A.</p> |
| 9 | Manning and "seafarers" of the future (safe manning document) | UNCLOS art. 94(4)(b) SOLAS chapter V, regulation 14 | RU and A | <p>In relation to safe manning levels, it is our conclusion that neither UNCLOS article 94(4)(b) nor SOLAS chapter V, regulation 14(1), will present barriers to unmanned ships (autonomy levels RU and A) to the extent it can be validated that an autonomous ship is capable of operating without manning, according to the ship's type, size, machinery, equipment and voyage plan. The provisions cannot be presumed to presuppose the on-board presence of a crew at any time if the ship is capable of operating safely without a crew.</p> <p>It will be necessary to consider whether to introduce new technical requirements for the safety of ships at autonomy levels RU and A to SOLAS, considering the fact that the ships will be unmanned.</p> | <p>Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the UN and the IMO so as to reach agreement about a common understanding of the provisions in relation to autonomous ships.</p> |

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| 10 | Manning and "seafarers" of the future (safe manning document) | MLC, regulation 2.7 | RU and A | To the extent that unmanned autonomous ships (autonomy levels RU and A) are safe without a crew on board in relation to UNCLOS article 94(4)(b) and SOLAS chapter V, regulation 14(1), MLC regulation 2.7 will not present a barrier to ships at autonomy levels RU and A. | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy levels RU and A.</p> |
| 11 | Manning and "seafarers" of the future (obligation to provide assistance to persons in distress at sea) | <p>UNCLOS art. 98(1)</p> <p>SOLAS chapter V, regulation 33</p> <p>Salvage Convention, art. 10(1)</p> | RU and A | It can be argued that the master's obligation to physically provide assistance at sea does not extend beyond the technical capabilities of the autonomous ship. In other words, the master (remote operator) is not obliged above his ability in relation to the specific ship's special design, equipment and arrangement. This interpretation of the purpose is supported by the wording of UNCLOS article 98(1) and SOLAS chapter V, regulation 33. | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provisions in relation to ships at autonomy levels RU and A.</p> <p>New regulation</p> <p>New requirements must be adopted on the technical arrangement on board unmanned autonomous ships needed for them to be able to provide satisfactory distress assistance, for example in the form of liferafts, emergency rations and other emergency equipment. It will be necessary to include the possibilities of providing emergency assistance in the design of autonomous ships in order to make</p> |

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| | | | | | unmanned autonomous ships able to provide emergency assistance at a satisfactory level that is not considerably different from that on fully manned ships (equivalence). |
| 12 | Manning and "seafarers" of the future (stowaways) | FAL Convention, Annex, section 4 | RU and A | Though the wording of the Annex of the FAL Convention, paragraph 4.4.2, does not permit exemptions from the obligation, it cannot be presumed that the intention has been to extend the obligation beyond the technical capabilities of the specific ship. When the wording was drafted, it was unthinkable that ships could, in the longer term, be unmanned (autonomy levels RU and A). It could be argued that the provision should be interpreted in the light of the possibilities and technical arrangement of the specific ship. | Amendment of regulation Considering that the obligation is of a fundamental humanitarian nature, the FAL Convention should be amended to include requirements for the technical arrangement of unmanned ships with a view to detecting and avoiding stowaways on board, including requirements for the facilities and equipment to be available on board as regards food, medical care and sanitation for stowaways who may have embarked the ship. |
| 13 | Manning and "seafarers" of the future (Polar Code) | Chapter 12 of the Polar Code | RU and A | Chapter 12 of the Polar Code presupposes that ships operating in polar areas are manned. | Amendment of regulation Chapter 12 of the Polar Code must be amended to make it possible to operate unmanned autonomous ships (levels RU and A) in polar areas. The new regulation will need to consider which technical solution can replace the crew's functions and safety preparedness. |
| 14 | Protection of the marine environment (reporting obligations) | MARPOL, Protocol 1 | R, RU and A | It must be presumed that the obligations resting with the master under MARPOL Protocol I and article 4 of the OPRC Convention could be met by a remote | Clarification of understanding and interpretation |

