Maritime and Aviation Law: A Relational Retrospect and Prospect on Unmanned Ships and Aircraft

Unmanned Ships and Aircraft

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1 Introduction and Prelude

Autonomous or unmanned[[1]](#footnote-1) ships is a relatively new phenomenon in the maritime domain, one which the International Maritime Organization (imo), its member States and the shipping industry alike are moving forward to understand, define and ultimately integrate. Developments have been made in varieties of software, such as those usable in sensor technology, surveillance, analysis and decision support. In addition, algorithms in respect of artificial intelligence usable for shipboard applications including navigation and awareness of particular situations, are rapidly increasing. These unprecedented technological advancements are instigating increasing demands for autonomous ships and remotely controlled navigation. They are shaping a trend that is accelerating towards a new era in maritime transportation. An essential factor in this development is the dire need for a regulatory framework, which is yet to materialize. This is a real concern for all involved in the legal side of the equation given the contemporary growth in the autonomous shipping market, estimated in 2020 to be valued at usd 85 billion, now projected by some to reach a staggering $165 billion by 2030. This represents a compounded annual growth rate of 6.8 percent from 2020 to 2030.[[2]](#footnote-2)The world’s first unmanned commercial shipping operation reportedly began on 7 May 2019. It was a contemporary event of ground-breaking maritime history when an unmanned vessel, the hull of which was constructed of aluminium and was 12 metres in length, transported a box of oysters from Essex in the United Kingdom to Belgian customs in Ostend. It was also reported that the craft in question was remotely controlled from a remote-control centre belonging to Hushcraft, its designer, situated in the village of Tollesbury on the coast of Essex.[[3]](#footnote-3) It must be noted at this juncture that whereas unmanned shipping is still in relative infancy, unmanned aircraft in the form of drones in both civil and military usage have been around for quite some time and today’s general public are very much aware of their existence. Technological advancement in aviation facilitated by a relatively advanced legal framework, can be of considerable referential value for articulation of the law on unmanned ships as they evolve in the current milieu.

In light of the above observations, the main objective of this article is to carry out a relational analysis of maritime law and aviation law focusing on a particular subject of contemporary interest, namely, that of unmanned ships. In that vein, it is considered expedient and instructive to examine it comparatively with the phenomenon of unmanned aircraft. The article is organized to reflect the different legislative initiatives on maritime and aviation automation at the international level. The comparative analysis presented herein spans all of the legal aspects of aviation and shipping, which is an ongoing challenge, to determine the most effective and efficient means of addressing the broad scope of topics. The discussion centres first on unmanned ships including current developments mainly in the realm of regulatory law in that field. Discussion on the law respecting unmanned aircraft follows, pointing to specific areas of commonality and lessons that can be learnt for the benefit of the corresponding maritime law.

2 The Maritime Dimension

2.1 The Definitional Aspect

An international definition of autonomous or unmanned ship is conspicuously absent; nor is there any definitional indication of the different levels of autonomy which leads to the question whether an autonomous ship is a ship by definition under existing internationally established legal standards. At the outset therefore, without further ado, it would be expedient to seek a definition for “autonomous ship” and ponder over its legal implications. Definitions can sometimes pose a dilemma. In conventions, it is often convenient to articulate them quite broadly to enable the subject of regulation to be adequately addressed; or to customize them to meet a specific need or purpose. One definition of “autonomous ship” is a ship “equipped with an operating system able to make decisions and determine actions by itself. It performs functions related to operation and navigation independently and self-sufficiently”. There is also the colloquial term “smart ship” defined as a “ship equipped with automation systems capable, to varying degrees, of making decisions and performing actions with or without human interaction”.[[4]](#footnote-4)

2.2 imo Scoping Exercise on mass

The Maritime Safety Committee (msc) of the imo undertook a “scoping exercise” to determine the scope of application of its regulatory instruments and their possible reach with respect to Maritime Autonomous Surface Ships (mass),[[5]](#footnote-5) a newly coined term defined as “a ship which to a varying degree, can operate independently of human interaction”.[[6]](#footnote-6) Four degrees of autonomy were established with respect to surface ships which are not intended to be hierarchical. First, there are the ships that have automated processes and are equipped with decision support systems. The systems are automated but may require human intervention at times which requires the presence of crew on board. Crew being available for the operation of shipboard systems as and when required, such ships are not unmanned *per se*. In the second degree, ships are controlled from a shore station but crew are available on board to carry out functions and take over control if need be. In the third degree, ships are remotely controlled from ashore without the presence of any shipboard crew. The fourth degree involves a fully autonomous ship with no crew where the onboard system is capable of making decisions and taking necessary actions without any support or assistance from anywhere.[[7]](#footnote-7)

An important strategic direction incorporated in the 2018-2023 Strategic Plan of imo is to “integrate new and advancing technologies in the regulatory framework”. The object is to create a balance between the advantages obtained from new technological advancements and concerns over safety and security, environmental impact and international trade facilitation, potential costs to industry, and last but not least their impact on shipboard and shore-based personnel.[[8]](#footnote-8)

In 2017, a proposal was made to the imo-msc to put on its agenda, a regulatory scoping exercise in respect of mass. The aim of the exercise was to “determine how the safe, secure and environmentally sound operation of mass may be introduced into imo instruments”.[[9]](#footnote-9) The msc realized the necessity for imo to adopt a positive and proactive stance and engage in a leadership role in view of commercial ships entering into the autonomous crewless shipping arena and taking advantage of the fast-growing technology. The Legal Committee and the Facilitation Committee of imo also put the regulatory scoping exercise on their respective agendas to draw in the convention instruments falling within their remit.[[10]](#footnote-10)

The scoping exercise is viewed as the launching pad for delving into a host of issues from the human element, safety and security concerns to such matters as protection of the marine environment including liability and compensation for damage suffered, interactions with ports, pilotage, and responding to maritime accidents and incidents.[[11]](#footnote-11) The framework and methodology for the regulatory scoping exercise for mass was approved at the 100th Session of the msc.[[12]](#footnote-12) The Legal Committee decided to follow suit with a slightly adjusted framework and methodology which was approved at its 106th Session, as did the Facilitation Committee which received approval of its framework and methodology at its 43rd Session.

