

SEAWORTHINESS AND AUTONOMOUS SHIPS: LEGAL IMPLICATIONS IN THE 21ST CENTURY

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This paper aims to analyse the doctrine of seaworthiness and how the doctrine applies to autonomous ships. Section 39 of the Marine Insurance Act 1906 imposed an implied warranty of seaworthiness for every voyage policy. Case laws in the United Kingdom and Australia indicate that the doctrine has remained uncontroversial in the past 200 years. The operation of autonomous ships in the near future, however, may pose a challenge to the said doctrine. Autonomous ships no longer require crew members to be on board, and the operation of the ships may be performed by computers instead of human beings, but the said doctrine is inadequate to cover legal liabilities that may arise from on-shore ship operation and Artificial Intelligence. For the future operation of autonomous ships, the authors suggest that a reformulation is needed for the said doctrine.

Introduction

The doctrine of seaworthiness plays an important role in both a contract of carriage of goods by sea and a marine insurance contract and its meaning and scope are understood in the same sense in both contexts.¹ This doctrine is encapsulated in Article 3(1) of the Hague Rules,² the Hague-Visby Rules,³ and the Amended Hague Rules in Australia,⁴ whereby the carrier is required to exercise due diligence ‘before and at the beginning of the voyage’ to ensure seaworthiness. According to this provision, the doctrine is delineated in three aspects: namely physical fitness; cargo worthiness, and crew competence. This duty is said to be an ‘overriding’ one in that any failure to comply with this duty resulting in any loss or damage will deprive the carrier to invoke an array of exceptions usually available to it under Article 4.⁵ Moreover, this duty is non-delegable.⁶ The breach is taken to be an innominate term depending upon the result.⁷

The Hague Rules, the Hague-Visby Rules, and the Amended Hague Rules in Australia only apply to a contract of carriage evidenced by a bill of lading. They do not apply to charter parties,⁸ unless a charter party contains a paramount clause importing either of these. In the absence of a paramount clause, the carrier’s obligation concerning seaworthiness will be a strict one in the sense that ‘[the carrier] will be liable irrespective of fault’.⁹ In the context of marine insurance, the doctrine of seaworthiness operates differently depending on the type of policy – being a voyage policy or a time policy.¹⁰ In the voyage policy, there exists an implied warranty of seaworthiness.¹¹ There is no similar implied warranty in the time policy. Yet, the insurer will be exempted from any need to pay if it can be proved the assured was privy to such unseaworthiness.¹² Since there has been no attempt to amend the *Marine Insurance Act 1909* (Cth), this statute which is virtually identical to the *Marine Insurance Act 1906* (UK), has become more traditional than its UK predecessor. Under this statute, the warranty requires strict compliance, or else the insurer is discharged from liability as from the time of the breach.¹³ In the United Kingdom, a similar provision has since been amended by the *Insurance Act 2015* (UK). In short, for any marine insurance policy that is concluded after 12 August 2016 with the English law governing the contract, any

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¹ Bariş Soyer, *Warranties in marine insurance* (Routledge, 3rd ed, 2017), 3.7.

² *International Convention for the Unification of certain rules relating to Bills of Lading*, 1924, 120 LNTS 155.

³ *Protocol to amend the International Convention for the unification of certain rules of law relating to bills of lading, signed at Brussels on 25 August 1924*, 1968, 1412 UNTS 127 (‘Hague Rules’); *Protocol amending the International Convention for the unification of certain rules of law relating to bills of lading, 25 August 1924, as amended by the Protocol of 23 February 1968*, 1979, 1412 UNTS 146 (‘Hague-Visby Rules’).

⁴ *Carriage of Goods by Sea Act 1991* (Cth), s 7 and Schedule 1.

⁵ Sir Guenter Treitel QC and F M B Reynolds QC, *Carver on Bills of Lading* (Thomson Reuters, 3rd ed, 2011), 9-141.

⁶ *Ibid* 9-139.

⁷ *Hong Kong Fir Shipping Co Ltd v Kawasaki Kisen Kaisha Ltd* [1962] QB 26, 71-72.

⁸ Article 5 of the *Hague Rules* (n 3) or the *Hague-Visby Rules* (n 3).

⁹ John F Wilson, *Carriage of Goods by Sea* (7th ed, 2010) 9.

¹⁰ *Marine Insurance Act 1909* (Cth) s 31(1): ‘Where the contract is to insure the subject-matter **at and from**, or from one place to another place or to other places, the policy is called a **voyage policy**, and where the contract is to insure the subject-matter for a definite period of time the policy is called a **time policy**. A contract for both voyage and time may be included in the same policy’.

¹¹ *Ibid* s 45(1).

¹² *Ibid* s 45(5).

¹³ *Ibid* s 39(3).

breach of warranty will only allow the insurer to suspend, but not discharge from the liability to indemnify the assured.¹⁴ This is only a change as to the legal consequence but not the change as to the notion of seaworthiness.

However, the very concept of seaworthiness has come to be under significant challenge with the rapid development of the technology on autonomous ships. There have already been trials for unmanned ships to operate for sea voyages without a human on board. For instance, the *Yara Birkeland*, which may potentially be the first unmanned container ship in operation, will carry out a two-year trial for autonomous operation in 2022.¹⁵ Whether and how the doctrine, which, among other things, requires the ship to have a competence crew on board, can be adjusted to match the pace of this technical front becomes the question that will be addressed in this article.