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| | | Article 4 of the OPRC Convention (oil pollution reporting procedures) | | operator for ships at autonomy levels R, RU and A to the extent that it will be technically possible to collect the necessary information about pollution of the sea. This is supported by MARPOL, Protocol 1, article 1, as well as article 4 of the OPRC Convention which imposes the reporting obligation on <i>"The master or other person having charge of any ship involved in an incident"</i> . | The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding in relation to ships at autonomy levels R, RU and A. |
| 15 | Protection of the marine environment (Emergency preparedness on board ships) | MARPOL Annex 1, chapter VIII, regulation 41 (STS Operations Plan) MARPOL Annex 1, chapter V, regulation 37 (Shipboard Oil Pollution Emergency Plan) MARPOL Annex II, chapter VII (Prevention of pollution arising from an incident involving noxious liquid substances) Article 3 of the OPRC Convention (Oil pollution emergency plans) | RU and A | The legal acts presuppose an on-board crew in the form of a local emergency preparedness in case of unintended incidents. This will present a barrier to ships at autonomy levels RU and A. | New regulation It will be necessary to introduce new regulation allowing for autonomous ships at autonomy levels RU and A by making technical requirements for a preparedness on board that could safely replace the manning on board ships. |
| 16 | Protection of the marine environment (cargo information) | SOLAS chapter VI, regulation 2(1) | R, RU and A | The purpose of this provision is to make the master or the one responsible for the operation of the ship aware of the properties of the cargo. This purpose could be met by giving a remote operator or the shipowner similar information in connection with ships at autonomy levels | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common |

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| | | | | R, RU and A since the provision makes it possible to also give the information to a representative of the master. | understanding of the provision in relation to ships at autonomy levels R, RU and A. |
| 17 | Protection of the marine environment (reporting obligations) | SOLAS chapter VII, regulations 6 and 7(4) | R, RU and A | It must be presumed that the obligation could also be met by a remote operator for ships at autonomy levels R, RU and A to the extent that it is technically possible to monitor the loss of goods via cameras/sensors on board since the remote operator will fall within the category: <i>"other person having charge of the ship"</i> . | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy levels R, RU and A. |
| 18 | Construction requirements and technical conditions for ships (information about ships' stability) | SOLAS chapter II-I, regulation 5(1) | R, RU and A | If the master is not on board the ship (autonomy levels R, RU and A), it must be presumed that the obligation can still be met. The essential must be that the stability information is available to the one steering/monitoring the ship as the basis for his decision competence in relation to the operation of the ship. | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy levels R, RU and A. |
| 19 | Construction requirements and technical conditions for ships (damage control plans) | SOLAS chapter II-I, regulation 19 | R, RU and A | According to the provision, damage control plans are always required to be available to the officer of the bridge watch. | Amendment of regulation It is necessary to amend the provision, for example by stipulating that damage control plans must be available to the one in control of the ship, possibly in electronic form. |
| 20 | Construction requirements and technical conditions for ships (engineer officer alarm) | SOLAS chapter II-I, regulation 38 as well as regulations 51-53 | R, RU and A | For autonomous ships at autonomy levels R, RU and A, the alarm must be arranged for sounding an alarm to the person performing/monitoring the engineer officer function ashore (presumably the remote | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach |

