COMITÉ MARITIME INTERNATIONAL

PRESIDENT

29 March 2017

Presidents of NMLAs

Copy to: Executive Councillors and Consultative Members

Dear President

Unmanned Ships - Questionnaire

I am pleased to **attach** a memorandum which has been prepared by Tom Birch-Reynardson, the Chair of the IWG on Unmanned Ships together with the Questionnaire and Position Paper which the IWG has prepared.

You will see from Tom's note that he would like to receive your responses within the next two months, that is by the end of May. It is appreciated that this may be difficult for many MLAs. The significance of that date is that the IMO's Maritime Safety Committee on Autonomous Vessels is likely to be discussing this topic on 8 or 9 June.

For your information I am also **attaching** the Maritime Safety Committee document MSC98/20/2 dated 27 February 2017.

If you are unable to complete the Questionnaire in time for that meeting this topic will also be the subject of a report to the Assembly meeting in Genoa and the more responses that have been received by then the better able the IWG will be able to proceed with its work.

With kind regards

Stuart Hetherington

STUART HETHERINGTON C/O COLIN BIGGERS & PAISLEY,
TEL: +61 2 8281 4477 E-MAIL: stuart.hetherington@cbp.com.au FAX: +61 2 8281 4567
REGISTERED OFFICE CMI, AISBL: Ernest Van Dijckkaai 8, B-2000 Antwerp, Belgium
Enterprise n° 0867 385 381
www.comitemaritime.org

JUZ84GTEC9

CMI INTERNATIONAL WORKING GROUP ON UNMANNED SHIPS – POSITION PAPER AND QUESTIONNAIRE

REQUEST TO RESPOND TO QUESTIONNAIRE BY 31 MAY 2017

We are enclosing the Position Paper and Questionnaire prepared by the CMI International Working Group on Unmanned Ships.

"Unmanned Ships" are becoming a reality, and it is anticipated that the first unmanned cargo ship may be launched as soon as 2018.

As is clear from the Position Paper, there is much to be done to prepare the legal framework for the safe operation of such ships (if ships they are), and this has now been recognised by the IMO Maritime Safety Committee which has included on the agenda for its June meeting a proposal by a number of countries that IMO should commence a scoping exercise to establish the extent of the need to amend the regulatory framework to enable a safe, secure and environmental operation of "unmanned ships" within the existing IMO instruments.

The IWG has been invited to attend this meeting and we anticipate participating in the exercise. It will be of considerable benefit if National Associations are able to respond to the questionnaire attached as soon as possible – preferably before the end of May – so that responses can be used to outline for the MSC some of the issues arising.

We very much hope that you will be able to respond to the Questionnaire by the deadline of 31 May 2017.

With many thanks,

Tom Birch Reynardson
Chair of CMI International Working Group on Unmanned Ships

CMI QUESTIONNAIRE ON UNMANNED SHIPS

INTRODUCTION

Unmanned ships are those which are capable of controlled movement on the water in the absence of any onboard crew. Control is performed in essentially two ways. It can be performed by remote-control, whereby a shore-based remote controller uses a computer and joystick to control the unmanned ship's movement and signalling using radio and satellite communications. In doing so the controller is aided by the streaming of the ship's vicinity effected by cameras and aural sensors affixed to the ship's hull / chassis. There is a small delay in the transmission of information to and from the ship, like with all forms of satellite communication. On the other hand, the ship may be "controlled" autonomously. This involves the ship being pre-programmed before deployment, and, thereafter, performs a predetermined nautical course without any human interaction. This control, as well as a degree of collision avoidance capability, is affected with the use of highly sophisticated software technology, control algorithms and sonar radar.

Whereas unmanned ships in operation today are small in size (<20m in length) and essentially used for marine scientific research and military purposes their number has risen exponentially in recent years and so has the number or research projects aimed at developing the first unmanned merchant ships of 500 grt or more.

In order to ensure that the required regulations are in place once these ships become a technical reality, CMI Executive Council has set up an International Working Group (IWG) to study the current international legal framework and consider what amendments and/or adaptions and/or clarifications may be required in relation to unmanned ships.

In answering the questions below please assume that they are made in relation to an unmanned ship of 500 grt or more.

1. National law

1.1. Would a "cargo ship" in excess of 500 grt, without a master or crew onboard , which is either

1.1.1.controlled remotely by radio communication?

1.1.2.controlled autonomously by, inter alia, a computerised collision avoidance system, without any human supervision

constitute a "ship" under your national merchant shipping law?

1.2. Would an unmanned "ship" face difficulty under your national law in registering as such on account of its unmanned orientation?

1.3. Under your national law, is there a mechanism through which, e.g. a Government Secretary may declare a "structure" to be a "ship" when otherwise it would not constitute such under the ordinary rules?

1.4. Under your national merchant shipping law, could either of the following constitute the unmanned ship's "master"

1.4.1.The chief on-shore remote-controller

1.4.2. The chief pre-programmer of an autonomous ship
1.4.3. Another 'designated' person who is responsible on paper, but is not immediately involved with the operation of the ship

1.5. Could other remote-controllers constitute the "crew" for the purposes of your national merchant shipping laws?

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

2.1. Do you foresee any problems in treating unmanned ships as "vessels" or "ships" under the Law of the Sea in your jurisdiction (i.e. that such ships would be subject to the same rights and duties such as freedom of navigation, rights of passage, rights of coastal and port states to intervene and duties of flag states) in the same way as corresponding manned ships are treated?

2.2. Paragraphs (3) and (4) of UNCLOS Article 94 include a number of obligations on flag states with respect to the manning of such ships. Do you think that it is possible to resolve potential inconsistencies between these provisions and the operation of unmanned ships without a crew on board through measures at IMO (under paragraph (5) of the same Article) or do you think other measures are necessary to ensure consistency with UNCLOS. If so, what measures?

3. IMO Conventions – The International Convention for the Safety of Life at Sea (SOLAS) 1974 (as amended)

3.1. Does your national law implementing the safe manning requirement in Regulation 14 of Chapter V of SOLAS require at least a small number of on board personnel or does the relevant authority have the discretion to allow unmanned operation if satisfied as to its safety?

3.2. Regulation 15 of SOLAS Chapter V concerns principles relating to bridge design. It requires decisions on bridge design to be taken with the aim of, inter alia, "facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation...". In the contest of a remote controlled unmanned ship, could this requirement be satisfied by an equivalent shore-based facility with a visual and aural stream of the ship's vicinity?

3.3. As interpreted under national law, could an unmanned ship, failing to proceed with all speed to the assistance of persons in distress at sea as required by Regulation 33 of SOLAS Chapter V, successfully invoke the lack of an on-board crew as the reason for omitting to do so (provided that the ship undertook other measures such as relaying distress signals etc.)?

4. The International Regulations for Preventing of Collisions at Sea, 1972 (COLREGS)

4.1. Would the operation of an unmanned "ship" without any on board personnel, per se, be contrary to the duty / principle of "good seamanship" under the COLREGS, as interpreted nationally, regardless of the safety credentials of the remote control system?

4.2. Would the *autonomous* operation of a "ship", without any on-board personnel *or any human supervision*, be contrary to the duty / principle of "good seamanship", under the COLREGS, as interpreted nationally, regardless of the safety credentials of the autonomous control system?

4.3. As interpreted under national law, could the COLREG Rule 5 requirement to maintain a "proper lookout" be satisfied by camera and aural censoring equipment fixed to the ship transmitting the ship's vicinity to those "navigating" the ship from the shore?

4.4. Would a ship navigating without an on-board crew constitute a "vessel not under command" for the purposes of COLREG Rule 3(f), read together with COLREG Rule 18, as interpreted under your national law?

5. The International Convention on Standards of Training Certification and Warchkeeping, 1978 (STCW Convention)

5.1. The STCW Convention purports to apply to "seafarers serving on board seagoing ships". Would it therefore find no application to a remotely controlled unmanned ship?

5.2. As interpreted under national law, can the STCW requirement that the watchkeeping officers are physically present on the bridge and engine room control room according to Part 4 of Section A-VIII/2 be satisfied where the ship is remotely controlled? Is the situation different with respect to ships with a significantly reduced manning (bearing in mind that the scope of the convention only applies to seafarers on board seagoing ships)?

6. Liability

6.1. Suppose a "ship" was navigating autonomously i.e. through an entirely computerised navigation / collision avoidance system and the system malfunctions and this malfunction is the sole cause of collision damage – broadly, how might liability be apportioned between shipowner and the manufacturers of the autonomous system under your national law?

6.2. Arts. 3 and 4 of the 1910 Collision Convention provide for liability in cases of fault. As interpreted under your national law, does the fact that the non-liability situations listed in Art. 2 are not conversely linked to no-fault, leave room for the introduction of a no-fault (i.e. strict) liability (for e.g. unmanned ships) at a national level?