The scoping exercise basically consists of two steps – the first one to review the adequacy of existing potentially applicable instruments, and the second to further assess and determine the most appropriate way of addressing mass operations. For the purpose of step one, each imo instrument related to maritime safety and security, or to liability and compensation, and for each degree of autonomy of mass, provisions will be identified which:

– Apply to mass and prevent mass operations; or

– Apply to mass and do not prevent mass operations and require no actions; or

– Apply to mass and do not prevent mass operations but may need to be amended or clarified, and/or may contain gaps; or

– Have no application to mass operations.

Once the first step has been completed, the next step is to analyze and determine the most appropriate way of addressing mass operations, taking into account, *inter alia*, the human element, technology and operational factors. The analysis will identify the need for:

– Equivalences as provided for by the instruments or developing interpretations; and/or

– Amending existing instruments; and/or

– Developing new instruments; or

– None of the above as a result of the analysis.[[13]](#footnote-13)

Originally, it was hoped that the scoping exercise would be completed by 2020,[[14]](#footnote-14) but it seems that realistically it is likely to be 2022 or even 2023.[[15]](#footnote-15)

2.3 Unmanned Ships in the Legal Framework: Public Law in Perspective

Given that unmanned or autonomous ships or mass is a technologically new phenomenon, the regulatory law governing such ships is of prime importance, particularly because the extant regulatory regime respecting conventional ships is well-established and highly clustered. Perhaps more importantly, at the centre of any discussion on unmanned ships, the operative word is “unmanned”, meaning there is no crew on board. Thus, the impact on crewing requirements and the governing maritime labour law pertaining to ships at present are of utmost relevance in tandem with the technological developments regarding unmanned ships. In this regard, the phenomenon of crewless ships, whether partial or total, is in juxtaposition to the concept of the human element; and arguably, autonomous ships pose less of a risk in safety terms which is doubtless of benefit to shipping. Needless to say, almost all of maritime law today, in particular, the regulatory and labour law aspects are subject to international conventions, and with few exceptions, all maritime States are parties to them. Apart from the so-called framework convention, the United Nations Convention on the Law of the Sea, 1982 (unclos),[[16]](#footnote-16) some aspects of which must ostensibly feature in this discussion, there are several conventions and related treaty instruments adopted under the auspices of the imo and also the International Labour Organisation (ilo).

2.3.1 unclos

It is notable that directing a ship’s navigation from a shore station is not a new thing. The functional concepts of vessel traffic systems (vts) and vessel traffic management systems (vtms) under unclos and solas have been around for several decades now. In several instances, instructions are given by pilotage authorities, but usually these are directed to pilots, not to shipboard navigators although it is acknowledged that a master is always in command of a ship even if a pilot conducts navigation. Several attempts have been made to widen the scope of shore-based control of navigation in pilotage waters. Over the last decade or so, the European Union project Motorways of the Sea and Electronic Navigation by Intelligence at Sea, otherwise known as monalisa, has been striving with some success to introduce shore-based navigational control of ships at sea but there has been serious resistance from the international seafaring community. Likewise, the imo was initially not very receptive to such propositions citing disruption of its existing realm of regulatory conventions and also relevant provisions of unclos.[[17]](#footnote-17)

Insofar as unclos is concerned, it is trite that it is virtually impossible to apply unclos rules and requirements to autonomous ships. Simply stated, unclos being a public international law convention, there are several treaty formalities posing as obstacles that are difficult to overcome. Additionally, there are conceptual barriers pertaining to unclos that prevent or impede the application of the convention to autonomous vessels. There are provisions that point to the master and crew of the ship that bear and impinge on rights, responsibilities and undertakings. The master as the authority on board is unequivocally bound by the convention provisions which in real terms is incompatible with the operation of an autonomous ship, in particular of the fourth degree. Among others, these are issues involving unclos that are yet to be seriously considered and resolved.[[18]](#footnote-18)

2.3.2 colregs

As mentioned above, the *status quo* involves requirements imposed by several international conventions. Of utmost importance is navigational safety and the primary instrument in this regard is the International Convention on Preventing Collisions at Sea, 1972,[[19]](#footnote-19) (colregs). The need for Collision Regulations to govern global shipping became apparent with the transition from sail to steam and the transformation of wooden to steel hulls. These were instances of law responding to technological development of the times, akin to what we are seeing today with the rapid acceleration of technology in the field of autonomous ships. Ironically, it was evident that the effects of collisions at sea resulting from these technological developments were exponentially more severe. Incidentally, the colregs also operate as penal law.[[20]](#footnote-20) The regulatory law dimension of collision law is correlated to the private law side of collisions involving civil liability arising from a maritime tort and provision of remedies commensurate with damage suffered.[[21]](#footnote-21)

The first point to note about the colregs is that they apply to “vessels”, a term conceptually wider than “ships”. The definition of “vessel” is “every description of watercraft including non-displacement craft and seaplanes used or capable of being used as a means of transportation on water” which does not preclude an autonomous ship from being described as a vessel.[[22]](#footnote-22) Under the colregs, vessels are required to carry out certain steering manoeuvres and movements forward and astern at a safe speed to prevent and avoid collisions, particularly where vessels are at risk of collision particularly in “head-on”, crossing and overtaking situations. It will be virtually impossible for unmanned ships under the fourth degree referred to above to comply with, among others, the aforementioned rules requiring navigational judgments to be made to prevent collisions in specific situations. Rule 2 states that no owner, master or crew member will be exonerated from “the consequences of any neglect to comply with the rules …”. Furthermore, under that Rule, no exoneration is to be afforded to consequences of “the neglect of any precaution, which may be required by “the ordinary practice of seamen”. An interesting question has been raised as to whether this or the related notion of “good seamanship” in Rule 8 referred to below can be replicated by any computer software.[[23]](#footnote-23) To enable compliance with Rule 2, control centres operating fourth degree autonomous vessels must perhaps employ persons with requisite seamanship understanding and experience; otherwise, the Rule may have to be amended to take account of the fact that autonomous vessels will not have seamen (seafarers) on board to ensure that their ordinary practice is observed.[[24]](#footnote-24) It is notable that in practical terms, Rule 2 allows for a departure, meaning a non-observance, in the event it is required for avoiding immediate danger.

