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An Evaluation of the Collision and Strict liability Framework for the Shipowner with respect to Autonomous vessels: A Norwegian Perspective

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1.0 INTRODUCTION

The shipping industry is a vital part of the world economy in every stage of every value chain, from transporting raw goods to a refinery to the delivery of finished products. Indeed, 90% of world trade is carried by the shipping industry,[1] which puts the scale of this industry into perspective. This is further emphasised when one examines the statistics: In 2017, 10.7 billion tons of cargo were transported by shipping,[2] with this estimated to be worth over half a trillion US dollars in freight rates.[3] These high volumes are carried by a world fleet of over 50,000 ships,[4] manned by over 1.5 million seafarers.[5]

Given the scale of the industry, it is of no surprise that losses occur. It should be noted, however, that 75% of insured maritime losses in 2016 were caused by human error.[6] Considering this, it is unsurprising that shipowners, insurers and cargo owners look for opportunities to reduce such losses, as this will provide both financial and operational benefits to them. With fewer losses, the shipowner will see reduced claims and therefore reduced premiums, better usage of their vessels as they will need fewer repairs from collision and other damage; the insurer will have to pay out fewer claims; and the cargo owners see a reduced risk to their cargo. Above all of this, fewer incidents means greater safety to the crew, officers and other agents who may be at risk in shipping.

Such an opportunity is the development of Marine Autonomous Surface Ships (MASS), which seek to replace on board crew with technology. The hope is that this will remove the element of human error, leading to fewer collisions and other incidents, and also serving to save costs as traditional crew will not have to be employed. The general definition fielded by the IMO of MASS is a ship able to "operate independently of human

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1 ICS (International Chamber of Shipping), 'Shipping and World Trade' <http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade>, accessed 09/01/2019.
2 United Nations Conference on Trade and Development, 'Review of Maritime Transport 2018' [UNCTAD/RMT/2018].
3 ICS, n1.
4 Ibid.
5 Howse T, 'Maritime autonomous surface ships - identifying and covering the risks' [Gard, 27/02/2019] <http://www.gard.no/web/updates/content/27188643/maritime-autonomous-surface-ships-identifying-and-covering-the-risks> accessed 21/07/2019.
6 Dean P, 'Autonomy at sea - the future?' [HFW law firm, April 2017], p 2.

interaction".[7] This is a similar definition used for autonomous underwater vessels, which are already in use for pipeline surveys.[8]

However, there are some challenges and negative impacts that come with the development of MASS. It has been pointed out that current technology will not be enough for deep sea vessels to operate independently of human interaction,[9] and so large parts of the discussion on MASS is based on speculation instead of fact. Indeed, whilst automation has the potential to solve issues, it also introduces new dangers and "points of failure"[10] which could be unforeseen and lead to catastrophic damage. It is also noted that whilst not employing crew will save costs on the ship, remote operators, communications centres, and the equipment needed will be very high and require a large up-front investment that may prove MASS to be more expensive.[11] Additionally, replacing crew with technology will leave the crew without work, having a significant impact on their finances and leaving many seafarers in a state of financial hardship.

A further flaw is the reliance on the cyberspace infrastructure, which will be a key vulnerability point for MASS as if this can be exploited by terrorists, pirates or others the entire vessel could become under the control of these other parties.[12] This vulnerability can also lead to significant disruption due to activities such as GPS spoofing. GPS spoofing is where GPS information is falsified, leading the system to believe it is in a location that it actually is not.[13] This occurred in 2017, where a number of vessels in the Black Sea had their locations' displayed as vast distances away from where they actually were, often in impossible areas such as an airport.[14] Whilst a crewed vessel could successfully deal with this GPS failure by reverting to traditional navigation methods,

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[7] IMO, 'IMO takes first steps to address autonomous ships', [Briefing 8, 25/05/2018] <http://www.imo.org/en/mediacentre/pressbriefings/pages/08-msc-99-mass-scoping.aspx> acessed 05/01/2019.

[8] Howse, n5.

[9] Commander Dubay D, 'Why we will never see fully autonomous commercial ships' [Maritime Executive, 25/06/2019] <https://www.maritime-executive.com/editorials/why-we-will-never-see-fully-autonomous-commercial-ships> accessed 05/07/2019.

[10] Ibid.

[11] Ibid.

[12] Ibid.

[13] HFW law firm, 'Autonomous ships: successfully navigating through the shallows?' [July 2018], p 3.

[14] Ibid.

MASS systems will need to develop their cyber-security as they will be more reliant on cyber systems.

Despite these problems, the potential of MASS is strong and being pursued with interest both theoretically and in practice. The Yara Birkeland project, being co-developed by Yara and Kongsberg, is to be the world's first autonomous container vessel, which will operate within Norway.[15] It is hoped to be launched from 2020, and will develop in phases from manned to remote, and then finally to being fully autonomous.[16]

However, there remain a number of questions that must be addressed in respect to liability. The current international liability framework has evolved with the human element in mind,[17] which presents a number of challenges which need to be overcome for the industry to properly and safely adopt the technology. For example, the SOLAS regulations explicitly refer to manning and the required actions of the crew, which may be transferable to remote operations, but see more difficulty being resolved with fully autonomous vessels.[18] Further, one of the biggest issues faced by the liability of MASS is that the maritime framework is generally fault based, for example the Collision Convention 1910 apportions liability based on the degree of fault.[19] For MASS vessels operating from an advanced AI system independently making decisions, the question of fault where an incident takes place will be more central than ever, as it will have to be established how fault will be assigned when the incident and loss is caused by the decision of an AI system, not currently recognised as a legal entity, instead of by a human.[20] The focus of this thesis will be to assess the suitability of the regulations and rules regarding collisions and strict liability.

Whether or not an AI system can be held accountable will be explored in this thesis, along with what other options there are to ensure that appropriate compensation can be paid to those who suffer loss as a result of MASS. This will involve discussions on the current

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15 Yara, 'Yara Birkeland press kit', <https://www.yara.com/news-and-media/press-kits/yara-birkeland-press-kit/> accessed 25/06/2019.

16 Ibid.

17 Howse, n5.

18 Ibid.

19 Ibid.

20 Ibid.

state of the law, whether new strict liability regimes should be introduced, and whether existing regimes should be adapted or expanded beyond their current positions to encompass developing MASS technology. First, however, it is prudent to properly define what MASS vessels are. Modern ships are already equipped with a number of systems that automate some functions, and when looking to the future it is clear that there will be a mix of remote and fully autonomous vessels, or vessels switching between the two during different stages of a voyage based on sea conditions and local legislation.[21] It is possible that the different levels of autonomy may require different legal solutions for their liability, and so the different potential categories of MASS will be examined.

The research conducted for this thesis was by evaluating a variety of sources on both practical, technical and legal aspects of autonomous shipping generally, artificial intelligences, the legal framework as it is today based on legislative instruments and case law and comparing views on how such legal instruments may need to adapt to accommodate developing technology. These sources vary from legal judgements, journal articles, website articles and official guidelines.

[21] HFW n13, p 4.