To do so, this article is divided into four parts. Immediately following this Introduction, the traditional notion of seaworthiness in the context of marine insurance law and the law on the carriage of goods by sea will be examined to ascertain its scope. Due to their similarity, both the laws of the United Kingdom and Australia will be dealt with together, with differences resulting from the recent statutory reform in the former will be noted. Afterwards, in the next part, the authors will explore recent technical developments of autonomous ships and identify potential legal issues that will impact the doctrine of seaworthiness. Afterwards, in the final part, the authors will suggest how the doctrine may be re-formulated in order to remain relevant in the era of autonomous ships.

The Traditional Doctrine of Seaworthiness

In a marine insurance context, an implied warranty of seaworthiness has been recognised at least since the eighteenth century as Lord Mansfield stated *obiter* in *Bermon v Woodbridge*.¹⁶ The case involved a policy of insurance on a ship which the voyage was described as from Honfleur to the coast of Angola and then to St. Domingo. However, on the way from Angola, the master steered the ship out of the usual route to St. Domingo.¹⁷ At issue was whether the voyage as described in the policy was one entire voyage or whether the voyage could be split into parts such that the premium may be returned for parts that did not actually occur.¹⁸ In the course of the discussion, Lord Mansfield put it that: ‘By an implied warranty, every ship must be sea-worthy when she first sails on the voyage insured, but she need not continue so throughout the voyage’.¹⁹ No authority was cited by Lord Mansfield in support of his stated legal position here but this was carried along until the nineteenth century when the legal position culminated in *Dixon v Sadler*²⁰ where Parke B elaborated upon the legal position:

In the case of an insurance for a certain voyage, it is clearly established that there is an implied warranty that the vessel shall be seaworthy, by which it is meant that she shall be in a fit state as to repairs, equipment, and crew, and in all other respects, to encounter the ordinary perils of the voyage insured, at the time of sailing upon it. If the assurance attaches before the voyage commences, it is enough that the state of the ship be commensurate to the then risk ... if the voyage be such as to require a different complement of men, or the state of equipment, in different parts of it, as, if it were voyage down a canal or river, and thence across to the open sea, it would be enough if the vessel were, at the commencement of each stage of the navigation, properly manned and equipped for it.²¹

The principle stated therein came to be codified in s 39 of the *Marine Insurance Act 1906* (UK), where an identical provision is found in s 45 of the *Marine Insurance Act 1909* (Cth), especially in sub-section (4) where it is stated: ‘A ship is deemed seaworthy when she is reasonably fit in all respects to encounter the ordinary perils of the seas of the adventure insured’.²² In his passage, Parke B also described the doctrine of stages which came to be enshrined in sub-section (3).²³ However, the doctrine of stages is of limited use in practice and the dearth of modern authorities involving this doctrine seems to suggest this doctrine does not give rise to many problems. In the context of marine insurance, the application of this doctrine appears to be confined to two instances. The first is where different equipment or preparation is needed for different stages of the voyage, for example, if the route

¹⁴ *Insurance Act 2015* (UK) ss 10 and 11.

¹⁵ Josiane Kremer, ‘Yara Birkeland’ (Web Page, 2021), *Yara International ASA* < <https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/>>.

¹⁶ (1781) 2 DOUGL 781; 99 ER 497.

¹⁷ *Ibid* 781-782; 498.

¹⁸ *Ibid* 783; 499.

¹⁹ *Ibid* 789; 502.

²⁰ (1839) 5 M & W 405; 151 ER 172, affirmed in *Sadler v Dixon* (1841) 8 M & W 895; 151 ER 1303.

²¹ *Ibid* 414; 175-176.

²² Indeed, according to Soyer, this s 9(4) is exactly derived from *Sadler v Dixon*: see Soyer (n 1) 3.4.

²³ Sub-section s 39(3) of the *Marine Insurance Act 1906* (UK) and s 45 of the *Marine Insurance Act 1909* (Cth) provide: ‘Where the policy relates to a voyage which is performed in different stages, during which the ship requires different kinds of or further preparation or equipment, there is an implied warranty that at the commencement of each stage the ship is seaworthy in respect of such preparation or equipment for the purposes of that stage’.

involved the ship to sail through the river and then out to sea.²⁴ The second is when there is a voyage to fill the bunkers.²⁵ The doctrine of stages remains applicable also in the strict common law position in the context of the contract for the carriage of goods by sea. This is primarily in the context of charter parties. It has been suggested that whether a voyage can be divided into stages ‘is a question of fact in each case, to be determined with reference to the subject-matter of the particular charter party and the exigencies of the adventure as contemplated by the shipowner and charterer’.²⁶ It appears that the reference needs to be made to the contract to determine if the voyage is dividable. Yet, there has been no case involving charter parties where the doctrine of stages was extensively discussed, and hence this is not a matter to be discussed further.