In Rule 5, it is mandated that a proper lookout must be by “sight and hearing as well as by all available means appropriate in the prevailing in the circumstances”. In this regard, one author seems to have the opinion that the requirement presupposes that all technical means of keeping a lookout have been exhausted and therefore highlights the need to resort to the human senses of sight and sound which trigger judgment and reaction based on experience to avoid collision.[[25]](#footnote-25)

As alluded to above, where collision avoidance action needs to be taken, Rule 8 requires good seamanship to be observed. Needless to say, these requirements of the colregs are food for careful thought in the context of autonomous vessels.[[26]](#footnote-26) Rule 17 speaks to last minute action to avoid collision. If one vessel required to keep out of the way fails to do so in good time, the other vessel finding itself too close must “take such action as will best aid to avoid collision”. How this can be safely achieved in the case of an autonomous ship is a valid point of query. As one author has observed, it will require “reliable, safe, and delay‐free communications coupled with secure and fast data transfer between the autonomous ship and the control centre”.[[27]](#footnote-27)

In the context of unmanned ships, a grim reality is that even with dramatic advancements in ship technology, safety remains a major cause for concern in shipping. The relatively recent foundering of the *Costa Concordia* in 2012 bears testimony to the contention that despite remarkable technological breakthroughs, regulatory stringency is not to be compromised.[[28]](#footnote-28) Autonomous ships invariably need to be adequately regulated through international instruments to ensure all round maritime safety across the vast expanse of the oceans of the world. Thus, there is a dire need for international regulatory maritime law encapsulating the peculiarities of autonomous vessels of all descriptions.[[29]](#footnote-29)

2.3.3 solas

Among other imo Conventions, several aspects of the International Convention on Safety of Life at Sea, 1974 (solas)[[30]](#footnote-30) warrant attention. First of all, attention must be drawn to Chapter 1 which houses the “Application” provision of the Regulations of the convention. Clearly, paragraph (a) of Regulation 1 states that the Regulations apply to ships “engaged on international voyages”. Furthermore, Regulation 3, paragraph (a) which lists all the varieties of ships excluded from the application of the Regulations, does not mention unmanned ships. Indeed, at the time solas was created, in response to the *Titanic* disaster of 1913, such ships were not in the foggiest contemplations of anyone. Needless to say, in order to accommodate unmanned ships within the legal framework of solas, a major amendment would be necessary.

The structural and ship safety requirements of solas are contained in Chapters ii-1 and ii-2. Detailed technical prescriptions of sorts elaborated in various instruments *para droit* known as Codes, which are mostly mandatory. Apart from those, perhaps the most important aspect of solas is the subject of Safety of Navigation contained in Chapter V. Regulation 14 of this chapter addresses Safe Manning which is of utmost importance in relation to unmanned ships. The first paragraph of this Regulation requiring ships to be “sufficiently and efficiently” manned runs totally contrary to the very essence of unmanned ships regardless of the degree of autonomy. It is postulated by one author that with regard to unmanned ships, the “sufficiency requirement may be met by control stations being “sufficiently manned” and the “efficiency requirement”, satisfied by means of the installation of adequate high technology systems. The requirements of Regulation 14 could thereby be fulfilled by a combination of these two elements of “remote command and control of the unmanned ship”.[[31]](#footnote-31) It would appear that the related provision in paragraph 2 requiring each State Party’s Administration to issue a “minimum safe manning document” to each of its ships is equally problematic in respect of unmanned ships.

As stated by Mingyu Kim and others.,[[32]](#footnote-32) unmanned ships possess certain characteristics which warrant serious consideration in terms of the application of the International Safety Management Code (ism Code) under Chapter ix of solas. Indeed, according to the views of those authors, there are a host of imo Conventions which should be amended as well. However, it is well recognized that such an initiative will be an uphill task requiring an inordinate amount of time and the cooperation of the numerous bodies within imo like the Committees and Sub-Committees to make it happen. In view of the enormity of this task, it would be more expedient to introduce fresh regulatory requirements employing a goal-based approach in line with the Goal-Based Standards (gbs) of the imo according to the revised generic guidelines produced by the msc.[[33]](#footnote-33) Specifically, these guidelines have been developed for the purpose of establishing safety goals and functional requirements taking into consideration a typical mass lifecycle. The objective to be achieved through the adoption of gbs is to ensure that the safety standards of remotely controlled unmanned ships are no less than those applicable to similar conventional vessels.[[34]](#footnote-34)

2.3.4 Other Regulatory Conventions

It is postulated that conventions do not expressly exclude autonomous ships from the ambit of their application. Apart from the functional necessity of being able to be in motion on water, there is seemingly no provision in international legislation that for a ship to qualify as a ship, it must be manned.[[35]](#footnote-35) Be that as it may, in the view of the present author, such a proposition is fallacious at least in terms of the maritime law and practice as it stands. Regardless of whether or not there is specificity in international instruments in this regard, which there is, since time immemorial, ships have been in fact manned until the recent advent of autonomous or unmanned ships which has not yet fully materialized. It is perhaps a valid proposition that in view of the technologically feasible reality of the autonomous ship, there should be a clear legal pronouncement that a ship in the current milieu could be one that is unmanned. That said, in numerous instances, international maritime conventions point to ships being manned by a duly qualified master, officers and crew.[[36]](#footnote-36) Indeed, solas provides for ships to have a safe manning document and the Maritime Labour Convention, 2006 (mlc 2006)[[37]](#footnote-37) deals *inter alia*, with the labour or employments aspects of ships’ masters, officers and crew.