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| | | | | <p>operator) so that it is possible for him to carry out the actions required.</p> <p>Compliance with the provision by autonomous ships is conditional upon it being technically possible for the person performing/monitoring the engineer officer function ashore to remotely monitor and control central parts of the engine room functions, thus enabling this person to react to the alarm. This is also true of the special requirements for alarm systems, safety systems and machinery and boiler installations as well as electrical installations under SOLAS chapter II-I, regulations 51-53.</p> | <p>agreement about a common understanding of the provisions in relation to ships at autonomy levels R, RU and A.</p> |
| 21 | Construction requirements and technical conditions for ships (steering propulsion machinery from the navigation bridge) | SOLAS chapter II-I, regulation 49 | R, RU and A | <p>If it is technically possible for an electronic bridge to meet the functional requirements of the provision, it cannot be presumed that the provision will present a barrier to autonomous ships.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy levels R, RU and A.</p> |
| 22 | Construction requirements and technical conditions for ships (fire safety) | SOLAS chapter II-II (especially regulations 7, 12, 13, 15 and 16) | RU and A | <p>The crew has a central role to play as a fire preparedness team (safety, detection, fighting) and an evacuation preparedness team on board. Naturally, this is especially so on passenger ships.</p> <p>The provisions of SOLAS chapter II-II will present a barrier to autonomous ships at autonomy levels RU and A.</p> | <p>New regulation</p> <p>In relation to ships at autonomy levels RU and A, it will have to be assessed on the basis of the technical possibilities whether acceptable technical solutions can be found that are capable of replacing the crew's role as a fire preparedness team in full</p> |

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| | | | | | or partly, and whether it will thus be possible to stipulate new SOLAS provisions on fire safety for ships at autonomy levels RU and A. It must be presumed that alternative fire safety measures will have to result in at least the same safety level as that of a manned ship in case of fire and that it will need to be demonstrated that the technical solutions meet this requirement. |
| 23 | Construction requirements and technical conditions for ships (life-saving appliances and arrangements) | SOLAS chapter III (especially regulations 10(3), 19 and 20) | RU and A | The above remarks in relation to fire safety apply similarly to life-saving appliances and arrangements. | <p>New regulation</p> <p>In relation to ships at autonomy levels RU and A, it will – on the basis of the technical possibilities – need to be assessed whether acceptable solutions can be found, capable of replacing the crew’s role in full or partly as an emergency preparedness team, and whether it will, thus, be possible to stipulate new SOLAS provisions hereon for ships at autonomy levels RU and A.</p> <p>It must be presumed that alternative emergency and rescue measures will have to result in at least the same safety level as that of a manned ship in case of</p> |

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| | | | | | emergencies, and that it will need to be demonstrated that the technical solutions meet this requirement. |
| 24 | Construction requirements and technical conditions for ships (radiocommunication) | SOLAS chapter IV, regulations 12 and 16 | RU and A | <p>Regulation 12 stipulates requirements for a constant radio watch on specific channels/frequencies when the ship is at sea.</p> <p>Regulation 16 requires each individual ship to have personnel on board that is qualified for distress and safety radiocommunication.</p> <p>In relation to unmanned ships, it will presumably be technically possible to ensure a constant radio watch from a shore-based control centre, cf. regulation 12.</p> <p>The requirement in regulation 16 for radio trained personnel to be on board the ship will, on the other hand, present a barrier to ships at autonomy levels RU and A.</p> | <p>Amendment of regulation</p> <p>It will be necessary to amend regulation 16 so that radio trained personnel are no longer required to be on board the ship.</p> |
| 25 | Construction requirements and technical conditions for ships (possibility of manual steering) | SOLAS chapter V, regulation 24 | A | <p>The purpose of regulation 24 is to ensure that manual steering becomes immediately possible in situations presenting a navigation risk.</p> <p>In relation to ships at autonomy level A, regulation 24 stipulates that – irrespective of whether the ship is fully autonomous – there must always be simultaneous monitoring by a remote operator who is capable of steering manually in situations considered to present a navigation risk.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy level A.</p> |