2.0 What is MASS?

It is important to understand that many of today's vessels have autonomous and partially autonomous systems on board. This can include navigation, routing, and the Automatic Identification System (AIS) that, amongst other features, shows the course of nearby vessels, meaning the seafarers need not manually calculate the course of such vessels. Furthermore, as on-board systems become more advanced and automated, there will be the potential for different stages of a voyage to operate at different levels of autonomy. This may occur due to it proving to be more appropriate for a vessel manoeuvring in port to be manually controlled, adverse weather requiring an operator to take control of certain systems to ensure safety, or a variety of other reasons. Because of these reasons, describing what exactly an autonomous vessel is becomes unclear. A vessel may have some systems that are highly advanced and may themselves be considered autonomous, but also have some manual systems. Vessels may also have a high potential of autonomy, but for one reason or another be forced to operate at a manual level despite its capabilities. This chapter will look to analyse the current models of autonomy with regard to their suitability for the maritime industry, and asses which parts of such models will be most pertinent for legal assessments of fault.

The IMO has given a broad definition for MASS as being a ship able to "operate independently of human interaction" to a varying degree.[22] This definition qualifies MASS as an umbrella term for all ships with systems designed to remove the need for seafarers to perform certain tasks, allowing for a single overarching category to be used when discussing autonomous technology. However, this may be too broad an interpretation as many modern vessels contain systems that could be said to automize certain functions, such as AIS (discussed above). This weakness in the IMO definition is somewhat resolved by one of their scoping exercises that models 4 levels of automation:[23]

1. Seafarers on board to operate the systems; some are automized.

[22] IMO, n7.
[23] Ibid.

2. Seafarers on board to oversee, but the vessel is remotely controlled.
3. The vessel is remotely controlled with no seafarers on board.
4. The vessel is fully autonomous.

These sub-categories provide a better picture of the capabilities of a vessel and provide a concise method of describing the status of any ship involved in an incident. This gives any interested party a tool to quickly understand the level of autonomy involved and particularly, the reference to the presence of seafarers on board is one of this model's greatest strengths as it clearly highlights whether there is any danger to life in the event of an incident, something of paramount importance to the Shipowner, insurers and others when organising their action plan.

However, this model oversimplifies the decision-making process involved in automized systems and their interaction with human operators, as effectively having only "remote controlled" and "fully autonomous" at the higher levels of autonomy creates a situation where autonomy is all or nothing, something that is not realistic and may not be cost effective either. It further leaves certain aspects too ambiguous to be practical, as it is unclear whether a system that analyses data and proposes options to an operator, or chooses an option itself and allows some time for an operator to intervene, would be classified as remote or autonomous. The lack of consideration for the decision-making process between systems and operators, and the fact there is not a defined expectation for the level of autonomy of the systems themselves, will be shown to be a weakness of this model when compared to those discussed below, as the IMO model does not provide a precise enough description of the actual level of autonomy of the particular system or function that may cause an incident and so, importantly, does not provide an accurate view as to whether the cause of such an incident is because of an error from the human or that of system.

2.1 The Sheridan and NASA Models

The Sheridan model is a 10-level scale used to asses automation, with 1 being no automation at all and 10 being a system fully automized and human operators are effectively ignored. An important consideration when comparing this model to the IMO model is that the Sheridan model is not specific to maritime vessels, but to be used for understanding and developing autonomous systems generally.[24] This is not to be considered problematic, as the general nature of the model being for all autonomous systems means that each different system on any vessel can be assessed independently unlike the IMO model that applied to the vessel as a whole, and that the Sheridan model can be adapted to meet any needs specific to the maritime vessels as it can be considered an open template.

One of the strengths with the Sheridan model when compared with the that of the IMO is that its focus is on the relationship between the human operator and the system, instead of attempting to give a stand-alone assessment of the system itself. This, combined with the greater number of levels (10 instead of the 4 in the IMO model) allows for a higher degree of precision when describing the level of autonomy, and of legal interest, conclude whether a particular decision was made by the system or the operator. This is done by assessing which level the relationship between the operator and system most accurately matches the reality. In the Sheridan model, Table 1 below, a relationship falling between levels 1-5 can be considered under human control, whereas those that fall between 6-10 are under the control of the system, with the human having reduced input as the levels progress.[25] The varying levels of autonomy within the human or system controlled halves of the model demonstrate that autonomy is not all or nothing, and that when under human control there are still distinct levels of autonomy to some extent under most levels, and conversely that there are still elements of human operator involvement under most system controlled levels. In addition to allowing fault to be decided between an operator

[24] Sheridan B, Parasuraman R, Wickens C, 'A Model for Types and Levels for Human Interaction with Automation', IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, Vol30, No3, 2000. p286.
[25] Ibid 287.

and the system, this also allows for the level of dependence on the other "party" to be determined, as a human decision at level 5 will be heavily reliant on the information provided by the system. With respect to looking at fault from a legal perspective, depending on the development of the legal framework for fault in MASS involved incidents, as discussed in later chapters, causes of fault which can be attributed to information relied on by the decision maker, provided by the other "party" (ie a decision made by a human based on information from a high level of autonomy system) may play a role in assigning liability.

Level	Description of Autonomy
1	The computer offers no assistance: human must take all the decisions and actions.
2	The computer offers a complete set of decision / action alternatives, or
3	Narrows the selection down to a few, or
4	Suggests one alternative
5	Executes that suggestion if the human approves, or
6	Allows the human a restricted time to veto before automatic execution, or
7	Executes automatically, then necessarily informs the human, and
8	Informs the human only if asked, or
9	Informs the human only if it, the computer, decides to.
10	The computer decides everything, acts autonomously, ignoring the human.

Table 1: The Sheridan Model of Levels of Autonomy[26]

Parasuraman further built on this model by breaking down the decision-making process into 4 separate stages:[27]

1. Information acquisition.
    a. Gathering and sorting information for analysis.
2. Information analysis.
    a. Analyzing the information acquired so it can be used to form a decision.

[26] Ibid.
[27] Ibid 288.

    b. Creating varying decision alternatives.
    c. I.E. Tracking the courses of nearby vessels and planning the vessels own course to avoid a collision.
3. Decision making.[28]
    a. Selecting the alternatives.
    b. Have alternatives added / removed based on conditions.
4. Action.
    a. Instigating and performing the decision.

Parasuraman notes that the levels of autonomy can be applied to each stage of the decision-making process, and that the level of autonomy does not have to be fixed for any system or function.[29] The level of autonomy may change where when a condition in the decision making process is found to be true, triggering the system to reduce its autonomy and request additional input from the human operator. This adds further difficulty to assessing the true level of autonomy at any given moment, so detailed records of the decision-making process will need to be logged in order to make this assessment to assign responsibility and potential negligence accurately.

The Sheridan Model provides a significantly greater degree of descriptive accuracy with regard to whether the human operator or system is making any given decision than the IMO Model, making it a more useful tool for investigators attempting to determine the cause of any incident. This is partly because of the acknowledgement that the operator and system will, in most instances, be symbiotic with each other except for at the extreme ends of the scale, and also due to it taking into account that levels of autonomy may vary across systems, stages of decision making, and change dynamically; both considerations lacking in the IMO Model which prescribes autonomy as an all or nothing reality. Parasuraman also indicates that the Sheridan levels of autonomy can be applied to the 4 different stages of decision making, however he does not detail how the Sheridan Model may need to be adapted for these different stages. Because of this, the Sheridan Model provides useful oversight regarding a particular system overall, but despite

[28] Ibid 289.
[29] Ibid.

Parasuraman's acknowledgment of the decision-making process, it cannot be said to be clearly applicable to the individual stages. This is something that NASA has addressed in their paper researching the potential for autonomy in spacecraft.[30]

Whilst this paper is focused on autonomy in spaceflight, the scale they developed to assess the autonomy of functions can be applied to any autonomous system and so presents no issue in being used to assess the systems on board a vessel. The NASA Model was developed by taking the Sheridan Model and applying it to the 4 different stages of decision-making they determined, which are similar to the stages cited by Parasuraman. The result is a scale with 4 distinct categories for each of the stages, with 8 different levels of autonomy which have been tailored to each category, where level 1 is complete human reliance and stage 8 being complete system reliance. This makes the scale more accurate than the Sheridan Model as it facilitates direct application of a level per decision-making stage, allowing each stage to be weighted differently.