According to the strict common law position, the doctrine of seaworthiness has been recognised as an implied obligation in the contract of carriage of goods by sea. This has been recognised as early as 1804 in *Lyon and Another v Mells*.²⁷ The case involved the damage to a quantity of yarn shipped on the defendant’s lighter to a sloop.²⁸ Lord Ellenborough CJ explained the extent of the implied obligation:

In every contract for the carriage of goods between a person holding himself forth as the owner of a lighter or vessel ready to carry goods for hire, and the person putting goods on board or employing his vessel or lighter ... it is a term of the contract on the part of the carrier or lighterman, implied by law, that his vessel is tight and fit for the purpose or employment for which he offers and holds it forth to the public ... the law presumes a promise to that effect on the part of the carrier without any actual proof; and every reason of sound policy and public convenience requires it should be so...²⁹

As can be observed from the passage of Lord Ellenborough CJ, this implied obligation at common law is a strict one.³⁰ He emphasised the fit state of the ship itself to encounter the voyage. Even in Parke B’s elaboration in the passage from *Dixon v Sadler* quoted above, the judge focused on the fitness of the ship and the crew to encounter the ordinary voyage. Such consideration is narrower than what Article 3(1) of the Hague Rules and the Hague-Visby Rules encapsulates in respect of the seaworthiness which encompasses the duty ‘to make the holds, refrigerating and cool chambers, and all other parts of the ship in which goods are carried, fit and safe for their reception, carriage, and preservation...’. In Australia, the application of this provision is explained by the High Court of Australia in *Great China Metal Industries Co Limited v Malaysian International Shipping Corporation, Berhad*.³¹ Relevantly, Gaudron, Gummow, and Hayne JJ emphasised that the concept of seaworthiness is elastic in that the standard of what constitutes seaworthiness ‘does rise with improved knowledge of shipbuilding and navigation’.³² This requires consideration of many factors³³ and that what must be taken into account as well is ‘the kinds of conditions that the vessel may encounter’.³⁴

At this point, a short note should be made. Reflecting the seaworthiness obligation in common law with the emphasis on the fitness of the ship and the crew, in marine insurance, the implied warranty is not extended to cargo-worthiness either. This is according to s 46 of the *Marine Insurance Act 1909* (Cth). Nevertheless, where the cargo is insured on a voyage policy basis, there exists an implied warranty that the ship is ‘reasonably fit to carry the goods or other movables to the destination contemplated by the policy’.³⁵ However, in practice, this has not been of much use because this type of implied warranty has been subjected to attack. As Soyer explained:

A claim under the policy will fail if the carrying vessel was uncargoworthy at the start of the voyage, even though the assured has no means of ensuring whether the ship was cargoworthy or not. For this reason, in almost all cargo policies, the implied warranty of cargoworthiness has been waived provided that the assured or their servants are not privy to such unfitness.³⁶

Hence, this aspect of cargo-worthiness of the ship will not be discussed further in this article.

The question remains how far the aspects of physical fitness of the ship and the crew goes. This question is asked in light of some modern authorities which appear to hint that a lack of appropriate documentation on board the ship can lead to unseaworthiness too. In Australia, this position is supported by academic treatises where it is

²⁴ Soyer (n 1), 3.54.

²⁵ *Ibid* 3.55.

²⁶ Siobán Healy, ‘The Vessel’, in Howard Bennett (ed), *Carver on Charterparties* (Thomson Reuters, 2017) 3-084.

²⁷ (1804) 5 EAST 428; 102 ER 1134.

²⁸ *Ibid*.

²⁹ *Ibid* 437; 1137-1138.

³⁰ Wilson (n 9) 9.

³¹ [1998] HCA 65; (1998) 196 CLR 161.

³² *Ibid* [30].

³³ *Ibid* [31].

³⁴ *Ibid* [33].

³⁵ *Marine Insurance Act 1909* (Cth) s 46(2).

³⁶ Soyer (n 1) 4.8.

explained that this obligation to maintain a seaworthy vessel encompasses an aspect of ‘documentary seaworthiness’ which involves ‘notification of nautical hazards, signals, up to date chart corrections (either hard copy or electronic), etc’³⁷ and unseaworthiness can occur due to ‘absence of the necessary documents to establish seaworthiness’.³⁸ In the United Kingdom, a recent decision handed down to this effect is that of the United Kingdom Supreme Court in *The CMA CGM Libra*.³⁹ The case involved the ship which was grounded on the way from Xiamen to Hong Kong.⁴⁰ The shipowners sought contributions from cargo interests for salvage costs incurred.⁴¹ However, some cargo interests refused to pay their part alleging that the ship was unseaworthy due to a defective passage plan.⁴² The United Kingdom Supreme Court rejected the shipowners’ argument that the passage plan ‘is not part of the documentary outfit of the vessel or a navigational tool’⁴³ and found that the overall purpose of the passage plan is ‘to assist in the navigation of the vessel’⁴⁴ and hence ‘a vessel is likely to be unseaworthy if she begins her voyage without a passage plan or if she does so with a defective passage plan which endangers the safety of the vessel’.⁴⁵ This is in line with what a commentator suggested:

So far as the obligation of seaworthiness is concerned, the shipowner must ensure that the ship has those documents relevant to the voyage as required by the ship’s flag, classification society, and the regulatory authorities at her ports of call (where known). These are likely to include a valid Document of Compliance from the ship’s flag and a valid Safety Management Certificate pursuant to the ISM Code. Required documents may also include a plan of the ship’s ballast and fuel systems. The ship’s maps and charts must be kept up to date at the start of the voyage.⁴⁶