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| 26 | Construction requirements and technical conditions for ships (reporting obligations) | SOLAS chapter V, regulation 31 | R, RU and A | <p>SOLAS chapter V, regulation 31, obliges the master to report situations that may present a navigation risk, especially hazardous weather, to all ships in the vicinity and to the relevant competent authorities. Such reports do not have to have a specific form.</p> <p>The provision will not present a barrier to autonomous ships to the extent that they are technically capable of detecting dangerous situations and notifying ships in the vicinity hereof. Considering the purpose of the provision, the obligation will have to be met by the remote operator for ships at autonomy levels R, RU and A.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to ships at autonomy level A.</p> |
| 27 | Construction requirements and technical conditions for ships (security alarm system) | SOLAS chapter XI, regulation 6 | R, RU and A | <p>In relation to ships at autonomy levels R, RU and A, the ship must, in order to meet the purpose, be technically capable of alarming the remote operator in case the autonomous ship is threatened by physical attacks, cyber attacks or failure of the communication link.</p> <p>If this is met, the provision will not present a barrier to autonomous ships.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to autonomous ships.</p> |
| 28 | Construction requirements and technical conditions for ships (master's discretion) | SOLAS chapter XI, regulation 8 | R, RU and A | <p>Pursuant to regulation 8, the master's professional discretion as regards the ship's security must not be restricted by the shipowner, the charterer or any other person. This is the case when it comes to denying both persons and goods access to the ship.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision</p> |

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| | | | | In relation to ships at autonomy levels R, RU and A, the master must be considered the remote operator. If the remote operator has the competence to take decisions independent from the shipowner, the provision does not present a barrier to autonomous ships. | in relation to autonomous ships. |
| 29 | Construction requirements and technical conditions for ships (sound and light signals) | COLREG chapter C, regulations 20-31, and chapter D, regulations 32-37, as well as appendices I-IV of COLREG | R, RU and A | If autonomous ships are technically capable of giving the correct signals in all navigational situations – also if the communication link between the control centre to the ship (autonomy levels R, RU and A) is lost – and are technically capable of detecting sound and light signals from other ships, the regulations will not present a barrier to autonomous ships. | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to autonomous ships. |
| 30 | Construction requirements and technical conditions for ships (EU regulation) | Directive 2009/45/EC of the European Parliament and of the Council | RU and A | The directive contains provisions on (i) communication between the engine room and the navigation bridge, (ii) fire safety, detection and extinction, and (iii) life-saving appliances, all of which require an on-board crew as well as a physically manned engine room and bridge. Thus, the directive presents a barrier to autonomous passenger ships at autonomy levels RU and A engaged in domestic trade within the EU. | Amendment of regulation It must be considered, on the basis of the technical possibilities, whether acceptable solutions can be found that can replace the crew's role in full or partly, and whether it will thus be possible to amend the directive and lay down new requirements for technical safety solutions for ships at autonomy levels RU and A. |
| 31 | Liability, compensation and insurance issues (right to limitation of liability for remote operators) | Article 1 of the 1976 Liability Limitation Convention | R, RU and A | It must be presumed that a remote operator of autonomous ships will also be covered by the right to limitation of liability under the 1976 Liability Limitation Convention, article 1, since the remote operator is performing a work function for | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach |

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| | | | | <p>the shipowner. It cannot be decisive for the application of the provision whether the work function is performed from ashore rather than at sea.</p> <p>However, a remote operator's right to limitation of liability is uncertain, especially if the remote operator has not been hired by the shipowner, but is an independent company acting as the operator of several shipowners.</p> | <p>agreement about a common understanding of the provision in relation to autonomous ships.</p> |
| 32 | <p>Liability, compensation and insurance issues (seaworthiness)</p> | <p>The Hague and Hague-Visby rules, art. 3(1)</p> <p>Section 262(2) of the merchant shipping act</p> | <p>RU and A</p> | <p>It must be presumed that ships at autonomy levels RU and A will be considered seaworthy to the extent that they are technically and safely capable of operating without a crew.</p> <p>However, challenges related to seaworthiness will arise where the operation requires human presence on board the ship.</p> | <p>Clarification of understanding and interpretation</p> <p>The interpretation given in the conclusion must be clarified among the contracting Parties to the Hague and Hague-Visby rules so as to reach agreement about a common understanding of the provision in relation to autonomous ships.</p> |
| 33 | <p>Liability, compensation and insurance issues (obligation to display "care for the cargo")</p> | <p>The Hague and Hague-Visby rules, art. 3(2)</p> <p>Section 262(1) of the merchant shipping act</p> | <p>RU and A</p> | <p>Today, the obligations are, to a wide extent, met by the master and the crew as the shipowner's representatives. The obligations could present a barrier to unmanned autonomous ships (levels RU and A) to the extent that it is not technically possible to arrange/equip ships with technical functions that can take care of the monitoring and handling of goods and, thus, perform the same function as that performed by the on-board crew today, depending on the type of goods.</p> | <p>Amendment of regulation</p> <p>On the basis of the technical possibilities, it must be considered whether acceptable technical solutions can be found capable of replacing in full or partly the crew's role in terms of "caring for the cargo", and whether it would thus be possible to amend the Hague and the Hague-Visby rules.</p> |