[30] Proud R, Jeremy H, Mrozinski R, 'Methods for Determining the Level of Autonomy to Design into a Human Spaceflight Vehicle: A Function Specific Approach', NASA Report, 11/10/2019.

Level	Observe	Orient	Decide	Act
8	The computer gathers, filters, and prioritizes data without displaying any information to the human.	The computer predicts, interprets, and integrates data into a result which is not displayed to the human.	The computer performs ranking tasks. The computer performs final ranking, but does not display results to the human.	Computer executes automatically and does not allow any human interaction.
7	The computer gathers, filters, and prioritizes data without displaying any information to the human. Though, a "program functioning" flag is displayed.	The computer anlayzes, predicts, interprets, and integrates data into a result which is only displayed to the human if result fits programmed context (context dependant summaries).	The computer performs ranking tasks. The computer performs final ranking and displays a reduced set of ranked options without displaying "why" decisions were made to the human.	Computer executes automatically and only informs the human if required by context. It allows for override ability after execution. Human is shadow for contingencies.
6	The computer gathers, filters, and prioritizes information displayed to the human.	The computer overlays predictions with analysis and interprets the data. The human is shown all results.	The computer performs ranking tasks and displays a reduced set of ranked options while displaying "why" decisions were made to the human.	Computer executes automatically, informs the human, and allows for override ability after execution. Human is shadow for contingencies.
5	The computer is responsible for gathering the information for the human, but it only displays non-prioritized, filtered information.	The computer overlays predictions with analysis and interprets the data. The human shadows the interpretation for contingencies.	The computer performs ranking tasks. All results, including "why" decisions were made, are displayed to the human.	Computer allows the human a context-dependant restricted time to veto before execution. Human shadows for contingencies.
4	The computer is responsible for gathering the information for the human and for displaying all information, but it highlights the non-prioritized, relevant information for the user.	The computer analyzes the data and makes predictions, though the human is responsible for interpretation of the data.	Both human and computer perform ranking tasks, the results from the computer are considered prime.	Computer allows the human a pre-programmed restricted time to veto before execution. Human shadows for contingencies.
3	The computer is responsible for gathering and displaying unfiltered, unprioritized information for the human. The human still is the prime monitor for all information.	Computer is the prime source of analysis and predictions, with human shadow for contingencies. The human is responsible for interpretation of the data.	Both human and computer perform ranking tasks, the results from the human are considered prime.	Computer executes decision after human approval. Human shadows for contingencies.
2	Human is the prime source for gathering and monitoring all data, with computer shadow for emergencies.	Human is the prime source of analysis and predictions, with computer shadow for contingencies. The human is responsible for interpretation of the data.	The human performs all ranking tasks, but the computer can be used as a tool for assistance.	Human is the prime source of execution, with computer shadow for contingencies.
1	Human is the only source for gathering and monitoring (defined as filtering, prioritizing and understanding) all data.	Human is responsible for analyzing all data, making predictions, and interpretation of the data.	The computer does not assist in or perform ranking tasks. Human must do it all.	Human alone can execute decision.

Table 2: NASA's Scale of Autonomy[31]

Importantly, NASA sought to ensure there was consistency between the levels across the different stages. This means that if the Observe and Orient stages are both ranked at level 8, but the Decide stage is ranked much lower, it is clear that the human operator made a decision relying purely on information gathered, analyzed and displayed by the system. This means that investigators can "easily and correctly"[32] identify the true level

[31] Ibid.
[32] Ibid.

of autonomy at each stage of the decision-making process, making this scale the most precise and accurate of the 3 discussed.

2.2 The Direction of DNV-GL

DNV-GL, a Classification Society based in Norway, issued a set of class guidelines for developers and other stakeholders for consideration in the creation of MASS.[33] In these guidelines they define the levels of autonomy they base their guidelines on, and whilst they are based on the IMO definitions, there is a clear influence from the Sheridan model. The 5 degrees they stipulate and more descriptive than that of the IMO version, but not so detailed as the Sheridan or NASA models, finding a middle ground between over-simplicity and potentially overwhelming detail, which could be particularly true for the NASA model. Furthermore, the description for the degrees far better shows the relationship between system and operator as an increasing scale of reliance on the system than the IMO definitions, although naturally not as detailed as the Sheridan or NASA models.

Autonomy Level	Description of Autonomy Level
M	Manually operated function.
DS	System decision supported function.
DSE	System decision supported function with conditional system execution capabilities (human in the loop, required acknowledgement by human before execution).
SC	Self controlled function (the system will execute the operation, but the human is able to override the action. Sometimes referred to as 'human on the loop).

[33] DNV-GL, ‘Class guideline- Autonomous and remotely operated ships’, DNVGL-CG-0264, September 2018.

A	Autonomous function (the system will execute the function, normally without the possibility for a human to intervene on the functional level).

Table 3: DNV-GL's Levels of autonomy[34]

Showing clear influence of the above discussion, DNV-GL also note that "a mix of human and system operated tasks is assumed", demonstrating the point that different system functions may operate at different levels of autonomy, and they also note that any one function may itself be subject to varying degrees of autonomy at different stages of the decision making process. As such, they define their 4 stages of any given process: [35]

1. Detection
2. Analysis
3. Planning
4. Action

The evident similarity between these 4 stages and the named ones in the Sheridan and NASA models demonstrates the importance of recognising that autonomy is not an *either-or* truth in developing the technology. As such, their degrees of autonomy can be used to define the autonomy of a given stage in the decision-making process similar to the NASA model, but without the same level of detail. Whilst this may make such descriptions less accurate, it does provide a simpler categorisation that will likely be more accessible and be susceptible to fewer errors. This is exemplified in an example scenario they have produced to show how a single function, in this case navigation, can vary in its autonomy:

[34] Ibid 51.
[35] Ibid.

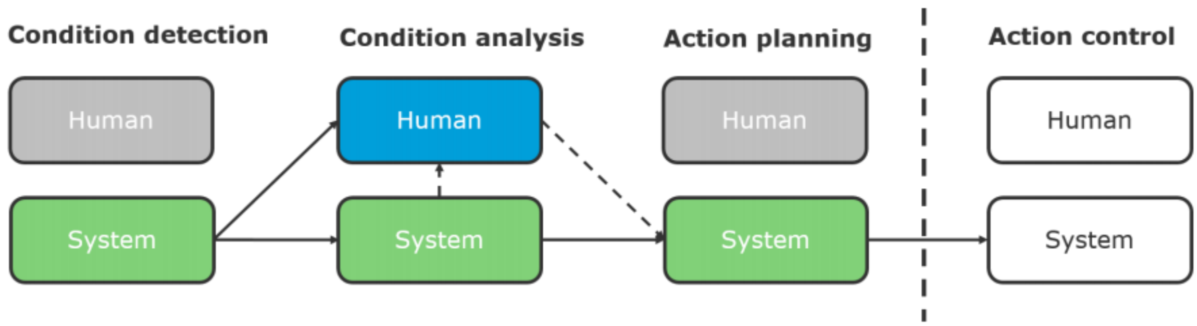

Figure 1: Control of a function[36]

Detection	Analysis	Planning	Action
Vessel is fitted with an object detection system, which identifies an object.	Vessel does not have sufficient object recognition capabilities, so depends on a human to recognize and classify said object as a threat or not.	When the object is classified, the system can calculate a new passage to avoid the object if necessary.	Based on updated passage plan the system will execute the new route.