Insofar as domestic legislation is concerned, whereas in the United Kingdom Merchant Shipping Act 1995, “ship” is simply defined in s.313(1) as including “every description of vessel capable of navigation” with no mention that it must be manned, the French *Code des Transports* 2010 specifically refers to a floating craft “*manned* for maritime merchant navigation”.[[38]](#footnote-38)

Looking to the future, with respect to the issue of safe manning, law makers internationally and nationally will need to generate new and appropriate legal regimes for autonomous ships belonging to the categories of degrees one, two and three. Regarding fourth degree ships, law makers and regulators must devise a proper regime for the “manning” of shore-based control stations.

The role of the master in the new first, second and third-degree autonomous ship regimes is particularly important as his/her powers will be significantly diminished. Concomitant with that, the question will arise regarding whether there will be a “master” of a shore-based control station remotely operating a ship at sea completely. One view is that remotely operated ships, with or without crew on board can meet the convention requirements for a master if the shore-based controller is appropriately qualified.[[39]](#footnote-39) In the opinion of the present author, such a proposition is unclear at best. Obviously, such qualifications will not be the same as those of a master serving on board a ship. Be that as it may, if the shore-based controller is clueless about practical seamanship and navigation, he/she will be ill-equipped to remotely direct the ship regardless of his/her hi-technology capability. This would be particularly important in respect of assisting vessels in distress at sea and search and rescue operations under the sar Convention[[40]](#footnote-40) and salvage under the Salvage Convention.[[41]](#footnote-41) These are substantive regulatory issues pertaining to autonomous ships *vis a vis* safe manning. In that vein, it is instructive to note a question raised by a duo of authors as to “whether it is possible for an unmanned ship, by its very definition, to have a master”.[[42]](#footnote-42)

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978/1993 (stcw Convention)[[43]](#footnote-43) applies to masters and seafarers’ qualifications, *i.e*., training and certification, as the title of the Convention states. It has no application to shore-based remote controllers of unmanned ships. Neither does the Convention apply to others such as programmers associated with the autonomous navigation of the ship. None of them are regulated by the stcw Convention because they are not on-board navigators even though in actual fact, they are engaged in navigating the ships. It is the view of the present author that navigation can be conducted remotely from ashore or a station set up for that purpose, but seamanship cannot be replicated. Good seamanship can only be carried out at sea.

With respect to the efficiency and capability of such shore-based personnel to remotely operate autonomous ships in practical seamanship terms, much depends on factors physically external to the control centre such as the geographical location of the ship, the cargo on board, the prevailing weather conditions and the safety and security of the ship. At the control centre itself, considerations of operator experience and competence and operator fatigue, among other things, are crucial. It is suggested by one author that these factors or prerequisites need to be incorporated into the stcw Convention for it to be up to date functionally and adequately tailored to meet the requirements of autonomous ships. The requirements for training and certification of such shore-based personnel should also include the standards applicable to operators of Vessel Traffic Services (vts).[[44]](#footnote-44) As far as the application of labour law to shore-based remote stations is concerned, most likely it would have to be the corresponding land-based law rather than the mlc 2006 which applies exclusively to seafarers.

To end the discussion on the public law implications, it must be noted that conventional ships are subject to coastal state jurisdiction when they traverse the waters of any of the maritime zones under unclos. In the territorial sea, foreign ships have right of innocent passage and in the exclusive economic zone they are entitled to exercise freedom of navigation. Pursuant to several imo conventions as well as mlc 2006 and unclos, foreign ships voluntarily entering a port or offshore facility of a coastal state are also subject to port state control (psc). How an autonomous ship remotely controlled from a shore station will be able to submit itself to coastal state jurisdiction under unclos and to psc under various maritime conventions is a questionmark. The absence of a legal definition of an autonomous ship poses a problem. Furthermore, under its flag state law, the autonomous ship may be considered a “ship” but a coastal state under its own law may not be willing to recognize an autonomous ship as a ship. This may impede the growth of autonomous shipping.[[45]](#footnote-45)

2.4 Unmanned Ships in the Legal Framework: Private Law in Perspective

In the private law sphere of the subject under discussion, two topics are addressed, namely the question of civil liability including its limitation, and the issue of seaworthiness in the context of marine insurance and carriage by sea.

Civil liability in the realm of shipping is essentially governed by national law, and with few exceptions is generally based on proof of fault regardless of the legal system. The difficulty with autonomous or unmanned ships operating with no human intervention such as those categorized in the third and fourth degrees as per the imo/msc standards, determination of fault on the part of a human being is virtually impossible. Navigation is conducted by remotely placed human operators or by artificial intelligence (ai) pursuant to algorithms that are pre-programmed. In some such instances, fault may be attributable to a human operator who has failed to properly monitor movements of the ship in question or to take adequate intervening action. In other instances, there may be a failure on the part of the owner or operator of the ship to maintain up-to-date software programmes or has been otherwise negligent. A shipowner or ship manger may be hit with allegations of vicarious liability for the fault of a remote operator who is an employee or agent or even a third party. Liability may rest on the vendor or provider of the software or of the technology used in its development. Needless to say, the relationship of a person actually at fault *vis a vis* his/her/its employer is crucial in terms of who can be liable.[[46]](#footnote-46)

In this context, the exposure to risk of liability is an important factor which must be considered, and the risk should be adequately insured. Civil liability risk and its protection through insurance in all its facets is a concern that begs attention. A related issue in this regard is whether there is any possibility of a shipowner facing strict liability whether by operation of law or through statutory action.[[47]](#footnote-47) Another question that arises is whether remote operators who in essence take the place of ships’ navigating officers in relation to unmanned vessels, should be held independently liable. In the current milieu of shipping, civil liability actions against masters and ships’ navigating officers are rare, mainly because they do not have “deep pockets”. It is therefore expedient in practical terms for a claimant to sue the employer. The same argument will probably prevail in the context of remote operators who are simply employees of shipowners or of corporate entities who can be held vicariously liable.

Shipowners, of course, can limit their liability pursuant to a convention such as the International Convention on Limitation of Liability for Maritime Claims, 1976 modified by its 1996 Protocol, (llmc)[[48]](#footnote-48) or other limitation regime under domestic law. The “conduct barring limitation” provision of llmc raises the question of its applicability to a remote operator of an autonomous ship and what would be an apt test for recklessness or knowledge assuming that the person alleged to be liable under that convention provision was the shipowner or the shore-based operator entity.