This notion of unseaworthiness in the sense of lack of proper documentation may be extended to the implied warranty in the voyage policy in marine insurance.⁴⁷

Different from the scheme of s 39(3) of the *Marine Insurance Act 1909* (Cth) referred to at the outset whereby the insurer is automatically discharged from liability once there is a breach of warranty, the statutory reform in the United Kingdom provided shipowners with the chance to rectify any breach of the implied warranty of seaworthiness. According to s 10(2) of the *Insurance Act 2015* (UK): ‘An insurer has no liability under a contract of insurance in respect of any loss occurring, or attributable to something happening, after a warranty (express or implied) in the contract has been breached but before the breach has been remedied’. Sections 10(5) and (6) provide further that:

- (5) For the purposes of this section, a breach of warranty is taken as remedied —
 - (a) in the case falling within subsection (6), if the risk to which the warranty relates later becomes essentially the same as that originally contemplated by the parties,
 - (b) in any other case, if the insured ceases to be in breach of the warranty.
- (6) A case falls within this subsection if —
 - (a) the warranty in question requires that by an ascertainable time something to be done (or not done), or a condition is to be fulfilled, or something is (or is not) to be the case, and
 - (b) the requirement is not complied with.

While there has been no case in the United Kingdom addressing the *Insurance Act 2015* (UK) and there is no judicial analysis of implications of this new provision on the effect of the warranty, some guidance may be obtained from the English and the Scottish Law Commissions in their report leading to the enactment of the statute. One example given was a ship sailing through the strait despite the warranty forbidding any sailing through such strait, and the ship comes out of the area without any accident or incident. In such a case, it should be taken that the breach is remedied according to s 10.⁴⁸ Another example, irrelevant to the contract of marine insurance, is

³⁷ Sarah Derrington and Michael White, *Australian Maritime Law* (Federation Press, 4th ed, 2020), 168.

³⁸ Martin Davies and Anthony Dickey, *Shipping Law* (Lawbook Co, 4th ed, 2016), 13.600.

³⁹ *Alize 1954 and another v Allianz Elementar Versicherungs AG and others* [2021] UKSC 51.

⁴⁰ *Ibid* [3].

⁴¹ *Ibid* [19].

⁴² *Ibid* [3], [21]-[22].

⁴³ *Ibid* [124].

⁴⁴ *Ibid*.

⁴⁵ *Ibid* [145].

⁴⁶ Healy (n 26), 3-124.

⁴⁷ This is at least a view as far as the compliance with the ISM Code and the ISPS Code is concerned. See Soyer (n 1) 3.97 and 3.113

⁴⁸ The Law Commission and The Scottish Law Commission, *Insurance Contract Law: Business Disclosure; Warranties; Insurer’s Remedies for Fraudulent Claims; and Late Payment* (LAW Com. No 353) (SCOT LAW COM No. 238) (July 2014), 17.32-17.33.

where the warranty requires a fire alarm to be inspected every 30 days, however, the inspection occurs on day 40. Once again, the breach should be taken as remedied.⁴⁹

So, the ambit of seaworthiness has been explored in this part of the article. The question is how this concept is to be perceived and applied to autonomous ships which are currently being developed at a fast pace.

Potential Seaworthiness Issues of Autonomous Ships

Overview

While the doctrine of seaworthiness appears to be well-settled and most cases considered in courts concerning this doctrine tend to be fact-specific, i.e., whether at the relevant time the ship is seaworthy, the operation of autonomous ships will pose new challenges to this area of law. At present, most of the autonomous ships' projects are still at trial stages. Yet, the industry's expectation is the commercial operation of these vessels will happen in the near future. The potentially first autonomous and zero-emission container vessel, *Yara Birkeland*, is now preparing for future autonomous operation.⁵⁰ Rolls Royce also predicted that fully automated ships would be commonly seen in 2030.⁵¹ To cope with such technological developments, practitioners and scholars around the world have been examining potential ramifications from the operation of autonomous ships. The Baltic and International Maritime Council ('BIMCO') is developing a new standard form contract based on the SHIPMAN 2009 agreement.⁵² The Comité Maritime International ('CMI') formed an international working group to conduct regulatory scoping exercises and review relevant international conventions that may be affected by the operation of autonomous ships and how these can be amended or changed.⁵³ Within the marine insurance industry, a report was published under the auspice of the joint project between CORE Advokatfirma and CEFOR which the International Group of P & I Clubs ('IG P & I') along with its members were consulted. The report examined liabilities and insurance issues relating to autonomous ships.⁵⁴ However, the seaworthiness issue did not receive sufficient analysis in the report.

In its work on the issue of autonomous shipping, the International Maritime Organization ('IMO') divided the operation of autonomous ships into four degrees. Some seaworthiness-related issues, such as survey, manning, crew competence, on-board system, and legal liabilities, will be analysed along with the framework of these four degrees of autonomous ships.