In this example scenario, all but the analysis stage is operating at a higher level of autonomy, but the system with insufficient capabilities to analyse and categorise the object led to the Analysis function reducing in autonomy and requesting input from the human operator. However, as this scenario doesn't perfectly fit into one of the 5 degrees of the DNV-GL model, it must be highlighted that their model is a starting point for understanding, and that the model must be adapted to the facts before a party seeking to analyse the degrees of autonomy involved in a given function at any time.

2.3 Conclusions on Defining MASS

[36] Ibid 52.

When attributing fault and responsibility where an incident takes place, the most important stage will be the Decision making (Planning) and Action categories, as these will indicate what options were considered, and whether the human operator or system made the final decision on how to proceed. That being said, all stages of the decision-making process will be important to consider as understanding where the information that was gathered and presented to the decision maker came from will be vital to assess whether the decision was a diligent, incorrect, or negligent decision. Being able to assess how involved the decision maker was in the information gathering and analysis will clearly be important in judging their responsibility, as if there is an error or negligence at an earlier stage that the decision maker cannot be said to have ought to have known about, finding them blameworthy for a resulting incident may be against principals of fairness and so shift the responsibility to whomever gathered or analysed the data. This may, based on discussions below, ultimately decide whether the fault lies with the Shipowner, system developer, or other party.

As has been shown, the IMO 4-part MASS Model does not sufficiently deal with the reality of autonomous systems on vessels in the modern fleet, nor for the future development of further autonomy. The 4-part system can provide a general sense of whether there are seafarers on board and whether it is remote control or fully autonomous, but as has been shown by the comparisons with the Sheridan and NASA Models, such absolute categories do not provide adequate depth with regard to the level of autonomy of a given function of a vessel. Instead, considering the above, MASS is not a category of vessel itself but merely a designation for any vessel using autonomous systems, whatever their complexity, as it is impractical to consider MASS vessels as a separate category to conventional vessels in the modern fleet due to the prevalence of autonomous systems used to some degree (albeit more primitive in most cases), a position supported by DNV-GL's use of a more detailed model of autonomy. As such, it is the autonomous function in question, rather than the potential level of automation of the vessel as a whole, that is relevant for this thesis.

3.0 FAULT BASED LIABILITY - COLLISIONS

Having established that the term MASS is a descriptor for any vessel with some level of automation to its functions and should not be considered as a separate category of vessel for the reasons outlined above, the discussion will shift to how the framework for how the basis of a Shipowner's liability may need to be adapted to deal with autonomous systems. This will be done by examining the rules around liability for collisions, as this is a common cause of liability and as such it will be important to understand how collision liability fits in to the MASS context. Of note is that collisions are rarely caused by a fault of the Shipowner them self, but by the master or a member of the crew whom the Shipowner is vicariously liable for. This principle of vicarious liability will be further examined in the MASS context in Chapter 4 of this thesis, but for present purposes it should be assumed that the Shipowner may be liable for any fault from the ship, master, crew or any remote controller – the discussion in this Chapter is with respect to finding the basis of liability itself, in the case of collision, that being fault.[37]

Under Norwegian law the liability for damage caused as a result of a collision is governed by the Norwegian Maritime Code (NMC) §161, which expressly provides for a fault-based liability approach. Where 1 party can be identified as being wholly responsible for the collision, that party will cover the loss, whereas if there is more than 1 party responsible those parties shall be liable to "cover the damage in proportion to the faults committed"[38]. This means that if 2 parties are involved, and the injured party can be said to be 33% to blame, then he must bear 33% of the loss and receive the remaining 67% from the other party.[39] In addition to this, if there is personal injury then all involved parties are jointly

[37] The Norwegian Maritime Code, §161-162.
[38] Ibid, §161.
[39] Thor F, Hans JB, Lasse B, 'Scandinavian Maritime Law; The Norwegian Perspective', (Universitetsforlaget, 4th Edn) 2017, 270.

and severally liable,[40] meaning that whilst liability may remain in those portions, the injured person(s) can recover against 1 of the parties for the full amount to ensure he receives all appropriate compensation, and then the party who paid may make a contribution claim against the other involved parties to recover the amounts paid to the injured party above what his proportion of the blame is.[41] Finally, §162 NMC also establishes that if the collision is due to an accident, or if fault cannot be established, then each ship will bear its own loss.

The above provisions are all the Norwegian implementation of the Brussels Collision Convention 1910,[42] which is the international framework for apportioning liability between colliding vessels. The intention to assign liability based on the degree of fault exhibited in the conduct of the involved vessels is clear, and it is submitted that no change to this approach is needed for MASS vessels; it remains the common-sense approach to keep liability apportioning based on fault. However, the concept of "fault" with respect to MASS must be examined, as the errors a system may make could be fundamentally different with distinct causes to the errors a human may make. To this end, evaluating "fault" from a physical, mechanical failure will be examined, as well as examining how errors in the decision making of a system can be "fault" to attach liability to will be examined. It is noted that the NMC does not provide much guidance as to what is considered "fault",[43] other than to say that whether there was time for deliberation must be especially considered.[44] As such, ordinary principles of tort must be used when evaluating fault to decide whether an act or omission was reasonable or can be shown to have caused the collision, and references to rules and best practices will be relied on.

[40] NMC (n37) §161.
[41] Thor (n39) 276.
[42] Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels, 1910.
[43] Thor (n39) 277.
[44] NMC (n37) §161.

3.1 Fault with Physical Failures

A sensor failing and not detecting an object, an engine failing and being unable to reverse to avoid another vessel or a rudder jamming making manoeuvring around another vessel impossible are all examples of physical or mechanical failures. When such a failure takes place and causes a collision, whether the failure is a fault incurring liability or an accident escaping liability depends on whether the collision was unavoidable.[45] Whether the collision was unavoidable will depend on 2 aspects.

The first aspect to consider is whether the failure itself was caused by any fault or neglect of the crew, as if the failure was caused by fault or neglect then the collision was not unavoidable. There are 2 cases that demonstrate this consideration. The first, *The Navion Hispania*,[46] was found liable when the *Navion Hispania* collided with a storage vessel due to a failure in its propulsion. The court rejected the submission that this failure was unavoidable as it was found the failure stemmed from contaminated bunkers which led to fuel starvation, something that should have been remedied long beforehand, and so the failure of the crew to remedy the contaminated bunkers was held to be blameworthy. In contrast, when the *Marna Hepsø*[47] collided with 2 other vessels because her reverse engine failed, leaving her unable to stop in time, it was found to be an accident as no fault could be found on the part of the crew with respect to the maintenance of the engine. These 2 cases demonstrate that in order for a failure to be unavoidable it must not be due to any act or omission of the crew, and so proper regular maintenance of the vessel and its equipment is vital to prevent and learn of any problems with a component or part in a timely manner so that that part can be replaced or repaired. With respect to MASS vessels, keeping regular surveys will be important, as vessels operating without crew will not have anyone on board readily available to inspect suitable parts. Such surveys for

[45] Thor (n39) 270.
[46] ND 2013.201 NCA Navion Hispania.
[47] ND 1971.36 NSD Marna Hepsø

MASS vessels do not currently have their own survey scheme, but they are likely to develop from current class systematics.[48]

However, as the technology develops it is expected that a number of functions and components will effectively be able to survey themselves and provide reports on their condition,[49] with the requirements for such reporting becoming more prudent as technology develops and a greater scope of information can be gathered by reporting technology. This will primarily benefit electrical components, but can also be used to show performance of non-electrical or mechanical functions, something that should allow Shipowners to readily see the condition of relevant components and plan around their repair/replacement cycle, and equally can be used to show negligence should these reports show that action should have been taken earlier if one of the components fails and this leads to a collision. Actively monitoring the condition of components where possible via such reports to ensure they are fit for purpose, as well as the remote operator or autonomous vessel supervisor ensuring that mechanical systems are operating within their safe operating limits, will prove to be an important factor to be successful in arguing that the failure itself was not the fault of the master or the crew for MASS vessels.