While it is trite that risk of liability is insurable, in private maritime law, there are more ways than one through which liability can arise. One of them, again in respect of the shipowner, is liability in connection with unseaworthiness of a ship which, in the realms of carriage of goods or passengers and marine insurance, is basically contractual in nature. In terms of carriage of goods by sea evidenced by bills of lading, such liability can arise under one of the international conventions such as the Hague-Visby Rules[[49]](#footnote-49) or the Hamburg Rules.[[50]](#footnote-50) These conventions pointedly require certain duties to be performed by the ship’s master and the crew. This can be problematic for autonomous ships. One author opines that when an autonomous ship is underway at sea, only the presence of onboard crew can “prevent accidents and keep the vessel seaworthy”.[[51]](#footnote-51) It must be duly noted however, that under the Hague and Hague-Visby Rules the duty is only to “exercise due diligence to make the ship seaworthy before and at the beginning of the voyage”.[[52]](#footnote-52)

In the normal course, if the master of a conventional ship is found to be incompetent, it is unlikely that the shipowner will be able to successfully invoke the navigational fault defence of the Hague or Hague-Visby Rules. If the shore-based operators of an autonomous ship are provenly competent individuals and are able to remotely navigate a third or fourth-degree ship safely, the question arises as to whether in those circumstances the seaworthiness requirement is met. On the other hand, if there is inherent failure of the software or of the electronic gadgetry, it is uncertain what the legal consequences might be. A definitive conclusion is seemingly not obvious. Be that as it may, perhaps in the not too distant future, artificial intelligence will take over and reduce or even eliminate the instances of human error.[[53]](#footnote-53) In such an eventuality, the legal regime will no doubt have to change correspondingly.

Seaworthiness of ships is a conspicuous element of the law of marine insurance. The universally well-known Marine Insurance Act 1906 of the United Kingdom provides for an implied warranty of seaworthiness in section 39. It is an absolute warranty and applies in respect of voyage policies at the beginning of a voyage. in respect that the vessel is “reasonably seaworthy in all respects”. This warranty applies to voyage policies of marine insurance at the commencement of the voyage and is now tempered by the more recent Insurance Act 2015 which applies to all insurance across the board. How the insurance regime will impact on autonomous ships is uncertain at this stage. Suffice to say that at the present time, unmanned ships will likely be considered unseaworthy under extant marine insurance regimes and will not be eligible for insurance cover.[[54]](#footnote-54)

3 The Aviation Dimension

3.1 Definition of Unmanned Aircraft

Unlike unmanned shipping, autonomous aircraft were already in existence at the time of the First World War, operated by both civil and military entities.[[55]](#footnote-55) As such, back to 1929 when a Protocol amending the Convention Relating to the Regulation of Aerial Navigation (Paris Convention),[[56]](#footnote-56) the starting point of the legal framework for international civil aviation, was formulated. That Protocol refers to pilotless aircraft in a subparagraph of Article 15 as “no aircraft of a contracting State capable of being flown without a pilot shall, except by special authorization, fly without a pilot over the territory of another contracting State”.In 1944, the Convention on International Civil Aviation (Chicago Convention)[[57]](#footnote-57) replaced the Paris Convention. Article 8 of the Chicago Convention entitled “Pilotless aircraft” provides as follows:

No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft.

The International Civil Aviation Organization (icao) adopted the concept of Unmanned Aerial Vehicles (uav s) in 2004 when it started to work on regulatory development in that field. An uav is defined as “a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous”.[[58]](#footnote-58) In 2007, icao suggested that uav s should instead be referred to as unmanned aircraft systems (uas). Compared with the term uav, the term uas is generally used to describe the entire operating equipment including the aircraft, the control station from where the aircraft is operated and the wireless data link.[[59]](#footnote-59)

The description “Remotely Piloted Aircraft Systems” (rpas) was subsequently introduced in 2009 by the Unmanned Aircraft Systems Study Group (uassg) to identify a subset of the uas.[[60]](#footnote-60) The uassg reached the conclusion that only remotely piloted unmanned aircraft could be integrated with and alongside manned aircraft in non-segregated airspace and at airdromes (aerodromes). The Group thus decided to narrow down the focus of its study to only remotely piloted uas rather than all categories of them. Thus, it was understood from the start that rpas are only one type of unmanned aircraft; all such aircraft being subject to the requirements of Article 8 of the Chicago Convention.[[61]](#footnote-61) In 2011, icao published a circular captioned *Unmanned Aircraft Systems* *(uas)*[[62]](#footnote-62) providing States with an overview of issues that would have to be addressed in the Annexes of the Chicago Convention to ensure compliance of rpas with the Chicago Convention. As such, icao regulations for manned aircraft apply in the same way as they do to uas.

Subsequently icao established the rpas Panel in 2014 to succeed the work of the uassg. The Panel reached the conclusion that the regulatory framework of rpas should be the same as that for conventional aircraft. icao published *Manual on Remotely Piloted Aircraft Systems (rpas)*[[63]](#footnote-63) in 2015, which set out its vision of rpas being included in the extant icao framework. More recently the icao Legal Committee adopted the following terms and their descriptions:

– Unmanned aircraft [ua]: An aircraft which is intended to operate with no pilot on board.

– Unmanned aircraft system [uas]: An aircraft and its associated elements which are operated with no pilot on board.

– Remotely piloted aircraft (rpa): An unmanned aircraft which is piloted from a remote pilot station.

– Remotely piloted aircraft system (rpas): A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.[[64]](#footnote-64)

3.2 icao Legislative Initiatives

The principal objective of the aviation regulatory framework is to achieve and maintain the highest possible uniform level of safety. In the case of uas, this means ensuring the safety of any other airspace user as well as the safety of persons and property on the ground. It is evident from the above explanation that icao has been mainly concerned with rpas and incorporating it into the existing regulatory framework.