CMI INTERNATIONAL WORKING GROUP POSITION PAPER ON UNMANNED SHIPS AND THE INTERNATIONAL REGULATORY FRAMEWORK

1. Introduction

Unmanned ships are those which are capable of controlled movement on the water in the absence of any onboard crew. Instead, control is performed in essentially two ways.[1] It can be performed by remote-control, whereby a shore-based remote controller uses a laptop computer and joystick to control the unmanned ship's movement and signalling using radio and satellite communications. In doing so the controller is aided by the streaming of the ship's vicinity effected by cameras and aural sensors fitted to the ship's hull / chassis. On the other hand, the ship may be "controlled" autonomously. This involves the ship being pre-programmed before deployment (or before setting sail), and, thereafter, performs a predetermined nautical course without any human interaction whatsoever. This control, as well as a degree of collision avoidance capability, is affected with the use of highly sophisticated software technology, control algorithms and sonar radar. There are other control methods between these two modes of operation although, as will be seen, it is this binary distinction which is relevant from the point of view of regulatory compliance. It is also important to note that both of these modes of operation may be used consecutively on the same voyage, depending on the ship's operational itinerary. For the purposes of this paper "unmanned" refers to both "remote controlled operation" as well as "autonomous operation". These will be referred to individually where a distinction is drawn. Autonomous ships may be either supervised or unsupervised by a shore-based remote controller. This distinction will be drawn where relevant.

At present the operational usage of unmanned ships is modest when compared to their manned counterparts. They are presently used predominantly by the marine scientific research communities and also the defence sector for a broad range of marine operations. Today's unmanned ships are also comparatively modest in size, with even the largest of unmanned ships seldom extending beyond 15-20m in length. However, this is about to change. Prototypes are currently being developed by a range protagonists to develop unmanned containers carriers and passenger liners of comparable size and operational capability with manned ships performing these functions.

---

[1] This is a simplification to assist analytical expression. There are many different formulations of the levels of autonomy, see e.g. See 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). To obtain a copy, please contact Mr. Paul O'Brien of the EDA at paul.obrien@eda.europa.eu. This study refers to the levels of autonomy established by the SARUMS Group. These are (0) Human on board; (1) Operated; (2) Directed; (3) Delegated; (4) Monitored and (5) Autonomous.

The exponentially developing nature of this unmanned technology makes regulatory preparedness an ever more pressing concern, not least because, at least in some types of operation, although there are obvious risks, there are also clear safety advantages to the exploitation of unmanned technology in carriage operations which come in the form of not having to expose seafarers to the still formidable perils of the seas.

2. The Regulatory Framework

Maritime law is a functional term used for describing a whole range of laws and other sources that govern the legal framework related to ships and their operation. It includes a variety of different legal systems, ranging from international law to regional and national rules and down to local rules. It covers issues of public concerns, such as safety, security and environmental protection as well as civil law matters, such as contracts of carriage, liability and compensation for damage, salvage and rules related to marine risks and insurance, to name but a few.

The prospect of unmanned ships addresses a very fundamental feature in shipping – the role of the master and crew on board a ship – and will hence affect a multitude of laws and regulation across the whole range of maritime law.

The focus of this paper is on the international (global) rules. Three main kinds of such rules need to be distinguished. First, there are jurisdictional rules, which lay down states' rights and obligations to take measures with respect to ships. These are mainly laid down in the 1982 UN Convention on the Law of the Sea (UNCLOS), which is discussed in section 3. Second, the technical rules covering safety, environment and training and watchkeeping standards etc. are discussed in section 4. They are usually adopted by specialized UN agencies, such as, notably, the International Maritime Organization (IMO). Third, a series of international rules have been established in the field of private law to harmonise issues such as shipowners' civil liability for pollution, collisions or cargo-related losses and how such claims may be enforced. These rules are not as complete or widely ratified as the public law conventions discussed in sections 3 and 4 and may therefore be subject to greater national variation. The main relationships of these liability rules to unmanned shipping are discussed in section 5.

3. Law of the Sea

3.1 General

The law of the sea deals with the rights and obligations of states over the seas. As far as shipping is concerned, the key issues addressed by this body of law include: to what extent ships can navigate in different sea areas; what obligations do states have over ships flying their flag; and what rights do other states have to interfere in the navigation of ships in different sea areas?

Today's law of the sea governing navigation is more stable than ever before in history. The 'Constitution for the Oceans', UNCLOS, enjoys a widespread formal acceptance worldwide (169 contracting parties) and its provisions concerning navigational rights and duties are widely accepted as representing customary law (and hence apply to non-parties as well). The convention lays down the rules on establishment and delimitation of maritime zones and includes detailed rules for each zone with respect to states' rights and obligations.

A first – and fundamental – question to be resolved is whether ships without a crew on board are 'ships' or 'vessels' within the meaning of the convention at all. The two terms are used interchangeably in UNCLOS, but neither is defined. Article 91 provides that each state shall fix the conditions for the grant of its nationality to ships, which implies that the national law of the flag state will be critical for the definitions used. It does, however, follow from the nature of the activities carried out by large, self-propelled, cargo-carrying, commercially-operated unmanned ships that they probably will have to be regarded as vessels/ships by virtue of their size, features and functions. Existing international conventions that define the term ship do not include references to crewing[2] and at national level, too, the definition of a ship is usually disconnected from the question of whether or not the ship is manned.[3] It would also seem unjustified that two ships, one manned and the other unmanned, doing similar tasks involving similar dangers would not be subject to the same rules that have been designed to address those dangers.

From the assumption that unmanned ships are 'ships' and 'vessels' within the meaning of UNCLOS, it follows that they are subject to the same rules of the law of the sea as any ordinarily manned ship. The same obligations apply to unmanned ships and their flag states with respect to compliance with international rules. On the other hand, they also enjoy the same passage rights as other ships and cannot be refused access to other states' waters merely because they are not crewed.

3.2 Flag State Jurisdiction

Flag state jurisdiction represents the traditional cornerstone of the regulatory authority over ships. UNCLOS establishes that all states have a right to sail ships flying their flag and to fix the conditions for granting nationality to ships (Articles 90 and 91(1)). However, the convention also includes a number of detailed duties for flag states.

Every state has the obligation to "effectively exercise its jurisdiction and control

---

[2] E.g. study by Professor Sozer, attached to CMI Working Group on Ship Nomenclature, (available at www.comitemaritime.org/Uploads/Work%20In%20Progress/Ship%20Nomenclature/Ltr%20to%20Presidents%20re%20IWG%20on%20Vessel%20Nomenclature%20-%20080316.pdf). analyses the definition of the terms in almost 20 key maritime conventions. Not a single one of these instruments links the definition of ship to the presence of crew on board.

[3] See 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). To obtain a copy, please contact Mr. Paul O'Brien of the EDA at paul.obrien@eda.europa.eu.

in administrative, technical and social matters over ships flying its flag" (Article 94(1)), including to "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" (Article 94(2)(b)). The flag state shall also "take such measures ... as are necessary to ensure safety at sea with regard, inter alia, to ... the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments" (Article 94(3)(b)), including measures necessary to ensure "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" (Article 94(4)(b)). When adopting these measures each flag state is required "to conform to generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance" (Article 94(5)).

UNCLOS, in other words, generally avoids the need to formulate more precise obligations of flag states by referring to an abstract, and continuously changing, set of international rules to be developed elsewhere. In this way it avoids 'freezing' the requirements at a given point in time or at a given technical level, while still preserving the international character of the rules in question. The more precise extent of flag states' obligations is hence left to be developed by the IMO in particular.

3.3 Port and Coastal State Jurisdiction

While the flag state's jurisdiction applies irrespective of the ship's location, other states' parallel jurisdiction over the same ship depends on the maritime zone concerned. The coastal state's authority over a foreign ship increases with the proximity of the ship to its shores.

If the ship is voluntarily present in one of its **ports or internal waters**, the coastal/port state has broad jurisdiction over foreign ships. Internal waters form part of the sovereignty of the state (Article 2) and in the absence of specific limitations, the jurisdiction over foreign ships in this area is therefore complete. Moreover, ships have no general right to access foreign ports and the port state's wide discretion to place entry conditions for foreign ships is widely acknowledged, including in UNCLOS Articles 25(2), 211(3) and 255. In other words, a port state may (unless it has accepted specific obligations to the contrary) refuse unmanned ships access to its ports or internal waters, provided that the refusal complies with certain more general criteria of reasonableness that exist in general international law, such as non-discrimination, proportionality between the measure and its objective and that the prohibition does not constitute an abuse of right (Article 300). This may turn out to be a significant limitation of the freedom of movement of unmanned ships, but the potential limitation is by no means unique to unmanned ships.

With respect to ships passing through its **territorial sea** (which may extend up to 12 nautical miles from the coastline/baseline), the rights of coastal states are

more limited. Under a longstanding principle of the law of the sea, all ships enjoy a right of 'innocent passage' through other states' territorial seas. Passage is deemed to be innocent as long as it is not "prejudicial to the peace, good order or security of the coastal state" (Article 19(1)). A list of activities that meet those criteria is given in Article 19(2), but as the list focuses on ships' *activities* (such as use or threat of force, military activities, fishing activities or wilful and serious pollution) questions related to a ship's manning will not as such render passage non-innocent under the wording of UNCLOS.