The second aspect to consider is whether or not the collision could have been reasonably avoided after the physical failure. This principle is best demonstrated by the Danish case of *The Libas,*[50] where the *Libas'* steering system failed causing a collision. The master was found to be at fault as he still had access to the emergency steering system and so could have avoided the collision. This case also showcases an important factor for MASS vessels: the possibility of an alternate, still working system or redundancy. In DNV-GL's guidelines, they expressly stipulate the need for redundancies in multiple functions at higher levels of autonomy, such as steering, that are completely disconnected from the main system so as to ensure that if the main system fails for whatever reason, the redundancy will not be hampered by that same failure.[51] As a result, it is important to ensure that all systems are operational and working appropriately to ensure that the

[48] DNV-GL (n33) 33-34.
[49] Ibid.
[50] ND 1994.47 DSC Libas.
[51] DNV-GL (n33) p21.

redundancy requirements, where applicable, are met, as whether a redundancy should have been operational or not will undoubtedly be considered by a court, and a failure that could have been countered by a redundancy that was not operational will likely lead to a finding of fault.

This principle should apply to situations where, for example, a sensor fails and fails to report information to a human operator, on board or remote, who then makes a decision based on the incorrect information that leads to a collision. The human operator relies on the information provided by such sensors, and so when such a sensor fails and provides incorrect information the question is whether or not that failure should have been detected by some form of electronic monitoring and allowing the operator to put the vessel into a "Minimum risk condition" (MRC)[52] whilst it is assessed how to proceed safely, and whether another system acting as redundancy should have provided the corrected information, on top of the responsibility of the Shipowner to ensure such sensors are properly maintained. If there is a justifiable reason why the failure still caused the incident that does not stem from neglect then such an incident should rightly be termed an accident as there is no fault from the Shipowner or the crew.

If it is not shown that the failure that caused the collision was due to the master or crew's negligence or any other fault, and that there was no way of preventing the collision after the failure of the physical part of mechanism, then the collision will be considered an accident and no liability will be imposed on the Shipowner. It is submitted that this liability mechanism does not need to be changed beyond embracing the additional requirements for redundancies, inspections and reporting from the Classification Societies, as for physical and mechanical failure the current framework is still suitable for MASS operations

[52] Ibid 13.

3.2 Fault with Decision-Making Systems

There is a variety of ways that an autonomous or remote ship may make decisions without input from a human. The predominant focus here will be on decisions made by a system without input from a human, ie self-reliant systems at the highest degrees of autonomy. As discussed in Chapter 2, there are a variety of functions that can be automised, from controlling and monitoring engine output to controlling navigation. This discussion will focus on navigational decisions, as decisions of a mechanical engineering function can be simply stated that such decisions should never push any mechanical component beyond the manufacturer's stipulated operating parameters, for example, driving the engines too hard so they overheat, fail, and cause a collision due to reduced manoeuvrability. Such an example is akin to faulty behaviour of the crew member in charge of that decision, and so fault should be applied in the same way.

Navigational decisions, however, require more nuance in their analysis. In evaluating how the current framework could be applied to autonomous systems, 2 linked considerations become apparent: the principle of equivalent safety, and the application of the Collision Regulations (ColRegs) which Norway is a party to.[53] DNV-GL have stated that autonomous systems should have at least the equivalent safety of manned ships.[54] This is important to note, as it means the burden of safety is not absolute safety, but relative to what can be expected of conventional ships.[55] However, some have raised the question of how such safety should be assessed: equivalently safe based on statistics or based on the best human operations?[56] In the maritime context the answer to this lies with compliance with the ColRegs, a set of international rules which set forth the *Rules of the Road* for ships at sea and can be considered similar to land traffic rules,[57] something that any collision avoidance system should be fully compliant with.[58]

[53] Convention on the International Regulations for Preventing Collisions at Sea, 1972.
[54] Ibid 17.
[55] Robolaw, '*Guidelines on regulatory robotics: Regulating emerging robotic technologies in Europe: robotics facing law and ethics*' 22/09/2014, 57.
[56] Ibid.
[57] Thor (n39) 278.
[58] HFW Law Firm, '*Maritime Autonomous Surface Ships – The Rise of the Machine*' July 2017.

A number of the ColReg rules should be programmable into a collision avoidance system with little issue. For example, Rule 14 provides that when 2 ships are heading towards each other they shall both alter their course to starboard to avoid a collision, and Rule 15 states that if 2 ships are crossing, the vessel with the other on her starboard side must give way. Rules such as these provide little legal or practical issues as the sensors and systems should detect other vessels, with the collision avoidance system implementing the proper course of action. Should an autonomous system violate these rules without good reason, then it should be treated the same as if a conventional vessel did the same and a finding of fault would be likely should a collision arise as a result. This should be the same even where the system behaves unexpectedly. Where circumstances become complex with multiple factors at play or in extraordinary circumstances a system may make unexpected decisions based on its programming as it extremely difficult to fully predict the behaviour of a computer system. An extremely clear example is that of the Gaak robot experiment which, whilst not maritime, demonstrates this unpredictability with programming. The experiment involved robots acting out a predator – prey situation, with some robots programmed to hide and escape from the predator hunters, who were programmed to hunt the prey robots. One of the prey robots managed to force its way out of the enclosure, escaping to a parking lot where it was hit by a car, something the programmers did not expect or consider a possibility at all.[59] This shows that systems can clearly act unexpectedly, and raises the question of whether a fault of this nature should be attributed to the system developer. It is submitted that even with such faults where the Shipowner has no control over unusual behaviour, the liability should still fall on the Shipowner as he is the one looking to profit from the technology and should have the proper insurances in play, and it allows the claimant the clearest route to compensation. In addition, the Shipowner's contract with the producer should stipulate any indemnity and recourse conditions, allowing this to be governed by the principles of freedom of contract.

[59] Paulius C, Jergita G and Gintare S, '*Liability for Damages Caused by Artificial Intelligence*' Computer Law and Security Review (2015) 376-389, 382.

However, there are some rules that may be difficult to be compliant with.[60] Rule 2 includes a notice that deviation from the Rules may be made based on the full circumstances presented to the vessel, and this has been highlighted as something that may be difficult for a system to adequately judge.[61] However, the need to deviate would likely arise from action not being taken soon enough, for example not following Rule 6 (to proceed at a safe speed) leaving the vessel unable to stop in time to avoid a collision. It has been suggested that the navigation and collision avoidance systems following the ColRegs more strictly than the crew of a conventional vessel will result in better planning and appropriate action being taken at an earlier time, meaning that such deviations will not be necessary.[62] This results in a greater level of safety than under conventional ships as the risk may be identified and acted upon at an earlier time.