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| | | | | A special issue may rise for unmanned autonomous ships in relation to the handling/disposal of dangerous goods during the ship's voyage, both in the form of goods that have been declared non-hazardous, but turn out to be dangerous goods, and goods that have been declared hazardous which threaten the ship's seaworthiness and other goods on board. | |
| 34 | Liability, compensation and insurance issues (exemption from liability for nautical faults) | The Hague and Hague-Visby rules, art. 4(2)(a) Section 276(1)(i) of the merchant shipping act | R, RU and A | <p>Autonomy levels R and RU For ships at autonomy levels R and RU, the remote operator will presumably be considered the "pilot" in relation to the ship's navigation, but faults committed in "<i>the management of the ship</i>" by other shore-based persons in the shipowner's organisation or among the partners will not necessarily fall within the scope of application of the provision.</p> <p>Autonomy level A In relation to ships at autonomy level A, there is hardly a possibility of claiming exemption from liability for navigation faults, considering that it is a question of pre-programmed algorithms, rather than navigation decisions which are due to simultaneous decision.</p> | <p>Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified among the contracting Parties to the Hague and Hague-Visby rules so as to reach agreement about a common understanding of the provision in relation to autonomous ships.</p> |
| 35 | Cybersecurity and anti-terror safeguards (access control and security plan) | Part A, regulations 7.2 and 9 of the ISPS Code | RU and A | To the extent that autonomous ships do not have a crew on board, it must be presumed that the obligations stipulated in regulations 7 and 9 could be met without human participation if it is technically possible to provide the same safety level without the physical presence of a crew on board the ship, for example | <p>Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision</p> |

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| | | | | through the use of cameras, sensors and heat-sensitive or movement-sensitive scanners. It will presumably also be a possibility to include a special port manning in the shipowner's ship security plan for autonomous ships at autonomy levels RU and A with special procedures for such a port manning. | in relation to autonomous ships. |
| 36 | Cybersecurity and anti-terror safeguards (security officer) | Part A, regulation 12, of the ISPS Code | RU and A | To the extent that a security officer could perform his ship security functions without being physically present on board through the use of technical aids, it must be presumed – based on an interpretation of the purpose – that the provision will not present a barrier to autonomous ships at autonomy levels RU and A. | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to autonomous ships. |
| 37 | Cybersecurity and anti-terror safeguards (obligation to have on board information about decision responsibility) | SOLAS chapter XI-2, regulation 5(2) | RU and A | It must be presumed that this function could, in relation to autonomous ships at autonomy levels RU and A, be met from ashore by the one in control of the ship (remote operator or shipowner). | Clarification of understanding and interpretation The interpretation given in the conclusion must be clarified within the IMO so as to reach agreement about a common understanding of the provision in relation to autonomous ships. |