Regarding the coastal state's legislative jurisdiction, Article 21(2) provides that a state may not impose its national requirements on the construction, design, equipment or manning of foreign ships in its territorial sea, unless those requirements are giving effect to "generally accepted international rules and standards" (Article 21(2)). Independently of what laws the coastal state has adopted, it may not "impose requirements on foreign ships which have the practical effect of denying or impairing the right of innocent passage" (Article 24(1)(a)). The right of innocent passage extends to ships that may be deemed to pose a particular risk for the coastal state, such as tankers and nuclear-powered ships and ships carrying nuclear or other inherently dangerous or noxious substances (Articles 22(2) and 23).

The areas of a coastal state's territorial sea which form part of a '**strait used for international navigation**' are subject to even more limitations for coastal states (and correspondingly stronger passage rights for ships). There are different kinds of such straits, but many of the most important straits that are completely covered by the bordering straits' territorial seas, such as the Straits of Dover and Malacca, are subject to the regime of 'transit passage', where ships' right of passage are granted and may not even be temporarily suspended by the bordering states (Articles 37-44). Many other important straits, including the Danish and the Turkish Straits, are governed by long-standing international conventions which guarantee the navigational rights of foreign ships (Article 35(c)).

The jurisdiction to prescribe national requirements is even more limited with respect to ships sailing in the **exclusive economic zone (EEZ)**, which may extend beyond the territorial sea, up to a maximum of 200nm from the coastline/baseline. In this zone freedom of navigation for all states applies, subject to having due regard to the interest of other states (Article 58). The most express prescriptive jurisdiction of coastal states over foreign ships in the EEZ concerns laws aiming at the protection of the marine environment and even here, coastal states' jurisdiction is limited to prescribing rules that give effect to international rules (Article 211(5)). Similarly, enforcement measures are limited to requiring information (Art. 220(3)), save for the most serious cases of pollution and damage where the coastal state may exceptionally interfere in the passage (220(5)).

In sea areas which lie beyond the jurisdiction of any coastal state, **the high seas**, the starting point is that the flag state alone has jurisdiction over the ship. A

number of exemptions to this main rule exist, but none of them is relevant for the question of navigational rights of unmanned ships.

3.4 Other relevant provisions in UNCLOS

Apart from the jurisdictional provisions, certain other UNCLOS provisions may turn out to be problematic for unmanned ships. The obligation set out in Article 94(4)(b) that each ship needs to have a (properly qualified) master and a crew has been mentioned above. While this requirement may arguably be met in case of remotely operated ships, it is less obvious how a fully automated ship would qualify. Since unmanned shipping operations will often involve differing degrees of automation, depending on sea areas, traffic density etc., further clarifications of this obligation may be needed, at least at the level of the 'generally accepted international regulations, procedures and practices' (Article 94(5)).

Another UNCLOS provision which presumes a crew on board is the obligation of the *master* to render assistance to persons in danger or distress according to Article 98(1) (as specified in SOLAS Regulation V/33). The rule would find no application to the extent that an unmanned ship has no *master,* although this is little comfort since this an express requirement of Article 94(4)(b) UNCLOS, as stated above. The communication part of the duty can presumably be met by remotely operated ships with relayed radio communications, but it is less clear how physical assistance can be rendered by a ship without a crew on board. The duties include qualifications by reference to "in so far as he can do so without serious danger to the ship" or "in so far as such action can be reasonably expected of him" which will probably reduce the extent of obligations for unmanned ships, as the available options will be fewer. However, the absence of a crew does not in itself obviate the duty to provide assistance to the extent necessary and reasonable.

4. Technical Requirements

4.1 General

There are over 50 IMO international shipping regulations and conventions in force today. The majority of the obligations imposed by IMO regulations are imposed on flag states, and these states must discharge these obligations by prescribing enforceable domestic shipping legislation reflecting the internationally agreed standards. State legislatures often delegate the tasks of enforcement of the domestic regulations to expert governmental maritime administrations or authorities. These administrations may not always have all the necessary technical expertise to cover every aspect of marine activity and hence essential expertise is also provided by classification societies. It will be seen that considerable discretion is afforded to the relevant maritime administrations and classification societies, particularly in terms of the adequacy of alternative compliance. Thus, each will play an integral role in the applicability of prescribed technical requirements to unmanned ships.

The following is not a comprehensive review of the application of IMO regulations to unmanned ships but instead an exploration of some of those regulations most pertinent in the context of the conduct of navigation of unmanned ships, both remote controlled and autonomous. These will be the essential initial regulatory hurdles to be negotiated if unmanned shipping is to become widespread. The analysis will consider the International Convention for the Safety of Life at Sea, 1974 (SOLAS), the International Regulations for the Preventing of Collisions at Sea, 1972 (COLREGS) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention). It will consider both applicability of these regulations to unmanned ships and the ability of such ships to comply with them, as well as how the relevant level of unmanned ship autonomy impacts upon the position.

4.2 The International Convention for the Safety of Life at Sea, 1974 (SOLAS)

The International Convention for the Safety of Life at Sea obliges contracting states to ensure minimum standards, in particular, in construction, equipment and operation with the view to ensuring the safety of life at sea. The SOLAS Convention is supplemented by a highly detailed annex which spans twelve chapters. These include: Chapter I *General Provisions* (including definitions); Chapter II-1 *Construction* (including structure, subdivision and stability, machinery and electrical installation); Chapter II-2 *Fire Protection, Fire Detection and Fire Extinction*; Chapter III *Life Saving Appliances and Arrangements*; Chapter IV *Radiocommunications*; Chapter V *Safety of Navigation*; Chapter VI *Carriage of Cargoes*; Chapter VII *Carriage of Dangerous Goods*; Chapter VIII *Nuclear Ships*; Chapter IX *Management the Safe Operation of Ships*; Chapter X *Safety Measures for High Speed Craft*; Chapter XI *Special Measures to Enhance Maritime Safety* and Chapter XII *Additional Safety Measures for Bulk Carriers.*

Chapter I – General Provisions

It can be assumed that, in general, the provisions of SOLAS would find application to unmanned ships to the extent that they are flagged and engaged on international voyages.[4] SOLAS prescribes no general definition of "ship" and so unmanned operability presents no impediment to applicability. Instead, SOLAS refers to "cargo ships" defined broadly as any ship which is not a passenger ship i.e. a ship not carrying at least 12 passengers.[5] Importantly, the Convention and its Annex generally find no application to ships of less than 500 gross registered tons (grt) although this is subject to the specific applicability provisions in each chapter.[6]

[4] Defined in 2(d) as "voyage from a country to which [SOLAS] applies to a port outside such a country, or conversely".
[5] Regulation 2(g).
[6] Regulation 3(a)(2).

SOLAS is not without flexibility. A Contracting Government may exempt from compliance with the provisions in Chapters II-1, II-2, III and IV those ships which "embod[y] features of a novel kind" to the extent that the application of such provisions "might seriously impede research into the development of such features and their incorporation in ships engaged on international voyages".[7] It can be argued that unmanned operability (both remote control and autonomous) constitutes a feature of a novel kind and therefore such ships may stand to benefit from this dispensation. Much depends on the attitude to the technology of domestic regulators. Further possibilities for the Contracting Government to grant exceptions to individual ships from the requirements of certain regulations are set out in the respective Chapters.

There is also considerable available "equivalence". When a SOLAS provision calls for a "particular fitting, material, appliance or apparatus, or type thereof, [to] be fitted or carried in a ship, or that any particular provision [to] be made", the relevant maritime administration may permit the use of alternatives to be carried if satisfied that these are at least as effective as the express provisions SOLAS prescribes.[8] It is doubtful that this would permit unmanned operability (to the extent that it is otherwise proscribed) since the ship's crew which, of course, is traditionally carried on board, cannot be understood to be a "fitting, material, appliance or apparatus".

Chapter II-1 Construction

Chapter II-1 deals with ships' structure, subdivision and stability, machinery and electrical installations. Ship structural requirements do not, in general, present particular difficulty for unmanned operability. The chapter does, however, include requirements which necessitate considerations of equivalence in an unmanned context. For example, there is the Regulation 5-1 requirement that the ship's "master ... be supplied with information ... as is necessary to enable him by rapid .... processes to obtain accurate guidance as to the stability of the ship under varying operating conditions". This information must be vested in shore-based remote controllers at all times in the decision making loop.[9] The chapter also makes reference to the need for, by way of example, engineers' alarms.[10] Whenever alarms designed to alert those in command of the relevant ship are required, the spirit of such rules requires alarms to similarly alert those remote controlling the ship from the shore. The spirit of such a regulation also requires autonomous ships to be capable of being brought under the immediate control of a remote-controller so that someone may act on the alarm signal. It should be noted that Regulation 55 of Chapter II-1 permits alternative design and arrangements in respect of machinery and electrical installations, subject to the prescribed evaluation and approval.

---

[7] Regulation 4(b). Such ships however shall comply with other safety arrangements suitable for the ship's intended service in the opinion of the Contracting Government.

[8] Regulation 5.

[9] See also Regulation 19, which requires the officer in charge of the ship to have access at all times, to damage control information.

[10] Regulation 38. See also Regulations 51 and 53(4).