The other main concern regarding compliance with the Rules is Rule 5, the duty to maintain a lookout "by sight and hearing… so as to make a full appraisal of the situation and of the risk of collision." The first issue identified is that of a technical one, as a system cannot hear or see,[63] however it is submitted that visual, infrared, radar, audio and an array of other sensors can provide the effect of awareness, and so interpreting this rule in the context of the current year compared to the inception of the ColRegs of 1972 should be used, and doing so easily allows this potential conflict to be remedies. Even if this is not satisfactory, under Rule 2 deviation from the rules is permittable under special circumstance, and an autonomous system with appropriate capabilities to replace a lookout with technological replacements should be considered as such a special circumstance.

The second issue with Rule 5 is that at present systems may not satisfy the requirement to be able to "make a full appraisal of the situation". This is because whilst current sensors can readily identify that there is an object in the water (object detection), there is great difficulty in identifying what the object is and whether is it a risk (object classification) to

[60] HFW Law Firm, '*Autonomy at Sea – The Future?*' April 2017.
[61] Ibid.
[62] Robert V and Michael T, '*The Integration of Unmanned Ships into the Lex Maritima*' Lloyds Maritime and Commercial Law Quarterly, (2017) 304-335, 325.
[63] Ibid 326.

the same standard that a human can,[64] clearly at odds with the principle of equivalent safety. This does not present an issue where a remote operator or autonomous supervisor is alerted to an object and the system requests the human's input to assess the situation but is an issue where full autonomy is the goal. The immediate solution is to, as indicated immediately above, require the autonomous supervisor to be ready to classify the risk of a detected object, and as the technology develops this should cease to be an issue. To this end, Rolls Royce and Google have launched a joint venture to develop object classification technology using Cloud computing,[65] demonstrating that even for conflicts existing at present there are solutions being worked on to bring full autonomy up to the equivalent safety standard.

The ColRegs should be applied to MASS vessels in almost the same way as they are for conventional vessels, however with a slightly wider interpretation to facilitate compliance with Rules 2 and 5 as outlined above. The larger issue with Rule 5 regarding the ability to make a full appraisal, on the other hand, should not be forsaken for the sake of developing technology, and so until such a venture as the Rolls Royce – Google one can produce an object classification system that can satisfy this requirement, operators of MASS vessels should be prepared to have a remote controller or autonomous supervisor be prepared to make assessments of detected risks to properly appraise them.

In addition to making navigation and collision avoidance systems compliant with the ColRegs, the provision in NMC §161 to consider whether there was time for deliberation must be considered in the MASS context. This will be most prevalent when a remote operator or autonomous supervisor will need to take control or make a decision for the vessel that it cannot render itself, for example to classify a potential risk of collision with an unknown object as outlined above, or to overrule or take control of the vessel for any given reason.[66] In order for the equivalent safety principle to be satisfied, this should not take significant time, and so the system should readily display the information needed to

[64] Rise of the Machine (n58).

[65] Rolls Royce, '*Rolls Royce joins forces with Google Cloud to help make autonomous ships a reality*' 03/10/2017, < https://www.rolls-royce.com/media/press-releases/2017/03-10-2017-rr-joins-forces-with-google-cloud-to-help-make-autonomous-ships-a-reality.aspx> accessed 27/10/2019.

[66] DNV (n33)

bring the human up to speed with the required situational awareness so they might make a suitable safe judgement on the situation.[67]

3.3 Conclusions on Fault in Collisions

The discussion above has shown that the current framework for apportioning liability does not need to be altered to be applicable for MASS vessels. Further, finding what constitutes fault will follow a broadly similar pathway in the MASS context. The key difference will be a greater reliance on rules and best practices such as the ColRegs for navigational systems to determine what fault is, as systems cannot be negligent in the traditional sense. These aids will need to be interpreted in the modern age, as many of them were developed before the concept of autonomy was thought possible, and so their content is framed with navigators and engineers being on board to apply them. With respect to physical or mechanical faults ensuring that maintenance and component condition is properly kept and monitored will be vital for Shipowners to disprove any allegation that they have not properly kept their vessel(s) seaworthy.

Keeping the basis of liability as similar as possible to that of conventional ships should be desired so as to avoid creating different sets of rules where they are not needed. By applying the current framework as described above the same rules are used, albeit in some cases with wider interpretations than may usually be given, keeping maritime liability unified across vessel types, giving both a satisfactory and simple result.

The discussion in this Chapter has been limited to collisions, which have certain rules and best practises, ie the ColRegs. However, the root basis of liability is fault, and so the analysis here can be applied to any other fault-based liability a Shipowner may have imposed against him. Therefore, it is submitted that fault-based liability may still be applied in the MASS context, with the above-mentioned focus on complying with objective best practises, stipulated parameters and proper maintenance and monitoring of

[67] Ibid

components being the main focus on whether or not a vessel is at fault for causing any loss.

4.0 VICARIOUS LIABILITY

Having established how the basis of fault can be found in the MASS context, the discussion will now turn to how this fault and subsequent liability is imposed on the Shipowner, because as pointed out in Chapter 3 the faults leading to liability on conventional vessels are usually from the master or crew. Vicarious liability is a form of liability that mixes fault and strict liability. It activates where an employee, or someone that the employer is responsible for based on defined criteria, causes damage or loss to a party through fault or negligence, and then the employer will be held liable for the fault of the employee, meaning that whilst this form of liability is based on fault in the tortious act itself, the mechanism by which the employer is held liable is effectively strict liability,[68] as the employer's conduct is not considered. This mechanism is found internationally, and by way of example has been described in English courts as something that has developed as a "just and practical remedy for harm"[69] born from "social convenience and rough justice",[70] a suitable description for this principle across jurisdictions. This is because whilst it steps away from the general principle internationally that tortious liability should be based on the fault of the defendant, by allowing such liability to be channelled to the employer 2 predominant benefits are identified across jurisdictions.

The first such benefit is that it ensures that the innocent, harmed party can be properly compensated. This is because of the *deep pockets* idea, that the employer has greater resources than the employee, and also will likely hold insurance which will aid in distributing those losses, particularly where reinsurance and other mechanisms are in place to further distribute those losses amongst insurers where appropriate.[71] This can be further justified when it is considered that the employer takes the benefit from the employee's work, and so it is appropriate that the employer also takes the risk of loss

[68] John H and John L, '*Tort Law*', (2nd edn, Oxford University Press) 2007, 271.
[69] Majrowski V Guy's & St. Thomas' NHS Trust [2006] 3 WLR 125.
[70] Imperial Chemical Industries v Shatwell [1965] AC 656.
[71] Kirsty H and Erik R, '*Tort Law*', (5th edn, Oxford University Press) 2017, 593.

caused by the employee done in the course of their work.[72] This approach ensures that the innocent party can seek a remedy where, particularly in the maritime world, any claim awarded against the actual tortfeasor may exceed their lifetime earnings by a considerable amount, making the award effectively unenforceable.[73]

The second benefit to vicarious liability is that it encourages employers to be diligent in their hiring and training of employees, as the employer will be liable for any loss caused by the employee in the course of their work. The result of this is that employers are incentivized to be responsible and so minimize the occurrence of loss-causing incidents.[74]

As one of the most common ways a Shipowner is held liable is through the fault of the master and crew of his vessel,[75] understanding vicarious liability in Norwegian law will be vital to understanding how the Shipowner may be liable for his vessel where the master and crew may be replaced by autonomous systems all together, particularly for collisions, where liability is generally found because of the fault of the master or crew. In Norwegian law, the Shipowner's liability for the master and crew, or more specifically the "reder", with respect to the operation of his vessel is specifically outlined in §151 of the Norwegian Maritime Code, which provides that:

"The reder shall be liable to compensate damage caused in the service by the fault or neglect of the master, crew, pilot, tug or others performing work in the service of the ship."