Degree One and Two Autonomous Ships (Semi-Autonomous Ships)

The first degree or step refers to 'Ship with automated processes and decision support'. At this degree, '[s]eafarers are on board to operate and control shipboard systems and functions'.⁵⁵ At this stage, only some systems are automated and it is still necessary for seafarers to be on board and ready to be in control.⁵⁶ At the next step, 'Remotely controlled ship with seafarers on board', as the name suggested, the ship is controlled from somewhere offshore but seafarers are still required on board 'to take control and to operate the shipboard systems and functions'.⁵⁷ Ships in these two stages of development can be categorised as semi-autonomous ships the operation of which still relies on crew members on board with part of the process automated by computers. As far as seaworthiness is concerned, it is suggested that the traditional doctrine of seaworthiness remains applicable as the management and decision-making are still performed by humans on board. As the seaworthiness doctrine is capable of evolving along with changes in shipping practices, seafarers will necessarily need to be equipped with sufficient knowledge in information technology or even in cyber security to operate semi-autonomous ships. In comparison with operating conventional ships, this may place a higher knowledge requirement for seafarers and

⁴⁹ Ibid 17.44.

⁵⁰ Kremer (n 15)

⁵¹ Rolls-Royce, *Autonomous Ships The next step* (Report, 2016) <<https://www.rolls-royce.com/~media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf>>.

⁵² Grant Hunter, 'First ever standard contract for autonomous ship underway', *BIMCO* (Web Page, 2020) <<https://www.bimco.org/news/contracts-and-clauses/20201106-first-ever-standard-contract-for-autonomous-ship-operation-underway>>.

⁵³ CMI, *Maritime Law for MASS* (Web Page, undated) <<https://comitemaritime.org/work/mass/>>.

⁵⁴ CORE Advokatfirma and CEFOR, *Maritime autonomous surface ships: Zooming in on civil liability and insurance* (Report, December 2018) <https://static.mycoracle.com/igpi_website/media/article_attachments/maritime_autonomous_ships_report_dec_18_6URrRcy.pdf>.

⁵⁵ International Maritime Organization, 'Autonomous Shipping' (Web Page, 2019) <<https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx>>.

⁵⁶ Ibid.

⁵⁷ Ibid.

increase how the standard of competence is judged. However, this does not require a change to the traditional doctrine of seaworthiness itself. The only change is how the competence of seafarers is to be assessed.

Degree Three Autonomous Ships (Shore-Based Control Ships)

The problematic part lies in further development into degrees three and four. According to the IMO, degree three, ‘Remotely controlled ship without seafarers on board’, ships will be completely operated from somewhere on shore.⁵⁸ This kind of ship is also referred to as the Shore-Based Control (SBC) ship. The problem is the traditional doctrine of seaworthiness requires the ship to be adequately manned by crew members. The operation of the SBC ship will raise the question of whether the competence of human controllers onshore can be taken into account in assessing whether an unmanned ship is seaworthy. The problem is also noted by Baughen in considering the exception of carrier’s liability in Article 4(2)(a) of the Hague-Visby Rules:

The absence of an on-board crew might be thought to remove this exception when the goods are being carried by an unmanned vessel. However, it is possible to regard the SBC as the functional equivalent of the master and therefore the carrier would still be able to rely on the exception in respect of loss or damage caused by any errors of navigation on their part. If the SBC is not regarded as the ‘master’ then they should constitute a ‘servant of the carrier’, although the SBC is not employed by the carrier but is an independent contractor this would not be the case. It is doubtful whether negligence by the voyage programmer would fall within the exception as such negligence would render the vessel unseaworthy. Establishing the vessel’s seaworthiness will now need to take in both onboard and shore-based conditions.⁵⁹

While the above passage does not directly address the doctrine of seaworthiness, it does suggest that the SBC will complicate how liabilities can be assessed under the traditional maritime cargo liability regime. As indicated by Baughen, the SBC is very likely to serve as either the master of the ship or the agent of the carrier or even both. So, the doctrine of seaworthiness will likely need to be extended such that both onboard and shore-based conditions will need to be evaluated. However, this approach will pose new challenges in practice. One of the potential problems is that this approach has not been embraced in the current survey procedure of classification societies. Taken the class renewal surveys / special surveys as an example, the International Association of Classification Society (IACS) explains the scope of work as follows:

The class renewal surveys / special surveys include extensive in-water and, in most cases, out-of-water examinations to verify that the structure, main and essential auxiliary machinery, systems and equipment of the ship remain in a condition which satisfies the relevant Rules. The examination of the hull is supplemented, when specified, by ultrasonic thickness measurements and the witnessing of tests as specified in the Rules and as deemed necessary by the attending surveyor. The survey is intended to assess whether the structural integrity remains in conformance with the standards contained in the relevant Rules and to identify areas that exhibit substantial corrosion, significant deformation, fractures, damages or other structural deterioration.⁶⁰

While the scope of the survey has covered a wide range of items, these items are indeed limited to the onboard inspections and physical fitness of the ship only. The current scope does not cover shore-based computers. For the time-being, there is no updated protocol on the survey relating to autonomous ships. This may cause a new problem as analysed by Veal and Tsimplis:

The problem, however, is that unmanned operability requires, inter alia, the introduction of new infrastructure, communication systems and, as will be seen, a variety of electronic sensors and receptacles, for the attainment of spatial acuity. UNCLOS requires that “each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of the ships”. In the specific context of the automated systems introduced by unmanned operability, such “qualified surveyors” and appropriate tests for the automated systems are being developed in parallel with the technology by some classification societies, but, as yet, there is no standardisation.⁶¹

In other words, the current survey scope cannot catch up with developments of technology and this may require differently trained surveyors who possess knowledge of information technology and cybersecurity to assess whether the onshore computers are competent to operate an SBC autonomous ship. However, the authors are not aware of any current training curriculum for such advanced knowledge. This issue can be problematic as most of the statutory survey requirements do not cover shore-based computers. In Australia, the statutory survey for domestic commercial vessels is governed by the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* (Cth). Under sections 43 and 44 of Schedule 1, the owner and master will commit an offence if they operate

⁵⁸ Ibid.

⁵⁹ Simon Baughen, ‘Who is the master now? Regulatory and contractual challenges of unmanned vessels’ in Baris Soyer and Andrew Tettenborn (eds), *New Technologies, artificial intelligence, and shipping law in the 21st century* (Routledge 2019), 144 fn 38.

⁶⁰ International Association of Classification Societies, *Classification societies – what, why and how?* (Report, 2020) <<https://www.iacs.org.uk/media/7425/classification-what-why-how.pdf>>.

⁶¹ Robert Veal and Michael Tsimplis, ‘The integration of unmanned ships into the lex maritima’ (2017) *Lloyd’s Maritime and Commercial Law Quarterly* 303, 315-316.

a domestic commercial vessel without a certificate of survey. The categories of the statutory survey are defined in section 21 of the *Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013*, which includes plan approval, stability approval, load line, electrical, hull, deck, superstructure, machinery, safety and communication equipment and commissioning. Apparently, section 21 only focuses on on-board inspection, and further amendments will be needed to cover the survey requirement of SBC autonomous ships.

Degree Four Autonomous Ships (Fully autonomous ship)

The situation will be more complicated when one attempts to apply the doctrine of seaworthiness to autonomous ships developed to the degree four level. The degree four is named 'Fully autonomous ship'. It will occur when the technology is developed to the fullest extent such that '[t]he operating system of the ship is able to make decisions and determine actions by itself'.⁶² For this kind of autonomous ships, Artificial Intelligence will be used to operate the ship. In this article, the term 'Artificial Intelligence' is used in the sense given by the International Business Machine Corporation (IBM):

In computer science, the term artificial intelligence (AI) refers to any human-like intelligence exhibited by a computer, robot, or other machine. In popular usage, artificial intelligence refers to the ability of a computer or machine to mimic the capabilities of the human mind — learning from examples and experience, recognizing objects, understanding and responding to language, making decisions, solving problems — and combining these and other capabilities to perform functions a human might perform, such as greeting a hotel guest or driving a car.⁶³

The problem is the current law on the seaworthiness is designed to hold humans liable, not computers. In case where a loss is caused by the 'Fully autonomous ship', there is no definite answer as to who will be liable. Sir Bernard Eder analysed the problem in the context of marine insurance law:

First, a threshold question arises with regard to the potential legal liability of a shipowner in circumstances where, for example, an autonomous vessel is navigated from ashore and there is a collision or grounding as a result of a software problem caused by some third party – for example, the manufacturer or installer of the automation system or internet provider. In truth, this is not necessarily very different from the legal problems which can arise in the conventional context. In such case, the broad question arises whether the shipowner can avoid liability because of the fault of the manufacturer or installer of the software system or the third-party provider.⁶⁴

In addition to the question of liability and exception, the main concern remains how any traditional legal doctrine can be applied in the context of Artificial Intelligence. The said problem is demonstrated in a case in Singapore in *Quoine Pte Ltd v B2C2 Ltd*.⁶⁵ Strictly speaking, this is not a case involving Artificial Intelligence. The case, however, considered how algorithms can be subject to legal assessments, and these assessments are directly applicable to Artificial Intelligence since it is also formed by algorithms. In this case, the appellant operated an on-line platform for cryptocurrency exchange.⁶⁶ The respondent was a user of the platform.⁶⁷ The trading software, which was used by the respondent, was designed by the director of the respondent, and it was considered as a fully automated program.⁶⁸ An error occurred in the platform due to the mistake of the appellant, the respondent's trading software completed 13 trades at a rate that was 250 times higher than the normal exchange rate. These trades were done through the platform.⁶⁹ The appellant discovered and cancelled these abnormal trades.⁷⁰ The respondent commenced litigation on the alleged breach of contract and breach of trust by the appellant.⁷¹ The appellant argued that they were entitled to cancel these abnormal trades based on the terms and conditions of the platform. They also maintained that the contracts were void under the doctrine of unilateral mistake at common law.⁷²

In the Singapore International Commercial Court, Simon Thorley JJ rejected all the appellant's defences and allowed both claims by the respondent.⁷³ He agreed that there was a platform contract between the appellant and the respondent, and the platform contract provided that 'once an order is filled, you are notified via the Platform

⁶² International Maritime Organization (n 55)

⁶³ IBM Cloud Education, 'Artificial Intelligence (AI)', IBM (Web Page, 3 June 2020) <<https://www.ibm.com/cloud/learn/what-is-artificial-intelligence>>.