Chapter II-2 Fire protection, Fire detection and Fire extinction
Chapter II-2 also prescribes structural requirements but with the specific aim of safety from fire. The chapter also prescribes detailed requirements for fire detection through appropriate alarm systems.[11] Regulations 15 and 16 concern onboard training and drills and operations, respectively. These are aimed at ensuring personnel charged with command of the ship are prepared in the event of fire to combat and contain it. This presents challenges of equivalence in the context of an entirely shore-based crew. Nevertheless, even to the extent that a strict application of the chapter presents difficulty for unmanned operations, Regulation 4.1 gives the relevant maritime administration the ability to exempt individual ships from the requirements of the chapter if minded that its full application is "unnecessary or unreasonable" if the relevant ship is not to exceed a distance of 20 miles from the nearest land. This dispensation will be important since arguably much of the spirit of the chapter is aimed at the preservation from fire of onboard personnel and/or passengers, which may lack application in unmanned operations. This is an issue which must be addressed by those developing the technology for unmanned shipping as well as regulators. The chapter also permits the use of alternative design and arrangements to those expressly prescribed after the necessary evaluation and approval.[12]

Chapter III - Life Saving Appliances and Arrangements
Chapter III prescribes the life-saving appliances to be carried on board the relevant ship and corresponding arrangements. It contains the same general exemption as Chapter II-2.[13] The chapter prescribes standards for onboard operations, such as maintenance;[14] again, consideration will be required as to its necessity and feasibility in an unmanned context. In the context of the carriage of passengers, however, passenger safety must be ensured to the same extent whether the ship is manned or unmanned. Some important requirements are, for instance, in the context of survival craft. Regulation 10 requires that "there shall be sufficient crew members, who may be deck officers or certified persons on board for operating the survival craft and launching arrangements." Whilst the chapter permits the use of alternative design and arrangements to those set out in this chapter,[15] it will be very difficult for an unmanned ship carrying passengers to comply with this regulation without posting onboard personnel trained in evacuation procedures.

Chapter IV – Radiocommunications
Chapter IV deals with radiocommunications and prescribes functional requirements for ships in the form of transmission capability. The chapter is exceptional in that it expressly applies to cargo ships of *300* grt upwards.[16] The

[11] Regulation 7 Detection and Alarm.
[12] Regulation 17.
[13] Regulation 2.
[14] Regulation 36.
[15] Regulation 38.
[16] Regulation 1. It thereby deviates from the main Rule in Chapter I Regulation (3)(a)(ii) referred to above stating that SOLAS does not, as a starting point, apply to cargo ships of less than 500 grt.

chapter requires continuous watches to be kept on prescribed channels.[17] Regulation 16 expressly requires that every ship "carr[ies] personnel qualified for distress and safety radiocommunications". This regulation presents difficulty for unmanned ships. From an equivalence standpoint, it is essential that the prescribed radiocommunications capabilities may be discharged by shore-based personnel. Again, the adequacy of any such arrangement will be subject to the satisfaction of the relevant maritime administration. Be it onboard or shore-based, the essence of the chapter speaks of human oversight. This presents acute difficulty for autonomous, unsupervised unmanned ships.

Chapter V – Navigation

For these purposes it is at least arguable that the most important regulation in Chapter V is **Regulation 14** on ships' manning. The regulation requires that from the point of view of safety, all ships are "sufficiently and efficiently manned". Contracting States are required to do this through the establishment of a transparent documentary procedure, i.e. ships' manning documentation. The regulation does *not require* that at least one crew member be on board at any one time. Nevertheless, it can be questioned whether a requirement of manning adequacy necessarily prohibits unmanned operability, since an unmanned ship is not at all manned, by definition. On the other hand, it is clear that the adequacy of manning arrangements is a concept relative to the particular ship in question, and its particular capabilities. It can be argued that if a ship utilises highly innovative communications technology enabling it to manoeuvre as responsively as when under the command of a conventional onboard crew, an onboard crew numbering zero may be technically adequate.[18] Both interpretations are equally feasible. However, it seems unlikely that the wording of Regulation 14 *necessarily* proscribes unmanned operations outright and in all circumstances. The regulation's aim is to establish a means by which the relevant administration may satisfy itself as to the safety credentials of a ship's complement rather than calling for any particular mode of operability. However, gaining the approval of maritime administrations may prove very difficult, particularly in the early phases of unmanned operability and in the absence of bespoke and codified regulations for the particular operations.

Regulation 15 prescribes principles in relation to bridge design. The first principle is "facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation..." In an unmanned shipping context, navigation will be performed from the shore but any substitute "electronic bridge" will need to comply with these principles if there is any prospect of addressing inevitable safety concerns and satisfying at least the spirit of this regulation. The same holds true for ships in autonomous mode, supervised with individuals qualified to assume remote-control of the ship immediately. A ship operating autonomously without any human oversight cannot comply with the Regulation. For such ships, there *is no* human appraisal (at least not contemporaneously). Regulation 22 prescribes minimum levels of visibility attainable on a ship's bridge. It is true that a ship may be dually-

[17] Regulation 12.

[18] IMO Resolution A.1047(27) provides that both level of ship automation and shore-based support may serve to reduce the relevant ship's onboard crewing requirements.

operable, i.e. capable of both unmanned and conventional manned operation. In such case, both the on-board bridge and the electronic bridge would have to comply with the bridge design requirements. Dual operability may also aid in complying with the required pilot transfer arrangements in Regulation 23 by enabling qualified persons to board and undertake the pilotage operations. Otherwise, the pilot transfer would have to be done electronically and the port facility would have to have the facilities to assume remote control.

Another particularly significant regulation is Regulation 24 (Use of heading and / or track control systems). It requires that in "hazardous navigational situations" it shall be possible to establish "manual control of the ship's steering immediately". Even on the assumption that manual control may be performed remotely, unsupervised autonomous unmanned ships will not be able to comply with this regulation which requires officers to be able to control the ship's movement immediately. In consequence, all unmanned ships must be supervised by qualified personnel capable of assuming manual control immediately.

Regulation 33 reiterates the obligation for the master of a ship, if in a position to do so, to proceed with all speed to the assistance of persons in distress at sea. For the duty to be of any relevance in an unmanned context, a member of the shore-side personnel controlling or supervising both remote controlled and autonomous ships must be deemed to be the unmanned ship's master. To the extent that this is the case, it is clear that the obligation is not confined to taking persons on board. In an unmanned context the duty may be discharged by ensuring that any distress signals received are relayed to the relevant search and rescue authorities or retaining a proximate position to form a hub for communications. The requirement that persons taken on board be treated with humanity is qualified by the reasonable capabilities and limitations of the ship and it can be argued that this qualification applies to the duty more generally.[19] On balance, if a remote controller of an unmanned ship were to discover persons in distress and does nothing at all to satisfy himself that the appropriate authorities are informed, he is in breach at least of the spirit of the duty and such conduct would not augur well for unmanned ship integration into the more conventional maritime community.

Importantly, Regulation 3 (Exemptions and Equivalence) provides that maritime administrations may grant exemptions and equivalence when an absence of general navigational hazards and "other conditions affecting safety" are such to render a full application of Chapter V "unreasonable or unnecessary". Specifically cited conditions are the duration of the voyage and the maximum distance of the ship from the shore. The extent to which an unmanned ship may rely on this flexibility will depend on its operational itinerary. Again, much will depend on the ability of a potential unmanned ship operator to convince the

[19] Under Article 98 UNCLOS, the master's duty to render assistance is qualified by the requirement the he can do so "without serious danger to the ship, the crew or the passengers". The specific requirement to "to proceed with all possible speed to the rescue of persons in distress " is qualified by the more relaxed condition that he does so "in so far as such action may reasonably be expected of him".

relevant authorities as to the safety of the alternative means by which the vessel will be commanded, be it remotely or autonomously.

Chapter VI – Carriage of Cargoes and Oil Fuels
Chapter VI deals mainly with operational requirements for the safe carriage of solid bulk cargoes. It contains special provisions for the carriage of such cargoes but also cargoes of grain. Regulation 2 requires the shipper to provide "the master or his representatives" information about the cargo. This function would need to be discharged by an alternative shore-based remote controller. Again, it is unclear the extent to which the performance of this function by a shore-based remote controller technically satisfies the requirement.

Chapter VII – Carriage of Dangerous Goods
The chapter seeks to ensure the safety of carriage of dangerous goods and requires their carriage to be in accordance with the International Maritime Dangerous Goods (IMDG) Code.[20] The chapter prescribes reporting requirements in respect of incidents involving such dangerous goods. The extent to which this may be discharged by shore-based personnel will depend on the surveillance technology enabling shore-based personnel to supervise stowed cargo.