This provides a 2-stage test; firstly, whether the entity causing the damage falls under the scope of §151, and secondly whether the damage was caused in relation to work performed in the service of the ship.

The second stage of this test will be dealt with here first, and can be described as an evaluation of the nature of the service provided, where it is required that the work performed is connected with a particular ship and carried out in its service.[76] This has been interpreted widely, and has covered navigational decisions of the master to

[72] Ibid.
[73] Thor (n37) 190.
[74] Robolaw (n54) 55.
[75] Thor (n37) 190.
[76] Ibid 202.

stevedoring activities;[77] it is generally clear whether an activity falls under the scope of §151, as if it relates to any aspect of a ships active operation, from navigation and discharging cargo to instructing maintenance and surveys, it will likely fall under this provision.[78] There are certain exceptions, however. It is noted that for public shipping services, such as the provision of navigation charts or errors in light-housing no responsibility is allocated to the Shipowner.[79] Further, the act or omission must be sufficiently proximate as work done on a ship is not by default considered as being in service of the ship, for example in *The Sardinia*[80] where the First Mate fired a rocket on New Year's Eve in celebration, which caused a fire to a nearby building, but this was insufficiently proximate to be classed as being in the service of the ship. However, it is no defence that an act or omission is done deliberately to cause damage or loss if it is held to be sufficiently proximate;[81] the Shipowner is liable for any damage or loss caused negligently or deliberately for any qualifying act or omission.

Considering this stage in the context of increasingly complex maritime systems, it should become apparent that there will be no issues in assigning work done by such a system as being in the service of the ship. Navigational aids are designed to assist in navigating safely, collision avoidance systems are designed to detect and avoid potential collision risks, and as these systems develop to take over navigating the vessel it is difficult to argue that such a purpose is not in the service of the ship, and other systems, such as those for automating engineering, cargo stowage and loading, etc, are again clearly in aid of safe and effective operation of the vessel and so the work done by them would safely fall under this stage of the test. The first stage of the test, however, presents significant issues with respect to increasing autonomy levels.

The first stage of the test is with respect to who the Shipowner is liable for, and specifically names the master, crew, pilot and tug, whilst also allowing for "others" not defined to fall under this provision where their work is in the service of the ship.[82]At lower levels of

[77] Ibid 200.
[78] Ibid.
[79] Ibid 203.
[80] ND 1914.159 NCC SARDINIA.
[81] RT 2015.475.
[82] NMC §151(1).

autonomy, where there are still crew on board and the systems are either aids or under close supervision, there will not be many issues presented as ultimately the master is still responsible for the vessel, and so any damage or loss caused will be his responsibility, and therefore the Shipowner will be liable. However, where the vessel is operated by a remote operator, or by the systems entirely, issues as to who holds responsibility arise, which can be problematic for current model of vicarious liability, particularly in the context of the international framework.

4.1 Responsibility for Vessels with Remote Functions – The Remote Master?

Where the responsibilities of the crew and master are performed by those persons on the vessel, there is no conflict with the current framework. Indeed, under the §151 NMC test there does not seem to be an issue with assigning the roles and responsibility of the master and crew to a remote operator working from a Remote Control Centre (RCC), as the open ended wording of the first stage of the test including the master, crew and "others performing work in service of the ship" would indicate that the Shipowner will be held to account for fault on the part of a remote operator performing the roles traditionally done by the master or crew, as these roles are clearly in the service of the ship. As such, the provisions of §151 NMC can be applied to remote operators with little conflict. However, it should be evaluated whether such an operator can be considered the master of the vessel or merely some other "helper" under §151, as the international legal framework requires there be a master and if a remote operator cannot be considered as such any vessel operating remotely may be in breach of the master requirement.

The United Nations Convention on the Law of the Sea 1982 (UNCLOS) sets a requirement that, in order to ensure safety at sea,[83] the ship is in the charge of an appropriately qualified master.[84] The immediate question, then, is whether the master

[83] UNCLOS Article 94(3).
[84] Ibid Article 94(4)(b).

must be on board the vessel for the ship to qualify as being in their charge. Unfortunately, this question is not answered in UNCLOS, so national legislation must be examined.[85]

By way of example, the national legislation of the United Kingdom and the Netherlands will be examined before exploring how Norwegian law may be interpreted. The United Kingdom provides an express definition for what the master is in their national legislation, providing that the master "includes every person (except a pilot) having command or charge of a ship…".[86] This definition outlines that any person with "command or charge of a ship" is the ship's master, however it does not stipulate any requirement for such a person to be on board the vessel. As such, under the law of the UK there is no bar to the master acting remotely from an RCC, and so the remote operator with overall responsibility, if for example there are various operators for navigational and engineering functions, should be considered as being in command and therefore the master of the vessel. Conversely, under Dutch law, the master is defined as being part of the crew,[87] with the crew being a category of persons who find themselves on board a ship.[88] When read together, these definitions of Dutch law have been suggested to require that the crew, and therefore the master, must be on board the vessel, and consequently that under this interpretation a remote operator could not be said to be the master under Dutch law.[89]

In contrast, Norwegian national law does not provide a solid definition for the role of the master, and so to evaluate whether there is any legal difficulty with having a remote master we must look to what other provisions exist under Norwegian national law for the master. The NMC does not stipulate whether the master must be on board or not, however it does provide for his obligations and responsibilities.[90] In particular, §136 NMC sets out rules for the absence of the master, which outline that in such absence the senior mate will make decisions, that the master give appropriate orders for dealing with eventualities to the senior mate and other rules regulating the command structure should the master not be present, which at face value suggest that the master must normally be

[85] Robert (n62) 317.
[86] Merchant Shipping Act 1995, S313(1).
[87] Dutch Civil Code Book 8: Transport Law and means of Transport, Article 8:6.
[88] Ibid Article 8:5.
[89] Robert (n62) 317.
[90] NMC Chapter 6.

on the vessel, but does not mean that if the master leaves the vessel, he is no longer the master. Further, on examining the purpose of the §136 provision it is apparent that their purpose is not to require the location of the master to be on board a vessel, but to ensure that there is a command structure and suitably instructed officers should the master be rendered unable to fulfil his duties. Whilst there are references to the master leaving the ship,[91] these should be interpreted in the light of the date of the legislation, which at the time of drafting did not consider the possibility of remote or autonomous vessels, and so were not intended to be a strict requirement for a master to be on board, but rather a reflection of the reality of that time, and so should be open to interpretation in light of modern technological developments. Indeed, this could be said to be supported by there being no explicit of the need for the master to be on the vessel, as it would have been presumed at the time of drafting that this would be the case due to the technology at the time.

As such, §136 NMC should be considered as provisions which ensure a command structure should the master be unable to perform his role, rather than provisions that require a master to be physically on board to perform his functions. Consequently, it is submitted that under Norwegian law there is no bar to considering the remote operator as the master, provided that the roles performed by the remote operator also satisfy the rest of the rules related to the master's roles in NMC Chapter 6. The result of this is that under the vicarious liability rules of §151 NMC, the Shipowner will simply be automatically liable for damage or loss caused by the fault or neglect of the remote operator acting as the master, as the master is defined within §151 and no further investigation into whether a remote operator would be under the Shipowner's responsibility is required.