However, as small uas which are usually less than 25 kg, appear to the general public more frequently, icao also started to consider the operation of this subset commonly referred to as “drone”. As uas develop progressively, their size, performance and complexity vary significantly as may be expected; so does the variety and complexity of their related operations. In some instances, the roles of uas will be similar to those of manned aircraft. The obvious difference between the two types is that in an unmanned aircraft there is no pilot on board. Thus, the regulatory logic and thought process associated with conventional manned aviation would be inappropriate for all types of uas. As stated by jarus, therefore, designing a regulatory regime that would allow industry to continue developing, often rapidly, while concurrently controlling undue risk exposure to other users of airspace and ground personnel and to critical infrastructure, would be a daunting task indeed. Whatever regulatory framework is designed and put into place, a whole host of envisaged systems and roles must be factored into it.[[65]](#footnote-65)

In June 2020, icao published a piece of model legislation[[66]](#footnote-66) that endorses an operation-centric and risk-based regulatory approach by creating uas operational risk categories and applying corresponding rules. This regulatory framework for uas emerged from jarus), a group of experts established in 2007 with the purpose of recommending certification, specifications and operational provisions to interested parties such as icao, national aviation authorities and regional authorities for their consideration and use.

According to the uas Operational Categorization[[67]](#footnote-67) document published by jarus in 2019, the operation-centric and risk-based approach is defined in terms of three operational categories as set out herein; namely, Category A (Open) representing very low risk operations, Category B (Specific) representing limited risk operations, and Category C (Certified) representing traditional high risk operations. Every uas should be characterized by one of these three categories according to the risks associated with the particular operation of the system. The standards for each category involves many operational factors, including the size of the aircraft, location, altitudes, airspace classification and complexity of the operation, day/night operations and mitigations that may be imposed.[[68]](#footnote-68) By reason of its operation-centric nature, the same uas can be operated under different categories because different operational scenarios can possibly be considered. Details and descriptions of each Category (A, B and C) are provided in Appendix I to this article. The value of categorization of uas operations lies in the application of different levels of regulatory involvement to mitigate the risks identified. There are many ways to mitigate the risks associated with uas operations, such as airworthiness requirements, operational limitations, operational approvals, the details of which are provided in Appendix ii to this article.[[69]](#footnote-69)

4 Summary, Conclusion and Recommendations

4.1 Maritime Law and Aviation Law Compared

The origins of *maritima* are lost in obscurity going back over millennia to when humankind first floated a piece of log in the water and learnt that, as a means of transportation, it was more efficient than the cart and the wheel. Maritime law is thus of ancient vintage, mature, and in maritime metaphoric jargon,well-anchored. By comparison, aviation has appeared on the horizon in relatively recent times. Even if several aviation law principles have been derived from maritime law, it must be emphatically acknowledged that in technological terms, aviation, since the latter part of the last century has skyrocketed ahead of shipping.

Against the above brief background, it is noted unsurprisingly that maritime law and aviation law, as modalities of transportation, mostly of an international nature, share important commonalities which engender legal challenges as well as opportunities for innovation providing mutual inspiration. With market expansion hand in hand with technology development, aviation law has grown into an independent legal domain and generated creative legal instruments which can serve as models for maritime law. Prime examples are the legal concepts and theory on unmanned aircraft which can be emulated to resolve legal issues regarding unmanned ships.

Unlike the international shipping regulations promulgated through numerous maritime conventions, there are only a few conventions regulating aviation. The main convention on aviation is the Chicago Convention together with its Annexes containing Standards and Recommended Practices. Unmanned aviation has been within the ambit of the Chicago Convention since its inception.

Shipping has, up to this point, been based on the notion of seafarers including master and crew, operating the ship from within the ship itself. The whole maritime law has been based on this proposition. Regulatory legislation dictates that manning is an essential ingredient for seaworthiness of a ship; it must be classed and authorized by a national legal regime to operate. Removal of manning from ships raises important technical, operational as well as legal issues, the extent of which is being actively studied by the maritime community. Despite the divergent approaches, some principles can be borrowed from legislative initiatives on unmanned aircraft in designing a new legal framework for autonomous shipping.

4.2 Recommendation: Operation-Centric and Risk-Based Regulatory Approach

As discussed, for carrying out the scoping exercise on unmanned ships, imo has categorized mass into four groups according to different degrees of autonomy. This method of categorization may serve the purpose of a scoping exercise but, in this author’s opinion, it is not compatible with making regulations designed to govern the operations of unmanned ships with different degrees of autonomy. So far, imo has placed more emphasis on the autonomous ship as a phenomenon but has given less consideration to its operational environment which may vary. The scoping exercise on mass is still continuing with the object of determining the extent to which they can be captured by existing conventions. Most likely, the extant legal and regulatory maritime framework will have to be modified to accommodate autonomous ships and facilitate their adaptation to the rules. To achieve this aim, it is advisable that regulations be developed that are consonant with corresponding technological progress in the field. While the lawmaker’s aim should always be to embrace the code of safety first, overregulation may have a negative impact on innovation and should be avoided.

In that vein, the recently-developed theory of the operation-centric and risk-based regulatory approach of uas in aviation law is a good model to follow. It exemplifies how adequate safety levels can be attained without sacrificing or impeding technological development. It has been demonstrated in the foregoing discussion how icao initially adopted the same stance as imo, by attempting to integrate rpas with the extant legal regime governing manned aviation. However, as different types of uas, especially smaller varieties of them were developed, icao altered its regulatory strategy for all uas and their associated operational environments to establish a risk-based form of categorization and corresponding rules.

An operation-centric and risk-based approach to regulating uas focuses on two principal operational risks shown in the following figure, namely, safety risks and other risks. Safety risks associated with uas operations can be grouped according to the parties who are the potential victims. These include people on the ground, other airspace users, and critical infrastructure such as unmanned aircraft causing a fatality to persons or damaging property on the ground. Likewise, there may be a collision between a ua and another airspace user in any phase of a flight. There are other risks outside the remit of the aviation regulator such as the risk of privacy infringement, security encroachments, environmental damage *etc*.