Chapter VIII – Nuclear Ships
The chapter prescribes, inter alia, certification requirements in respect of nuclear ships. It has no unique relevance in the context of unmanned operations. Although, Regulation 3 states that a nuclear ship shall not, in any circumstances be exempted from compliance with "any regulations of [the] Convention". Thus, any exemptions discussed in the context of SOLAS which unmanned ships may stand generally to benefit from will not be available in the context of unmanned nuclear ships

Chapter IX – Management for the Safe Operation of Ships
The chapter principally requires that the relevant "Company" [21] and ship comply with the requirements of the International Safety Management (ISM) Code. The ISM Code requires the shipowner or such person who has assumed responsibility for the ship to establish a safety management system. The ISM Code seeks to ensure greater integration of the shore-based company in the safety management of ships. The ISM Code includes a requirement that the master's responsibilities be clearly defined as well as arrangements for shipboard operations, procedures and documentation.

From a regulatory perspective there is little or no codified practice guidance in the area of full shore-based control of a ship. Such guidance and practices must be developed. Arguably, the ISM Code is an appropriate instrument for this development.

---

[20] Regulation 7-4.

[21] Company, according to Regulations XI-2/1.7 and IX/1.2, means 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.

Chapter X – Safety Measures for High Speed Craft
Safety measures for high speed craft have no unique relevance in the context of unmanned operability.

Chapters XI (-1 & -2) Special Measures to Enhance Maritime Safety / Security
The chapters prescribe additional measures aimed at enhancing safety and security of ships. Regulation 4 of Chapter XI-1 provides that a ship in a port of another Contracting Government will be subject to control by authorized officers of the port state when there are clear grounds for believing that the master or crew are not familiar with essential shipborne procedures relating to safety. Under Chapter XI-2, Regulation 3 requires the relevant maritime administration to "set security levels and ensure the provision of security-level information" to their flagged ships. Unique security challenges are posed in the context of unmanned operability, be it remote controlled or autonomous, particularly with regard to cyber infiltration. Regulation 6 requires ships to have a ship security alert system which has the ability to transmit ship-to-shore security alerts to designated authorities, indicating the ship's location and that its security is under threat. This system must be able to be engaged from the ship's bridge and at least one other place. In an unmanned shipping context, there must be a similar ship-to-shore alert mechanism in place to alert those at the shore-based facility as to when the ship's physical or cyber-security has been compromised. Regulation 8 requires that the master's discretion is not to be constrained by the Company or any other person in respect of ship safety. In principle, a chief shore-based remote controller may be given this role and undertake such authority in respect of the safety of an unmanned ship in spite of his shore-based location. The chapter calls for compliance with the International Ship and Port Facility Security (ISPS) Code, which concerns, inter alia, the specific obligations on ship companies in respect to security, including security procedures, the employment of security-focused personnel and certification and verification requirements. Regulation 11 gives contracting governments the permission to conclude bilateral agreements for alternative security measures in respect of shorter voyages between ports of those contracting states. Regulation 12 permits the Maritime Administration to allow a particular ship or group of ships to make use of alternative equivalent security arrangements, provided such measures are at least as effective as those prescribed by Chapter XI-2 and the ISPS Code.

4.3 The International Regulations for the Preventing of Collisions at Sea, 1972 (COLREGS)

The International Regulations for the Preventing Collisions at Sea set out the navigational rules to be followed by vessels with the aim of avoiding collisions. The COLREGS are divided into five parts, Part A sets out general provisions for applicability, Part B prescribes the detailed steering and sailing rules, Part C sets out requirements for lights and shapes and Part D prescribes sound and light signalling requirements. Part E prescribes select exemptions from the Rules.

Part A – General

By **Rule 1** The Rules apply to "all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels".[22] Vessels, for these purposes, include "every description of water craft .... used or capable of being used as a means of transportation on water."[23]

Rule 2 is arguably the most important provision in the COLREGs. It provides that "nothing in [the] Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any ... neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case". The Rule reaffirms the importance of good seamanship over and above a strict compliance with the Rules' steering rules and expressly states that in select circumstances, deviation from the Rules is mandatory. The Rule requires contemporaneous human judgement in the decision making loop, not least in deciding on when a COLREG prescribed manoeuvre is required or alternatively, something potentially completely different. In principle, this judgement may be provided remotely, subject to the sophistication of the relevant communications technology. Even autonomous ships under permanent supervision paired with an ability to assume remote control arguably satisfy this requirement. Autonomous and unsupervised ships, however, would fall foul of Rule 2 in its current form.

Part B – Steering and Sailing Rules

Rule 5 requires that "every vessel ... at all times [maintains] a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances ... to make a full appraisal of the situation and risk of collision". Reference to "sight and hearing" clearly requires a human input in surveying and assessing the situation and collision risk, consistently with Rule 2. As such, autonomous ships relying, for instance, on algorithmic collision avoidance technology would not satisfy the requirement of appraisal by sight and hearing. Of course, one might envisage a future of exclusively autonomous ships all communicating with each other so as to prevent close quarters situations. In such a case, the breach of Rule 5 would only be technical, but a breach no less. Even in such a case it can be argued that the currently prescribed human element would provide an essential back-up to an autonomous network.

The present generation of unmanned craft use sophisticated aural and camera sensors to project the vessel's vicinity to shore-based remote controller. This arguably satisfies the Rule 5 requirement with the requisite human input still firmly in the appraisal process in the sense that the use of an electronic aids does not take the arrangement outside of the spirit or wording of Rule 5. Neither does its shore-based orientation. This is a point which must, however, be clarified.

Under **Rule 6** vessels must at all times "proceed at a safe speed so that [they] can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions". This is a

[22] Rule 1(a).
[23] Rule 3(a).

corollary of Rules 2 and 5 and any foreseeable delay in communications should be factored into the safe speed calculation. The transfer of data to the shore-based remote controller and transfer back of orders to the vessel inevitably will involve a delay of some duration, as will any satellite communications. The same can be said of **Rule 8** which requires that any action taken to avoid collision "shall be taken in accordance with the Rules of this Part and shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship". The remainder of Part B prescribes the detailed steering and sailing directions to be observed. The key point is that compliance with these provisions presents no difficulty if the relevant unmanned ship has the situational awareness required, in particular, as set out in Rules 2 and 5. As stated above, the required human appraisal arguably is satisfied in the context of remote controlled operation and even supervised autonomous operation so long as there is an ability to assume remote control immediately. Autonomous ships, which are unsupervised, however cannot meet the requirement.

Finally, under this Part, attention should be drawn also to **Rule 18** on "Responsibilities between vessels". In particular, it gives navigational priority to vessels "not under command" defined in Rule 3(f) as a "vessel which through some exceptional circumstance is unable to manoeuvre as required by the Rules and is therefore unable to keep out of the way of another vessel". This Rule usually covers vessels which have come into difficulty on account of engine failure, for instance. "Not under command" status might feasibly include an unmanned ship which has lost communications. In such a case, raising the appropriate signals to inform proximate sea users about this status is critical. However, the reference to "exceptional circumstances" clearly refers to circumstances other than a vessel's ordinary operational arrangements and so would not generally cover unmanned operability.

Part C & D: Lights and Shapes / Sound and Light Signals

Parts C and D set out detailed requirements for the signalling vessels must use to communicate with other sea users. The special technical requirements are specified in the COLREGS **Annexes I-IV**. Importantly, these requirements also serve an alternative use in demonstrating the required sophistication of an unmanned ship's electronic look out arrangements, since the ship must at a minimum be able to detect signals of other vessels. In general, making signalling capability resilient to ordinary communications failure, i.e. to ensure continued signalling capability when routine communication is lost, will be an important step for the unmanned ships in demonstrating their safety credentials. It should be noted, however, Governments may accept "closest possible compliance" with the requirements of Parts C and D in respect of "number, position, range or arc of visibility of lights and shapes as well as the ... characteristics of sound signalling appliances" in respect of vessels of "special construction or purpose".[24] The extent to which unmanned ships may benefit from this dispensation will be subject to the dialogue between operators and the relevant maritime authorities.

[24] Part A, Rule 1(e).

4.4 The Convention on Standards of Certification, Training and Watchkeeping (STCW)

The STCW Convention, amongst other things, prescribes qualification standards for masters, officers and watchkeeping personnel on board seagoing ships. It also deals with watchkeeping procedures. Through Article III, the Convention expressly applies to "seafarers *serving on board* seagoing ships entitled to fly the flag of a Party".[25] The Convention would thus ordinarily find no application to exclusively unmanned operations.

Unmanned operability introduces into the maritime domain an entirely new range of personnel charged with navigating the relevant ship. Such personnel currently lack a counterpart qualification regime. This must be addressed if unmanned shipping is to become widespread. In the absence of a uniform qualification standard for shore-based controllers and pre-programmers and also a codified standards regime for the relevant communications technology, satisfying a maritime administration as to the safety of an unmanned ship becomes more challenging. In particular, obtaining its satisfaction as to the safety of its proposed unmanned operability under SOLAS would be very difficult.

To a limited extent, the STCW Code – containing technical details associated with provisions of the STCW Convention – might be used as a blueprint for the development of a new qualifications regime. The Code's detailed watchkeeping provisions serve as guidance as to the extensiveness of the obligations to be discharged by shore-based personnel in at least equivalent terms. It was suggested in the context of Rule 2 of the COLREGS that unmanned ships must be able to conform to the requirements of good seamanship, thus remote-controllers of unmanned ships must be suitably qualified in maritime navigation to be able to practically discharge this duty. This will, of course, need to be accompanied by the technological training made necessary by the inevitably increased used of IT in the navigation process.