⁶⁴ Sir Bernard Eder, 'Unmanned vessel: challenges ahead' (2018) *Lloyd's Maritime and Commercial Law Quarterly* 47, 51-52.

⁶⁵ [2020] SGCA(I) 02.

⁶⁶ Ibid [1].

⁶⁷ Ibid [2].

⁶⁸ Ibid [15].

⁶⁹ Ibid [2].

⁷⁰ Ibid.

⁷¹ Ibid [3].

⁷² Ibid [4].

⁷³ *B2C2 Ltd v Quoine Pte Ltd* [2019] SGHC(I) 03.

and such an action is irreversible'.⁷⁴ He also agreed that the cryptocurrencies of the platform users were held separately from the cryptocurrencies of the platform operator. Thus, the platform operator managed the user's cryptocurrencies as a trust.⁷⁵ In assessing the appellant's defence in relation to the unilateral mistake, Simon Thorley JJ adopted a new approach as the transactions were performed by a fully automated system without human intervention. He affirmed the common law position that, to render a contract void due to the unilateral mistake, the appellant has to prove:

...first, that there was a sufficiently important or fundamental mistake as to a term of the contract, in the sense that the offeror did not intend the terms of the offer to be that which on its face was offered and, secondly, that the Plaintiff who is seeking to enforce that contract must have actual knowledge of the mistake.⁷⁶

He then expressed his view on how these requirements could be applied to an automated system:

Where it is relevant to determine what the intention or knowledge was underlying the mode of operation of a particular machine, it is logical to have regard to the knowledge or intention of the operator or controller of the machine. In the case of the kitchen blender, this will be the person who put the ingredients in and caused it to work. His or her knowledge or intention will be contemporaneous with the operation of the machine. But in the case of robots or trading software in computers this will not be the case. The knowledge or intention cannot be that of the person who turns it on, it must be that of the person who was responsible for causing it to work in the way it did, in other words, the programmer. Necessarily this will have done at a date earlier than the date on which the computer or robot carried out the acts in question.⁷⁷

Applying the above principle to the fact, Simon Thorley JJ held that the knowledge of the respondent's programmer, who designed the trading software and completed the disputed trades, should have been subject to examination.⁷⁸ As the said programmer had no actual or constructive knowledge of the mistake, Simon Thorley JJ held that the appellant could not rely on the unilateral mistake to render the contract void.⁷⁹ In the Court of Appeal, the appeal on the breach of contract was rejected and it found the appellant was still liable to compensate the respondent. While the majority upheld the judgment of Simon Thorley JJ on the point of unilateral mistake, it is worthy to observe the dissenting judgment of Jonathan Mance JJ as follows:

The law must be adapted to the new world of algorithmic programmes and artificial intelligence, in a way which gives rise to the results that reason and justice would lead one to expect. The introduction of computers no doubt carries risks, but I do not consider that these include the risk of being bound by an algorithmic contract, which anyone learning of would at once see could only be the result of some fundamental error in the normal operation of the computers involved. Computers are outworkers, not overlords to whose operations parties can be taken to have submitted unconditionally in circumstances as out of ordinary as the present. I do not think that the obvious malfunctioning of a computer-based system should be given the dominance that B2C2's case implies.⁸⁰

Jonathan Mance JJ suggested that the question that should have been asked in this case was whether a reasonable trader would have noticed that the trades were concluded based on fundamental mistakes. As the respondent knew the market price well, it was evident that the respondent would have known that the trades were completed by mistakes.⁸¹ It is noteworthy that the disputed trading software was only formulated by simple algorithm.⁸² As Simon Thorley JJ described, it is 'largely deterministic; it produces the exact same output when provided with the same input'.⁸³

Artificial Intelligence, however, is more sophisticated as it will be able to learn new knowledge through machine learning and complete tasks like humans. Currently, there is no definite answer as to how Artificial Intelligence can be assessed under any legal doctrine, but the sophisticated nature of it would undoubtedly create new issues when the doctrine of seaworthiness is applied to degree four autonomous ships. One of the examples is the black-box characteristic of Artificial Intelligence. The problem of black-box characteristic is described by Bathace as follows:

If an AI programme is a black box, it will make predictions and decisions as humans do, but without being able to communicate its reasons for doing so. The AI's thought process may be based on patterns that we as humans cannot perceive, which means understanding the AI may be akin to understanding another highly intelligent species — one with entirely different senses and

⁷⁴ Ibid [136].

⁷⁵ Ibid [145].

⁷⁶ Ibid [188].

⁷⁷ Ibid [210].

⁷⁸ Ibid [211].

⁷⁹ Ibid [231] and [239].

⁸⁰ *Quoine Pte Ltd v B2C2 Ltd* (n 65) [193].

⁸¹ Ibid [194]-[195].

⁸² Ibid [15].