Figure 15.1 Here

Regulators of global aviation must face the challenge of putting into place methods and criteria commensurate with uas approval requirements respecting design, construction, production and operation taking account of safety factors relating to integration into airspace. This can be achievable through a non-prescriptive, performance-based regulatory approach. While it can be expected that uas will adopt certain roles similar to those prevailing in manned aviation, it must also be envisaged that given the fact that they will be without pilots, some of the conventional devices utilized in the regulation of manned aviation will become obsolete. In view of further advancements in terms of the range of uas types, changes in future operating environments and performance variations call for a flexible regulatory approach, one that is susceptible to relatively easy adoption. All said, a risk-based approach is the one that is most compatible with the established scheme of operational categories.

The categorization invariably leads to different regulations designed to mitigate risks at different levels according to the nature and extent of the involvement of the regulator. It would, for example, be appropriate to employ traditional approval devices used in manned aviation for uas operations that are at the highest level of risk. On the other hand, where it is possible, less onerous regulatory measures such as airworthiness requirements or operational limitations could be adopted to mitigate risk at a lower level.

Rapid advancements taking place in the current technological milieu will make fully autonomous shipping a viable reality, perhaps in the not too distant future. However, we must not lose sight of the fact that maritime technology is subject to a plethora of regulatory requirements designed to foster safe and environmentally sound operations. The shipping industry provides an indispensable service to global seaborne trade and commerce. If autonomous shipping is looking to acquire regulatory approval to prosper, it must be demonstrated that the technology involved is uncompromisingly safe and sound, no less than that which is expected of conventional ships.

It is recommended by the present author that the operation-centric and risk-based regulatory approach utilized in the aviation sector be emulated in the maritime sector for the development of a regulatory scheme for unmanned ships or mass. That is not to suggest, however, that exactly the same legal methodology that has been developed for autonomous aircraft should apply to autonomous shipping. In this article, legal barriers to regulating unmanned ships through extant maritime conventions have been pointed out and examined. In that vein, it is suggested that corresponding legislative initiatives pertaining to unmanned aircraft be consulted, given that unmanned ships and unmanned aircraft share several legal commonalities. The main recommendation directed at the maritime lawmaker is to concentrate on the risk-based regulatory approach which will require, in the first instance, categorization of unmanned ships into different types according to their operational risks, and apply appropriate levels of regulation. It would be expedient for imo to conduct a full risk assessment of autonomous ships together with their various operations in different environments and to create a risk-based categorization by considering appropriate parameters. Then, commensurate regulatory measures could be applied by imo to reduce risks identified in the categories through means like seaworthiness, operation approval, operator competence, *etc*.

Inevitably, the law on autonomous shipping and aircraft will have to undergo changes as technology evolves and market demands accelerate. There may also be other aspects worth examining as the icao model legislation on uas progresses. It is not beyond expectations that the law on unmanned ships might grow to be more advanced and become a model for unmanned aircraft. This article has attempted to shed some light on the common denominators of the two modalities of unmanned ships and unmanned aircraft and instigate a measure of mutuality in the articulation of regulatory legal regimes on both fronts. The recommendations are intended to apprise the rulemaking authorities on possibilities for the future regulation of unmanned ships or mass operations and provide a baseline regulatory structure.

Appendix i: uas Operational Categories   
(Excerpts from *jarus uas Operational Categorization*)

2.5 uas Operational Categories

Based on the unmitigated risk associated with uas operations, every uas operation should be characterized by one of three categories. It should be noted that the same uas can be operated in principle in different categories because of possible different operational scenarios considered.

Category A (Open)

This category identifies those uas operations that present low unmitigated risk. The concept that there will be minimal regulatory involvement applies in this category. Self-certification or adoption of industry standards may apply but there are no mandatory airworthiness requirements. Risk mitigation is applied through the adoption of operational limitations (e.g. limited to specific geographical locations and in visual line of sight) and hence there will be no mitigation applied through approvals issued by an aviation regulator. The operator *per se* is responsible for safe operations.

Category B (Specific)

Where an uas operation goes beyond the operational limitations of Category A and safety is not (at least fully) assured by relying on a certificated design as foreseen in Category C, the operation will need to be independently assessed by the authority under this category. An acceptable level of risk is ensured by a risk assessment of the operation that identifies the applicable mitigations, which can contain requirements addressing the design, operational limitations, and qualifications of the operator or of the pilot. Varying levels of oversight will be needed in this category. The aviation regulator will need to decide what level of oversight is required and issue an operational approval.

Several operators may want to conduct similar types of operations in category B. In such cases, compliance with the assumptions and conditions of a generic risk assessment endorsed by the authority may be acceptable in lieu of requiring an individual risk assessment for all operators concerned.

Category C (Certified) – Represents Traditional High Risk Operations

Full regulatory oversight will apply in this category following the traditional approach to manned aircraft regulation. The uas in this category will carry high levels of risks, which cannot be solely mitigated through operational limitations. A level of risk mitigation will be applied through regulatory oversight. A uas in this category would likely require a Type Design approval (e.g. Type Certification), a Certificate of Airworthiness, Flight Manuals, Instructions for Continued Airworthiness, production approvals and other associated certificates of traditional civil aviation.

Appendix ii: Risk Mitigation Strategies   
(Excerpts from *jarus uas Operational Categorization*)

2.4 Risk Mitigation Strategies

There are many ways to mitigate risks associated with uas operations. Traditional approval mechanisms from manned aviation are appropriate and should be applied to the highest unmitigated risk uas operations. Conversely, a less burdensome means of mitigating risk could be applied to lower unmitigated risk operations. This section describes some of the primary means of mitigating uas operational risks.