In terms of the STCW's watchkeeping requirements, Chapter VIII is titled "Standards regarding watchkeeping". Part 4, paragraph 10 (Watchkeeping at Sea) states "when deciding the composition of the watch on the bridge ... the following factors, inter alia, shall be taken into account". One of such listed factors includes "at no time shall the bridge be left unattended". In addition, paragraph 24 provides that "the officer in charge of navigational watch shall" "keep the watch on the bridge" and "in no circumstances leave the bridge until properly relieved". Furthermore, paragraph 24.2 provides that the officer in charge of the navigational watch shall "in no circumstances leave the bridge until properly relieved". To the extent that the STCW Convention finds application, these provisions presents difficulty for unmanned ships.

[25] Emphasis added.

4.5 International Convention for the Prevention of Pollution from Ships (MARPOL)

MARPOL is the primary IMO regulation, which addresses select forms of pollution from ships. It includes provisions from construction and equipment requirements of, for example for oil tankers, to operational and procedural requirements, including discharge limits, procedures for ship-to-ship transfers and numerous reporting requirements in case of spills. Unmanned ships will have to comply with the provisions of MARPOL to the same extent as their manned counterparts, although relative to the other IMO regulations considered the obligations under MARPOL are unlikely to present the most onerous challenges to unmanned operations.

5. General Liability Rules

5.1 The Current State of Play

Unmanned ships and especially autonomous navigation has the potential to alter the way in which liability is distributed in respect of accidents or incidents at sea. The careful navigation of a ship has traditionally been entrusted to trained seafarers whose competence the relevant shipowner can ensure based on codified standards. Navigation in an unmanned context will be the task either of a shore-based remote controller or alternatively, the developers and pre-programmers of software technology seeking to perform this task, or both. In other words, new liability players are introduced and even those retained arguably assume very different responsibilities.

Unlike matters subject to IMO regulations, the general liability position, which may be enforced at national level differs, potentially quite drastically, from jurisdiction to jurisdiction. Which law will apply to a dispute involving a ship "incident" at sea will depend on a number of factors and in particular, which waters the incident occurred in, the nature of the incident and sometimes the flag of the relevant ships and the nationality of persons involved. In which court such a dispute may be brought is subject to similar considerations. This section, therefore, is only meant to give a brief introduction into the potential issues that may arise in relation to the potential liabilities which may arise in relation to the operation of unmanned ships.

One of the main ways in which general civil liability differs between jurisdictions is the grounds on which it attaches. In most jurisdictions, civil liability is dependent on fault, be it through being negligence or breaching codified duties or rights. Fault-based liability is prescribed internationally in the context of collisions at sea. Under the Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels, 1910, liability is apportioned in accordance with the fault of the respective vessels.[26] In other jurisdictions,

[26] Article 3.

however, merely causing the relevant harm will suffice to attract liability. Such "strict liability" is also prescribed internationally for select types of incident.[27]

Another issue is exactly which particular person or persons attract liability. In a maritime context it is the shipowner who effectively assumes an overarching responsibility for most maritime liabilities. This will either be because of a specific provision for such a position, again in the context of collision, the 1910 Collision Convention places liability on the relevant "ship" rather than individual seafarers. In any event, most jurisdictions recognise vicarious liability pursuant to which, in this case, the shipowner will be responsible for the negligence of his servants / employers, which traditionally has included, inter alia, the ship's master and crew.

The fact that the shipowner often bears this overarching responsibility – *and* that in some cases, this liability will be strict – has given rise to an off-set in form of a general right, somewhat unique to the maritime domain, which is the right of limitation of liability for select maritime claims.

Potentially complex issues arise in the context of accidents at sea attributable to defects in the ship itself. The range of different types of technical issues is broad. The division of liability between the shipowner and, for instance, the shipbuilder or the manufacturer of an individual component is not always easy to draw. Many factors could play a role in this, not least the latency of the defect, in other words the extent to which any relevant defect might have been detected by due diligence on the part of the shipowner. In principle, however, the shipbuilder and component manufacturers are potential targets for liability if the relevant claimant can demonstrate fault, which is causative of their loss. The above pose difficult questions. What is the nature of the unmanned shipbuilder or component manufacturer's duty? In other words, for what ought the manufacturer be liable? Further, when can even a proven negligent defect on the part of the manufacturer be deemed to have caused an accident, bearing in mind the shipowner's obvious duty of maintenance and inspection? Case law assists to a limited extent but ultimately, each case is likely to turn on its own facts. Product liability and manufacturer liability exists in its own legal regime of case law, statute and European regulation.[28] Under this regime, manufacturers may face strict liability for harm caused by their products if they fall below a level of safety which might reasonably have been expected of them.

Criminal liability is even more varied at the national level. In particular, different offences are prescribed for different parties and perhaps equally significantly, the mental element required for liability to attach, may differ. Some criminal offences require no guilty mindset. The majority, however, require either intent

[27] For instance, under Article 10 of the Nairobi International Convention on the Removal of Wrecks, unless an exception applies, "the registered owner shall be liable for the costs of locating, marking and removing [a] wreck". Under article III of International Convention on Civil Liability for Oil Pollution Damage, 1992 "the owner of a ship at the time of an incident, ... shall be liable for any pollution damage caused by the ship as a result of the incident".

[28] Directive 85/374 in the approximation of laws, regulations and administrative provisions of the Member States concerning liability for defective products.

or recklessness. In some jurisdictions there is a large body of offences for negligent acts. In a maritime context it is the shipowner and the ship master who are usually criminally liable.

5.2 Implications of Unmanned Ships

It is not possible to simply transplant the existing liability rules applicable in the context of traditional manned maritime activity to its unmanned counterpart. Although parallels may be drawn between shore-based remote controllers and conventional seafarers and although autonomous navigation software is essentially another form of fitting or installation, the proposed technological shift impacts on the nature of the responsibilities assumed. Not least the relevant level of unmanned ship autonomy will impact profoundly on this question.

Unmanned ships will have to place far greater reliance on IT, software and communications systems and it will be foreseeable that there will be no personnel on board or in the vicinity to diagnose and "troubleshoot" even minor defects or glitches. This may have an important bearing on the respective duties assumed. Between manufacturer and shipowner these responsibilities may be apportioned contractually but in respect of harm occasioned on third parties the position is less clear. It is also not clear how and in what circumstances liability to third parties might attach to software designers and manufacturers and whether the liability would be fault-based or strict. Liability of producers under the European Product Liability Directive,[29] for instance, is strict in respect of matters within its scope. However, the extent to which ordinary manufacturers' liability will apply to unmanned shipping is yet to be determined. Shipowners will be expected to monitor, inspect and supervise their products and installations to a higher standard than consumers.

There is no reason in principle why the owner of an unmanned ship ought not to be given the benefit of the general right of limitation of liability currently enjoyed by manned shipowners. One of the most powerful arguments in favour of unmanned ships being regarded as "ships" and for their integration into the existing legal framework is that their operation would involve many of the same risks of collision and pollution as their manned counterparts.

The role of a remote-controller of an unmanned ship is in a sense similar to that of a master in that both assume real-time command of the movement and signalling etc. of the relevant ship. A pre-programmer of an autonomous unmanned ship, by contrast, enjoys a role unparalleled in the traditional maritime domain. He is potentially the last human input into the ship's navigational course but unlike a master, he does not exercise real time decision-making influence. The pre-programmer is in that sense more akin to an engineer or even a component manufacturer but unlike each of these, in the context of an autonomous collision avoidance system with no onboard oversight, his before-the-event conduct potentially has a far more profound bearing on the ship's

[29] 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.

navigational safety than the ordinary component manufacturer of a manned ship. Applying ordinary principles, liability stemming from an accident involving a pre-programed autonomous unmanned ship stand to be apportioned in some proportion between the shipowner, the software manufacturer and the pre-programmer. Each of these could be separate or conjoined corporate entities, which adds to the complexity. To what extent liability between these parties should be joint and several must be considered, as must the entitlement or otherwise of the pre-programmer to invoke the liability limitations of the shipowner.

What is clear is that new regulations and practices will need to develop to cover the activities introduced by unmanned operability. This will most likely involve further standards of due diligence on the part of the shipowner, additional certification requirements for component / software developers and a new training and qualification standards for pre-programming and shore-based navigation. It will also involve maritime administrations and classification societies gaining expertise in such operations in order to discharge their own important regulatory functions. In either case, these developments will probably adopt some aspects from existing maritime law, technical standards and manufacturers' liability law but also introduce new provisions for the innovative practices presented by unmanned shipping.

6. The way forward

The absolute priority in the regulation of unmanned shipping is safety. With the proposed innovative technology, the level of safety currently ensured by manned ships is the obvious benchmark. It is not realistic to expect regulators or the broader shipping community to tolerate a lower standard.

From the point of view of the exploitation of the technology, the most expedient mode of regulation would be for unmanned ships to come within the ambit of the existing framework, with some important modifications, based on the findings in the preceding pages.