B: Danish regulation

| No. | Regulatory theme | Legal act and provision | Autonomy level | Conclusion | Recommendation |
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| 1 | Exercise of authority (customs clearance) | Section 17(1) of the customs clearance act | RU and A | For ships at autonomy levels RU and A, the obligation for the master to “ <i>identify and open or uncover all accessways to cargo, spaces and hiding places</i> ” stipulated in section 17(1) of the customs clearance act will present a barrier. | <p>Amendment of regulation</p> <p>To the extent that the shipowner could authorise a local port representative or agent to meet this obligation and be available to the customs authorities while the ship is in port, this will presumably be the solution in practice.</p> <p>This should be clarified through an amendment of the provision.</p> |
| 2 | Navigation and regulations for preventing collisions at sea (in general) | Order on regulations for navigation, etc. in certain Danish waters | R, RU and A | <p>Autonomy levels R and RU</p> <p>To the extent that it will be technically possible for autonomous ships at autonomy levels R and RU to meet the obligations of the order (inter alia that the local harbour master can get in contact with the master of a remotely controlled ship at autonomy levels R and RU), the special Danish regulations for preventing collisions at sea will not present a barrier to autonomous ships at autonomy levels R and RU.</p> <p>Autonomy level A</p> <p>Just like COLREG, the order presupposes simultaneous human decision competence and a seamanlike assessment in the specific situation. Thus, the order will present a barrier to autonomy level A.</p> | <p>Autonomy level A</p> <p>New regulation</p> <p>It will be necessary to introduce new regulation in the form of regulations for preventing collisions at sea for ships at autonomy level A (see more about the necessary elements in such regulation under item 3 (Navigation and regulations for preventing collisions at sea) (in general)) in table A above.</p> |

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| 3 | Navigation and regulations for preventing collisions at sea (periodically unmanned (physical) bridge) | Order on watchkeeping on board ships | All | The order transposes the STCW Code into Danish law. It will be necessary to consider the conclusions and recommendations given in barrier 4 of the international regulations (Appendix 3, Part A) in relation to the regulation of autonomous ships in Danish law. | |
| 4 | Navigation and regulations for preventing collisions at sea (reporting obligations) | Order no. 924 of 25 August 2011 on the ship reporting system SOUNDREP and on notification when passing the Drogden dredged channel for ships the height of which exceeds 35 metres. Order no. 820 of 26 June 2013 on the ship reporting system BELTREP and navigation under the East Bridge and the West Bridge in the Great Belt. | A | The orders oblige passing ships to make reports via VHF to call stations upon entry into the reporting areas and to keep a continuous listening watch. The reporting obligations will present a barrier at autonomy level A. | Amendment of regulation The orders must be amended to allow for automatic reports in digital format from ships at autonomy level A. |
| 5 | Navigation and regulations for preventing collisions at sea (reporting obligations) | Order on technical regulation on a vessel traffic monitoring and information system in Danish waters and ports | R, RU and A | The order transposes into Danish law directive 2002/59/EC of the European Parliament and of the Council, as amended by directive 2009/17/EC of the European Parliament and of the Council. It will be necessary to consider the conclusions and recommendations mentioned in barrier 7 of the international regulations (Appendix 3, Part A) in relation to the regulation of autonomous in Danish law. | |
| 6 | Manning and "seafarers" of the future (the concept of a master) | Part 6 of the merchant shipping act (sections 131-143) | R, RU and A | The following provisions presuppose that the master is physically present on board the ship (sections 131, 133, 134, 135, 136, 138, 142 and 143). | New regulation It is possible to remove the regulatory barriers of the merchant shipping act by |