2.4.1 Airworthiness

Less risk-bearing uas operations could be deemed fit to fly solely by the operator without interaction with an aviation authority or any type of airworthiness approval. More risk-bearing uas operations would demand more traditional approval means. The issuance of a Certificate of Airworthiness (CoA) is one means of mitigating risks associated with uas operations. By terms of icao Annex 8, a CoA shall be issued by a contracting Authority based on satisfactory evidence that the aircraft complies with the design aspects of the appropriate airworthiness requirements. This implies a fundamental level of regulator involvement in the oversight of the design aspects and a set of appropriate airworthiness requirements for the uas. Each of these provides an additional layer of safety, backed by the experience of manned aviation, to ensure the uas has an appropriately airworthy design. Additionally, it will help ensure that the quality of the production of the uas is able to catch defects and non-conformities to the design.

2.4.2 Operational Limitations

Operational limitations are another way to manage the risks of uas operations. There are many operational limitations that could be applicable including altitude limitations, airspeed limitations, geographical limitations, temporal limitations, line of sight limitations, etc. For example, altitude limitations can prevent a small uas from being lethal in the event of crash or they could control exposure to airspace where manned aviation is frequently found.

2.4.3 Operational Approvals

Operational approvals could include such documents as uas operator certificates, specific approvals, flexibility provisions (e.g. exemptions) or permissions. These should be considered based on a risk- and performance-based approach as well as proportionality. For lower risk operations the requirement of operator or pilot certificates might be too burdensome for operators as well as for authorities. For highest risk operations operator and pilot certificates should be required; the requirements should be comparable to requirements concerning manned aviation. Between the highest risk and lowest risk operations there is a great variety of operations. In most cases the need of operational approvals should be considered thoroughly, and a pilot certificate should be required. Local circumstances (e.g. population density) should be taken into account when considering whether the certificate or approval is required or not, for a certain type of operations. Equipment capability (e.g. number of rotors, fail-safe functions, and redundancy systems) should be a factor when determining appropriate level of requirements. Self-declaration (e.g. registration) could also be considered in some cases.

2.4.4 Operator Competence

The operator competence will mitigate risks associated with uas operations. A competent operator will reduce incidents with regard to the operational limitations set forth by the Authority and ensure proper coordination, as needed, with other airspace users. Basic navigation skills remain important in many uas operations to ensure the aircraft is flown safely. System specific training will also mitigate operational risk by ensuring proper normal and emergency procedures are followed for each aircraft type.

2.4.5 Identification

Proper means of identification of the ua (e.g. in flight) and its operator will mitigate some risk from irresponsible or uninformed use. It would provide a compliance and enforcement tracking mechanism which would instill a level of responsibility in the operator for safe operations. Electronic identification of uas may in most cases be more practical than visual identification. The standard registration marks for international operation in place for manned aviation could be applicable to uas, but may not be appropriate for certain types and uses which would require the development of new identification means.

2.4.6 Design Approvals and Features

Historically, regulator design approval of all aircraft has been used as an additional layer of safety in protecting the lives of the pilots, passengers, and people on the ground. This paradigm, the risk profile, shifts with the introduction of unmanned aircraft where the crash of the vehicle no longer implies fatalities on-board the aircraft. Fatalities to other airspace users and people on ground are still a possibility. However, aircraft design approval, at a vehicle and component level, can mitigate the safety risks associated with uas operations.

Design approval can be of the rigor used for manned aviation where regulators or designees extensively review and approve all engineering aspects of the aircraft and its components to ensure it will operate its intended mission with the highest level of confidence. Design approval could also potentially be scaled down to a less onerous process. Component level approval, rather than that of the entire aircraft, could be used to mitigate specific risks. For example, an appropriately designed and installed parachute could mitigate the risk of life and property on the ground. Many Authorities already have regulatory means to approve aircraft component design, e.g. Technical Standard Orders, which could be used in this new capacity.

Design ‘features’ implies the requirement for specific functionality or capability on an aircraft without regulatory involvement in the design or installation of the functionality. In instances where the risk is relatively low, this ‘soft’ requirement could provide a level of safety assurance to an uas operation. Standards for consumer products could be one means of scaling down regulator involvement as a ‘softer’ requirement than full design approval.

P.S. Such categorization and the sora for Specific Category has been endorsed by EU[[70]](#footnote-70) and finally incorporated by icao in its model Regulation for harmonization in uas legislation.

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figure 15.1 uas risks

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43. International Convention on standards of training, certification and watchkeeping for seafarers (stcw), (adopted 7 July 1978, entered into force 28 April 1984) 1361 unts 2. [↑](#footnote-ref-43)
44. Komianos (n 22) 341. [↑](#footnote-ref-44)
45. UK P&I (n 4) 4. [↑](#footnote-ref-45)
46. UK P&I (n 4) 6. [↑](#footnote-ref-46)
47. ibid. [↑](#footnote-ref-47)
48. International Convention on Liability for Maritime Claims, (adopted 19 November 1976, entered into force 1 December 1986), 1456 unts 221; 16 ilm 606; rmc i.2.330, ii.2.330 as amended by Protocol of 1996 (adopted 2 May 1996, entered into force 13 May 2004), 35 ilm 1433. [↑](#footnote-ref-48)
49. International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (The Hague Rules) (Adopted 25 Aug 1924, entered into force June 2, 1931) 120 lnts 155 as amended by the Visby Amendments, Protocol to Amend the International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (Visby and Hague Rules), (adopted 23 February 1968, entered into force 23 June 1977) 1412 unts 128.. [↑](#footnote-ref-49)
50. United Nations Convention on the Carriage of Goods by Sea (The Hamburg Rules), (adopted 31 March 1978, entered into force 1 November 1992) 1695 unts 3. [↑](#footnote-ref-50)
51. Komianos (n 22) 345. [↑](#footnote-ref-51)
52. Art. 3(1). [↑](#footnote-ref-52)
53. UK P&I (n 4) 5. [↑](#footnote-ref-53)
54. See reference to statement by Andrew Bardot, Executive Officer of the International Group of P&I Clubs in Komianos (n 22) 345. [↑](#footnote-ref-54)
55. Manual on Remotely Piloted Aircraft Systems (rpas), icao Doc.10019. [↑](#footnote-ref-55)
56. International Convention for the Regulation of Aerial Navigation (Paris Convention)(adopted 15 October 1919, entered into force 1 June 1922) 11 lnts 173. [↑](#footnote-ref-56)
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