There is no reason why unmanned ships ought not to be regarded as "ships" so as to fall within the ambit of UNCLOS and why, therefore, the rights and obligations of flag and coastal states ought not to apply to them, *mutatis mutandis.* This is the case even though UNCLOS was not drafted with unmanned ships in mind.

As far as compliance with the existing IMO regulatory framework is concerned, it is clear that the level of unmanned ship autonomy is of profound importance. In particular, there is an important distinction to be drawn between, on the one hand, remote controlled unmanned ships (or those at least supervised by persons capable of assuming immediate remote control) and, on the other hand, autonomous ships operating without any human supervision. This is because the IMO Regulations, in particular SOLAS, the STCW and the COLREGS, make it clear that contemporaneous human involvement in the decision-making process is

essential, even if on-board attendance is not always. For remote-controlled ships, only modest amendments or perhaps only clarifications of the existing regulations may be needed. For this purpose, potentially only supplementary or interpretative guidelines may be needed. However, considerable amendment to the existing framework is needed for the operation of the latter kind of unsupervised autonomous unmanned ships. Amendment to the established IMO Regulations is likely to take considerable time as agreement between only a small number of states is not sufficient to affect change at the international level.

With the international position yet to crystallise, domestic and regional interest groups, largely comprising stakeholders in the unmanned maritime industry itself, have taken the prudent steps of beginning to draft codes of practice for unmanned operations. In some instances this is being undertaken in collaboration with national maritime authorities and classification societies. In the absence of international agreement, this could be an interim solution, as regulatory change is more easily achieved in the domestic sphere for obvious reasons.

The international regulatory framework is of more limited importance in the context of unmanned operations taking place within the confines of one coastal state's internal or territorial waters. Thus, domestic operations in unmanned shipping presents the most convenient opportunity for the new technology to demonstrate its safety credentials to national administrations, whose discretion has a major role to play, in due course, in the compliance of the technology with the currently enacted international requirements. With the technology still developing, persuading national administrations to exercise their discretion favourably will be a long-term process, but it is essential if the technology will ever flourish, both domestically and internationally.

As far as the international regulators are concerned, a number of measures are currently needed. There must be a more comprehensive review of the current regulatory framework to assess its applicability to unmanned ships as well as whether unmanned ships can comply with it and also the extent to which amendment to or clarification of, is necessary. It will also be import to identify and separate those provisions which are prescriptive and compulsory in nature from those which are permissive. A start has already been made in the academic community.[30]

Once this is undertaken, the position will be much clearer as to the extent of the measures needed to integrate unmanned ships. In other words, it will be clearer where soft law guidance and clarity is needed and, on the other hand, where convention amendment is essential and thirdly, where new provision is needed. In the latter case, a decision will have to be made as to whether such new regulation is itself prescriptive or more goal-based. Certainly as regards remote

[30] R Veal and M Tsimplis, "The integration of unmanned ships into the *lex maritima*", [2017] LMCLQ 303. See also E Van Hooydonk, "The law of unmanned merchant shipping – an exploration", [2014] JIML 403.

controlled operations, for the reasons set out previously, it is suggested that soft law guidance would in most cases be the most appropriate and expedient option.

What is currently missing, however, is sufficient dialogue on this issue internationally. This is where the CMI Questionnaire on unmanned ships can assist. It will give maritime law associations the opportunity to consider the most salient questions which go the very heart of the issue of unmanned shipping regulation, focusing on the domestic law of each as well as the international conventions to which their respective States are party. It will also serve to encourage discussion in consequence, both between maritime law associations and their respective national authorities as well as between states at international level. This will serve to uncover any barriers to consensus and the greater use of the technology.

INTERNATIONAL MARITIME ORGANIZATION

E

MARITIME SAFETY COMMITTEE
98th session
Agenda item 20

MSC 98/20/2
27 February 2017
Original: ENGLISH

WORK PROGRAMME

Maritime Autonomous Surface Ships
Proposal for a regulatory scoping exercise

Submitted by Denmark, Estonia, Finland, Japan, the Netherlands, Norway, the Republic of Korea, the United Kingdom and the United States

SUMMARY

Executive summary:	The use of Maritime Autonomous Surface Ships (MASS) creates the need for a regulatory framework for such ships and their interaction and co-existence with manned ships. This document invites the Committee to undertake a regulatory scoping exercise to establish the extent of the need to amend the regulatory framework to enable the safe, secure and environmental operation of MASS within the existing IMO instruments.
Strategic direction:	5.2 and 5.4
High-level action:	5.2.1, 5.2.2, 5.2.4 and 5.4.1
Output:	No related provisions
Action to be taken:	Paragraph 25
Related document:	MSC 95/INF.20

1 This document is submitted in accordance with paragraphs 4.8 and 6.12.6 of MSC-MEPC.1/Circ.5 on *Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies*, taking into account resolution A.1099(29) on *Application of the Strategic Plan and High-level Action Plan of the Organization*, and proposes a new output to undertake a regulatory scoping exercise to establish the extent of the need to amend the regulatory framework to enable the safe, secure and environmental operation of entirely or partly unmanned Maritime Autonomous Surface Ships (MASS) within the existing IMO instruments.

Introduction

2 The maritime sector is witnessing an increased deployment of MASS to deliver safe, cost-effective and high quality results. In this context, MASS could include ships with different levels of automation, from partially automated systems that assist the human crew to fully autonomous systems which are able to undertake all aspects of a ships' operation without the need for human intervention. Significant academic and commercial research and development (R&D) is ongoing on all aspects of MASS, including remotely-controlled and autonomous navigation, vessel monitoring and collision avoidance systems.

3 Whilst technological solutions are being developed and deployed, the co-sponsors are of the view that there is a lack of clarity about the correct application of existing IMO instruments to MASS. The co-sponsors believe the IMO needs to ensure that MASS designers, builders, owners, and operators have access to a clear and consistent regulatory framework (guided by the principles of resolution A.1103(29)) in order to be able to demonstrate compliance with IMO instruments.

4 It is therefore proposed by the co-sponsors that a regulatory scoping exercise of IMO instruments should be undertaken with the aim of identifying:

.1 IMO regulations which, as currently drafted, preclude unmanned operations;

.2 IMO regulations that would have no application to unmanned operations (as they relate purely to a human presence on board); and

.3 IMO regulations which do not preclude unmanned operations but may need to be amended in order to ensure that the construction and operation of MASS are carried out safely, securely, and in an environmentally sound manner.

5 It is the co-sponsors intention that this proposal will help IMO understand the full range of regulatory implications arising from MASS and plan appropriately for this important work stream. The overall aim is to ensure that safety, security, environmental protection and efficiency of shipping are maintained, and potentially improved, so that the flow of seaborne international trade continues to be smooth and efficient.

IMO objectives

6 The proposed regulatory scoping exercise would allow IMO to respond proactively to the growth in the use of MASS in a timely manner and thereby continue to promote safe, secure, environmentally sound, efficient and sustainable shipping.

7 Within the scope of the responsibilities of the MSC, this proposal would relate to the Strategic Direction 5, and in particular High-level Action 5.2.1 "Keep under review the technical and operational safety aspects of all types of ships, including fishing vessels". As such, this proposal is deemed to be within the scope of the Strategic Plan and the related High-level Actions.

Need

8 Technological advances have resulted in the introduction into service of a variety of MASS. The size of these MASS and geographical spread of their use are both growing.

9 Some Classification Societies have recognized this trend and have already published design criteria and guidelines for MASS. In addition, some States have established national guidelines for the operation of MASS within their jurisdiction (for example via the dissemination of Maritime Safety Information (MSI) to warn other shipping).

10 However, the co-sponsors are of the view that as the number, type and size of MASS increase, these arrangement may become unsustainable and potentially unsafe.

11 Moreover, the existence of different national regulatory frameworks may render the construction and operation of MASS unmanageable, and may hamper innovation and technological developments.

12 IMO in its role as the primary international forum for technical matters of all kinds affecting international shipping should therefore take a proactive role to ensure there is a harmonized international approach to MASS. The co-sponsors are also of the view that there are a number of IMO regulations that currently present a challenge to achieving this goal. This includes:

.1 IMO regulations which, as currently drafted, preclude unmanned operations;

.2 IMO regulations that would have no application to unmanned operations (as they relate purely to a human presence on board); and

.3 IMO regulations which do not preclude unmanned operations but may need to be amended in order to ensure that the construction and operation of MASS are carried out safely, securely, and in an environmentally sound manner.

13 The co-sponsors, therefore, consider that there is a need to establish an output under the purview of the Maritime Safety Committee, to undertake regulatory scoping exercise so that there is a common understanding of the measures which would be necessary to enable the safe operation of MASS. This would be an initial step and it may also be necessary to undertake similar work under the other Committees.

Analysis of the issue

14 To date, consideration of the construction and operation of MASS has not been undertaken by the international maritime community. Whilst the operation of the current MASS may be manageable in the short term, for the reasons set out above, the co-sponsors propose that the Organization should now begin to consider what steps might be needed to include MASS within the framework of existing IMO instruments.