⁸³ *B2C2 Ltd v Quoine Pte Ltd* (n 73) [82].

powers of perception. This also means that little can be inferred about the intent or conduct of the humans that created or deployed the AI, since even they may not be able to foresee what solutions the AI will reach or what decisions it will make.⁸⁴

In other words, while humans will be able to describe the input and output of Artificial Intelligence, they will not be able to identify the decision-making process as well as the reasons behind the decision. This black box problem may pose a new challenge to assess whether a degree four autonomous ship is seaworthy, as there is no way to evaluate whether the algorithms are fit for the voyage. In addition, the *Insurance Act 2015* (UK) imposed a change to the breach of insurance warranty, where the insurer's liability is only suspended until the breach is remedied by the assured. With the black-box characteristic, it will be hard for the judges to determine when the breach is being remedied as the algorithms are not readable.

To sum up, the traditional doctrine of seaworthiness has been working well since the eighteenth century, if not before. However, with the advancement of technology and the introduction of autonomous ships, new legal issues are created, and the current doctrine of seaworthiness does not seem to be sufficient to address the problems. In this regard, the authors think that there must be a reformulation of the doctrine of seaworthiness for the operation of autonomous ships. Such reformulation will be considered in the next section.

Conclusion: How Should The Doctrine of Seaworthiness Be Reformulated?

The conclusion we have reached is that the traditional doctrine of seaworthiness does not fit to be applicable to autonomous ships. So, in this section, the authors aim at suggesting how the doctrine should be reformulated so it can be apt for the future operation of autonomous ships. First, under the reformulated doctrine of seaworthiness, the properly manned requirement should be applied differently to human-crewed and unmanned ships. For human-crewed ships, including conventional ships and semi-automated ships, the traditional doctrine of seaworthiness is still applicable to assess the competence of the crew members and the vessel. However, the training programme of crew members should be altered to accommodate technologies used in semi-automated ships. For example, a class 1 engineer, who works for an Australian registered vessel operating in international water, must hold a certificate issued under *Marine Order (Engineer Officers) 2014*.⁸⁵ Under the said Order, the class 1 engineer will need to complete courses such as Engineer Class 1 – STCW Reg III/2, basic safety training, advanced firefighting, proficiency in survival craft and rescue boats other than fast rescue boats and medical first aid.⁸⁶ It is suggested that courses such as information technology and cyber security, which is relevant to the operation of semi-autonomous vessels, can be added to the Engineer class 1 – STCW Reg III/2 course to address the concerns regarding crew competence.

For SBC ships, the doctrine of seaworthiness should be extended such that both onboard and on-shore conditions are taken into account. As discussed in the previous section, some amendments will need to be introduced to domestic legislation and regulation such as the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* (Cth) and the *Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013* to address the survey requirement of SBC ships. Further, international instruments such as the *United Nations Convention on the Law of the Sea* may also need to be amended. Article 94(3) requires the State Party to ensure the safety of the ships flying its flag. Article 94(4) further stipulates that the member states shall take measures 'that each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of ships, and has on board such charts, nautical publications and navigational equipment and instruments as are appropriate for the safe navigation of the ship'. Similar to the domestic legislation, the international law is also inadequate to address the survey requirement for SBC ships, and thus, amendments will also be required.

For fully automated ships, despite the lack of definite answer at the moment as to how Artificial Intelligence should be assessed under the law, it is suggested that the doctrine of seaworthiness should still be applicable. The straightforward approach will be to require judges to examine the algorithms behind Artificial Intelligence to determine whether Artificial Intelligence is fit for the voyage. Ship-owners may find themselves be liable in failing to exercise due diligence in using appropriate algorithms. However, a serious barrier would be the black box characteristics which will necessarily pose difficulties for judges to examine the algorithm. Therefore, it is necessary to ensure that the law requires Artificial Intelligence to be written by transparent and explainable

⁸⁴ Yavar Bathace, 'The Artificial Intelligence: black box and the failure of causation and intent' (2018) 31 *Harvard Journal of Law and Technology* 889, 893.

⁸⁵ Australian Maritime Safety Authority, 'Engineering Class 1' (Web Page, 17 September 2021) <<https://www.amsa.gov.au/qualifications-training/international-qualifications/engineer-class-1#78775>>.

⁸⁶ Ibid.

algorithms for fully automated ships. One example can be found in the *Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts*.⁸⁷ Draft Article 13(1) in Chapter 2 states that:

High-risk AI systems shall be designed and developed in such a way to ensure that their operation is sufficiently transparent to enable users to interpret the system's output and use it appropriately. An appropriate type and degree of transparency shall be ensured, with a view to achieving compliance with the relevant obligations of the user and of the provider set out in Chapter 3 of this Title.

While the European Commission has not yet established the detailed technical requirements of transparency, this is a significant first step to overcoming the problems of black box characteristics. A similar transparency requirement should be introduced to any legislation that governs the operation of fully autonomous ships.

While there are still many complicated issues that are yet to be defined for this reformulated doctrine of seaworthiness, it is suggested that this is only the first step. Perhaps, the most completed version of this re-casted doctrine of seaworthiness can be given in the future by all stakeholders in the maritime industry. In this regard, it is suggested that the stakeholders, including crew members, masters, surveyors of the classification societies, and also maritime lawyers and judges, need to keep themselves updated with the knowledge of information technology and computer sciences so that all stakeholders are ready to reformulate the doctrine of seaworthiness and embrace the use of autonomous ships in the future.

⁸⁷ European Commission, *Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts* (2021) < <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206> >.