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| | | | | <p>These provisions present barriers to autonomous ships at levels RU and A.</p> <p>Furthermore, several of the provisions stipulated in part 6 of the merchant shipping act concern the master's right to represent the ship and the shipowner, which is also reasoned by the master's physical presence on board the ship, and which should presumably be amended in relation to ships at autonomy levels R, RU and A (sections 137, 138, 139 and 141).</p> | <p>inserting a new part 6a in the merchant shipping act, stipulating the rights and obligations of remote operators.</p> <p>The chapter should contain a definition of a "remote operator" as well as a definition of "autonomous ships".</p> <p>As a general principle, the remote operator should be considered equal to the master in the merchant shipping act and have the same rights and obligations with the amendments following from the nature of the relation. As regards navigation, the remote operator should be subject to the principles of section 132 of the merchant shipping act.</p> <p>See section 4.5.9 for a description of the most important amendments needed.</p> |
| 7 | Manning and "seafarers" of the future (act on safety at sea) | Section 10 of the act on safety at sea | R, RU and A | Section 10 of the act on safety at sea imposes upon the master the obligation for the ship to be seaworthy. | <p>Amendment of regulation</p> <p>It will be necessary to amend the provision to stipulate that the obligation for the ship to be seaworthy rests with the shipowner and not with the remote operator in relation to</p> |

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| | | | | | ships at autonomy levels R, RU and A. Section 4.5.9.1 includes a new draft wording of section 10. |
| 8 | Manning and "seafarers" of the future (act on the manning of ships) | Section 3 of the act on the manning of ships | R, RU and A | <p>According to section 3 of the act on the manning of ships, a master must always be physically present on board.</p> <p>In addition to stipulating that a master must always be physically present on board, the term <i>"the crew required to ensure the safety of human lives at sea"</i> stipulated in section 3 of the act on the manning of ships should be clarified as regards unmanned ships (autonomy levels RU and A).</p> <p>Finally, the act on the manning of ships should contain a legal basis for the Danish Maritime Authority to lay down training and certification requirements for remote operators.</p> | <p>Amendment of regulation It will be necessary to make a number of amendments to section 3 of the act on the manning of ships to allow for ships at autonomy levels R, RU and A.</p> <p>A proposal for the wording of the necessary amendments to section 3 of the act on the manning of ships has been included in section 4.5.10.</p> |
| 9 | Manning and "seafarers" of the future (order on ship logs and radio logs) | Section 2 of the order on ships logs and radio logs | RU and A | Section 2 of the order presents a barrier to autonomous ships (autonomy levels RU and A) since there is no legal basis for keeping a radio log electronically from ashore. | <p>Amendment of regulation A proposal for the wording of the necessary amendment of the order has been included in section 4.5.11.</p> |
| 10 | Construction requirements and technical conditions for ships | <p>Notice B from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of ships</p> <p>Order on Notice B from the Danish Maritime Authority, technical regulation on the</p> | R, RU and A | In relation to these Danish order, which transpose SOLAS into Danish law, it will be necessary to consider the conclusions and recommendations mentioned in barriers nos. 2, 4, 6, 9, 11, 16-29 and 37 of international regulations (Appendix 3, Part A) in relation to the regulation of autonomous ships in Danish law. | |

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| | | <p>construction and equipment, etc. of ships</p> <p>Order on Notice D from the Danish Maritime Authority, technical regulation on the construction and equipment, etc. of passenger ships on domestic voyages</p> | | | |
| 11 | Protection of the marine environment (reporting obligations) | <p>Order on reporting pursuant to the act on protection of the marine environment</p> <p>Order on places of refuge and plans hereon</p> | R, RU and A | In relation to these Danish orders, it will be necessary to consider the conclusions and recommendations mentioned in barrier no. 14 of international regulation (Appendix 3, Part A) in relation to the regulation of autonomous ships in Danish law. | |
| 12 | Protection of the marine environment (preparedness on board ships) | <p>Order on technical regulation on ship emergency preparedness plans caused by hazardous or noxious substances</p> <p>Order on the transfer of liquid cargoes between ships in Danish and Greenland territorial waters (STS operations)</p> <p>Order on the transfer of bunker oil between ships in Danish territorial waters</p> | RU and A | In relation to these Danish orders, it will be necessary to consider the conclusions and recommendations mentioned in barrier no. 15 of international regulations (Appendix 3, Part A) in relation to the regulation of autonomous ships in Danish law. | |