Analysis of implications

15 Given the current proposal is only to undertake a regulatory scoping exercise there would be no costs to the maritime industry or administrative requirements arising from this output in itself, and the Checklist for Identifying Administrative Requirements, as set out in annex 1, has been completed on this basis.

16 Following the scoping exercise, the Committee would have to consider how best to address any issues identified, and it is the intention that the scoping exercise would provide the basis for consideration of the implications at that stage.

17 However, the co-sponsors would note that the consequences of not undertaking the proposed scoping exercise could contribute to the proliferation of MASS in an unregulated manner which may lead to adverse impacts on maritime safety, security and the protection of the marine environment.

Benefits

18 As the technology matures there will be an increasing number of maritime activities which could benefit from the deployment of MASS, and this regulatory scoping exercise would be the first step in ensuring the IMO regulatory framework was prepared for the full commercial utilization, which is likely to be realized within the next decade.

Do adequate industry standards exist?

19 There are a number of relevant industry standards which are already being applied by the manufacturers and operators of MASS. While these may be adequate for the limited scale on which MASS are being operated at this stage, as has been noted above, they are unlikely to be adequate in the future if the trend towards increased size and geographical deployment continues. In addition, there would be advantages to ensuring harmonization of applicable standards through existing IMO instruments.

Output

20 The proposed output would be:

Maritime Autonomous Surface Ships regulatory scoping exercise; identification of:

.1 IMO regulations which, as currently drafted, preclude unmanned operations;

.2 IMO regulations that would have no application to unmanned operations (as they relate purely to a human presence on board); and

.3 IMO regulations which do not preclude unmanned operations but may need to be amended in order to ensure that the construction and operation of MASS are carried out safely, securely, and in an environmentally sound manner.

Human Element

21 Given the current proposal is only to undertake a regulatory scoping exercise there would be no implications for the Human Element arising from this output in itself, and the Checklist for identifying human element issues, as set out in annex 2, has been completed on this basis. However, the co-sponsors are mindful that while the MASS would be unmanned many of the issues that need to be considered would relate to the interactions of between the MASS and humans, either on board other vessels or in shore based roles, and as such the Human Element would be an area of consideration within the proposed scoping exercise.

Urgency

22 The Committee is considered to be the appropriate body to coordinate and complete this scoping exercise given it would cut across remit of the different subsidiary bodies, it is therefore envisaged that input from subsidiary bodies to the areas related to their technical expertise would also be needed. This would be an initial step and it may also be necessary to undertake similar work under other Committees, which would be put forward, as appropriate, by separate proposals to the relevant Committees.

23 Four sessions are estimated to be necessary to complete the work. Therefore, it is proposed that this proposal should be considered by the Organization for inclusion in the High-level Action Plan of the Organization for the 2018-2019 biennium (and in due course the 2020-2021 biennium). The co-sponsors consider that there is an urgency in starting the scoping exercise during the next biennium, given the time the exercise will take, and the need to follow up the exercise with any regulatory changes that are identified to ensure the IMO regulatory framework is prepared for the full commercial utilization, which is likely to be realized within the next decade.

Action required

24 It is proposed that the Committee includes a new output on its work programme as suggested in paragraph 20 to undertake a regulatory scoping exercise in order to allow future sessions of the Committee to make informed decisions about the work required to accommodate MASS within the IMO's regulatory framework.

Action requested of the Committee

25 The Committee is invited to consider the information provided above and agree to the request for a new output as proposed in paragraph 20.

***

ANNEX 1

CHECKLIST FOR IDENTIFYING ADMINISTRATIVE REQUIREMENTS

This checklist should be used when preparing the analysis of implications, required for submissions of proposals for inclusion of outputs. For the purpose of this analysis, the terms "administrative requirements" is defined in resolution A.1043(27) i.e. administrative requirements are an obligation arising from future IMO mandatory instruments to provide or retain information or data.

Instructions:

(A) If the answer to any of the questions below is **YES**, the Member State proposing an output should provide supporting details on whether the burdens are likely to involve start-up and/or ongoing cost. The Member State should also give a brief description of the requirement and, if possible, provide recommendations for further work (e.g. would it be possible to combine the activity with an existing requirement?).

(B) If the proposal for the output does not contain such an activity, answer **NR** (Not required).

(C) For any administrative requirement, full consideration should be given to electronic means of fulfilling the requirement in order to alleviate administrative burdens.

1. Notification and reporting? Reporting certain events before or after the event has taken place, e.g. notification of voyage, statistical reporting for IMO Members, etc.	NR ✔	Yes Start-up Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes) As explained in paragraph 15 of paper, given the output is only for regulatory scoping exercise, no administrative requirements arise from it.		
2. Record keeping? Keeping statutory documents up to date, e.g. records of accidents, records of cargo, records of inspections, records of education, etc.	NR ✔	Yes Start-up Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes) See Q1.		
3. Publication and documentation? Producing documents for third parties, e.g. warning signs, registration displays, publication of results of testing, etc.	NR ✔	Yes Start-up Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes) See Q1.		
4. Permits or applications? Applying for and maintaining permission to operate, e.g. certificates, classification society costs, etc.	NR ✔	Yes Start-up Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes) See Q1.		
5. Other identified requirements?	NR ✔	Yes Start-up Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes) See Q1.		

***

ANNEX 2

CHECKLIST FOR CONSIDERING HUMAN ELEMENT ISSUES BY IMO BODIES

Instructions:
If the answer to any of the questions below is:

(A) YES, the preparing body should provide supporting details and/or recommendation for further work.
(B) NO, the preparing body should make proper justification as to why human element issues were not considered.
(C) NA (Not Applicable), the preparing body should make proper justification as to why human element issues were not considered applicable.

Subject Being Assessed: (e.g. Resolution, Instrument, Circular being considered)

MASS regulatory scoping exercise

Responsible Body: (e.g. Committee, Sub-committee, Working Group, Correspondence Group, Member State)

MSC

1.	Was the human element considered during development or amendment process related to this subject?	Yes	No	✔	NA
2.	Has input from seafarers or their proxies been solicited?	Yes	No	✔	NA
3.	Are the solutions proposed for the subject in agreement with existing instruments? (Identify instruments considered in comments section)	Yes	No	✔	NA
4.	Have human element solutions been made as an alternative and/or in conjunction with technical solutions?	Yes	No	✔	NA
5.	Has human element guidance on the application and/or implementation of the proposed solution been provided for the following:	Yes	No	✔	NA
	• Administrations?	Yes	No	✔	NA
	• Ship owners/managers?	Yes	No	✔	NA
	• Seafarers?	Yes	No	✔	NA
	• Surveyors?	Yes	No	✔	NA
6.	At some point, before final adoption, has the solution been reviewed or considered by a relevant IMO body with relevant human element expertise?	Yes	No	✔	NA
7.	Does the solution address safeguards to avoid single person errors?	Yes	No	✔	NA
8.	Does the solution address safeguards to avoid organizational errors?	Yes	No	✔	NA
9.	If the proposal is to be directed at seafarers, is the information in a form that can be presented to and is easily understood by the seafarer?	Yes	No	✔	NA

10.	Have human element experts been consulted in development of the solution?	Yes	No	✔	NA
11.	**HUMAN ELEMENT: Has the proposal been assessed against each of the factors below?**				
❑	CREWING. The number of qualified personnel required and available to safely operate, maintain, support, and provide training for system.	Yes	No	✔	NA
❑	PERSONNEL. The necessary knowledge, skills, abilities, and experience levels that are needed to properly perform job tasks.	Yes	No	✔	NA
❑	TRAINING. The process and tools by which personnel acquire or improve the necessary knowledge, skills, and abilities to achieve desired job/task performance	Yes	No	✔	NA
❑	OCCUPATIONAL HEALTH AND SAFETY. The management systems, programmes, procedures, policies, training, documentation, equipment, etc. to properly manage risks.	Yes	No	✔	NA
❑	WORKING ENVIRONMENT. Conditions that are necessary to sustain the safety, health, and comfort of those on working on board, such as noise, vibration, lighting, climate, and other factors that affect crew endurance, fatigue, alertness and morale.	Yes	No	✔	NA
❑	HUMAN SURVIVABILITY. System features that reduce the risk of illness, injury, or death in a catastrophic event such as fire, explosion, spill, collision, flooding, or intentional attack. The assessment should consider desired human performance in emergency situations for detection, response, evacuation, survival and rescue and the interface with emergency procedures, systems, facilities and equipment.	Yes	No	✔	NA
❑	HUMAN FACTORS ENGINEERING. Human-system interface to be consistent with the physical, cognitive, and sensory abilities of the user population.	Yes	No	✔	NA

Comments:
As explained in paragraph 21 of the document given the current proposal is only to undertake a regulatory scoping exercise there would be no implications for the Human Element arising from this output in itself.

However, the co-sponsors are mindful that while the MASS may be unmanned many of the issues that need to be considered would relate to the interactions of between the MASS and humans, either on board other vessels or in shore based roles. As such the Human Element would be an area of consideration within the proposed scoping exercise, and it could be the scoping exercise that provides some of the answers to the Human Element checklist when it is associated with any follow-up proposal for actually regulatory changes.