4.2 Responsibility for a Decision-Making System

The most complex legal challenge facing the vicarious liability principle comes where decisions are not made by a person, but by a system operating at a high level of

[91] Ibid §136(2-3).

autonomy. Liability has only been assigned to legal entities such as humans and registered companies,[92] and so at present there is no mechanism to hold a computer system legally responsible for damage or loss caused by it, and so such liability cannot be passed on to the Shipowner through vicarious liability. As a result, there may not be a clear solution for a claimant who has suffered due to the fault of a computer system, and so it will be explored how new liability rules can be introduced, or existing rules can be adapted, to provide a clear path for a claimant seeking compensation against systems operating at the highest degrees of autonomy.

Considering the previously mentioned points, that vicarious liability is a mechanism that developed out of "social convenience"[93] to facilitate compensation where it otherwise might go unpaid, and to encourage Shipowners to act responsibility with regard to their company policies to minimize the number of incidents, a flexible approach should be taken to provide a method of facilitating proper compensation. To this end, 3 alternative potential solutions are submitted: (1) introduce new legislation for the liability with regard to decisions made by systems that cause loss; (2) Require any system to be directly supervised, whatever its level of complexity and intelligence, so that a human can be held responsible similar to the situation for remote vessels discussed above; and (3) to expand §151 NMC to include decision-making systems.

(1) Introduction of new, specific legislation

Introducing tailor made legislation to assign liability may provide the most comprehensive and expansive solution to injured parties looking for compensation where their loss has been caused by a decision-making system, as it would allow for all aspects of liability and other points of law, such as who the master would be if such a role is even deemed necessary at the highest levels of MASS, and the consequences thereof to be considered. However, as with any legislation dealing with artificial intelligences and decision-making systems, such legislation would deal with continually evolving technology, and it has been noted that any such legislation must be one of two things. Either general in nature, and

[92] Paulius (n59) 383.
[93] Imperial Chemical Industries (n58).

therefore universal to hold long-standing effectiveness,[94] meaning that it may come with inherent ambiguity that would be unsatisfactory to stakeholders due to the legal uncertainty that would follow, but also be open to interpretation in courts to allow it to be adaptable to varying circumstances and technological developments. The alternative to this is that such legislation is detailed and specific so as to avoid any ambiguity, but this may render the legislation unsuitable to deal with the legal challenges that emerge as the technology develops, resulting in either the stagnation of technological development or open interpretation of the legislation by the courts, both undesired outcomes. The only way to prevent this would be for legislation of this style to be continually updated to ensure its continued suitability.[95]

Furthermore, introducing new legislation, potentially with a new liability mechanism for decision-making systems, raises the issues discussed in Chapter 2 – that it may become difficult to be able to differentiate between whether the damage or loss was truly caused by the system or the human interacting with the system at a higher degree of autonomy. Questions as to whether the fault was on the part of the human, system or a mix inherently confuse whether the older law, applied as discussed above, applies or whether the new legislation applies, and setting a clear distinction between them will prove difficult for the same reasons discussed in Chapter 2 and could present a jarring conflict. This, in addition to the lengthy process that researching drafting and debating such legislation would be, means that whilst the introduction of new legislation to fill the liability hole in the current framework for vicarious liability when decisions begin to be made by systems could provide a workable solution, it is the least recommended of the 3 options submitted.

(2) Require all systems to be supervised

Under the current technological capabilities it does not seem overly restrictive to require any system, regardless of its complexity or capability, to be directly supervised so that any decision it intends to take can be overridden, and therefore its actions attributable to the supervisor. Indeed, this approach may be the simplest, as by requiring a supervisor who is ultimately responsible that person can be considered the master under Norwegian

[94] Paulius (n59) 377.
[95] Ibid.

law as discussed above, and can be the person whom liability flows through to the Shipowner under the §151 NMC rules, providing a simple solution to the hole in vicarious liability at decision-making systems levels of autonomy. This has also been mentioned by DNV-GL as a requirement for certain navigational functions, where they state that even with self-controlled navigational systems the supervisor "should however have the possibility to intervene".[96] This solution does not have to be legislated, but could be adopted by Classification Societies as a requirement of class, meaning that it would not be subject to the lengthy process of legislating, and could be amended quicker than equivalent legislation.

However, such a solution may not stand the test of time, as the capabilities of the systems become ever more advanced, the presence of a human supervisor may prove redundant, at which point a different approach may be required. Despite this, the interim period would allow for more research, both technically and legally, to allow legislators to develop rules more appropriate to deal with the challenges without placing them under undue strain or time constraints.

(3) Expand §151 to include decision-making systems

To amend §151 NMC to explicitly include decision-making systems as an entity the Shipowner is responsible for where such decisions cause loss or damage is, on the face of it, a simple solution. However, to do so would effectively to be to recognize such a system as a legal person, radically expanding the conservative concept of legal persons.[97] Legal persons, that is to say entities who are subject to rights and obligations,[98] are traditionally only considered as living humans and incorporated companies.[99] It is submitted that it is not too big of a leap from the current law, as personhood is already split into organic persons (humans) and artificial persons (companies), so affording decision-making systems personhood would simply be adding another entity to the artificial person category.[100] This is an approach that has often been discussed favourably

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[96] DNV-GL (n33) 62.
[97] Paulius (n59) 383.
[98] Lawrence B.S, '*Legal Personhood for Artificial Intelligences*', (1992) 70 N C L Rev, 1231-1288, 1238.
[99] Paulius (n59) 383.
[100] Ibid.

in academic writing by those involved in technology law,[101] and will also stand up to the test of time as more and more systems across disciplines, not just the maritime world, become automated and the need to allocate liability when loss is caused by those systems' fault, and adopting such a liability system would allow maritime legislators to spearhead this area of law. Furthermore, the fact that the system itself does not have the facility to pay compensation where it is at fault does not represent an issue in this context, as it to facilitate the Shipowner being liable for the system performing work he takes the benefit from.

As such, this option is submitted as being the best of the 3, however any have the potential to provide a working solution for many years. As such, it can be said that there are solutions to ensure a party can receive proper compensation should they suffer loss due to the fault of a decision-making system, and the options discussed above range from non-legislative rules to an addition to the concept of a legal person. The area of decision-making systems cannot currently accommodate proper compensation, however with some alteration of the current framework this can be readily solved.

4.5 Conclusions

Vicarious liability demonstrates the difficulty in resolving fault-based liability with whether the entity causing the fault was a human, a remote human or a decision-making system. It has been shown that even up to remote operation levels the current framework under Norwegian law can be applied without issue, only at the highest levels of automated decision-making systems will there be need for either a broadened interpretation of the current framework, or new legislation or rules to be introduced, with the submission that the 3rd option provided, to encompass decision-making systems under NMC §151 being the best suited solution.

[101] Ibid, see also Lawrence (n87).

5.0 The Shipowner's Strict Liability

As discussed above, a Shipowner's tortious liability usually arises out of negligence, however there are limited circumstances where a Shipowner may be liable without being at fault.[102] Where liability is found purely because damage or loss is shown to have materialised without consideration being given to whether the defendant acted negligently or was at fault is known as strict liability. In the maritime context, it has been said that this mechanism for providing compensation comes from the inherent risk of maritime activities, and that the Shipowner, the person looking to profit from such hazards, must bear the burden when those risks materialise.[103] Such liability has developed both from statutory provisions, often from international conventions, and also by the courts in certain circumstances, and this chapter will discuss 3 types of strict liability: liability for oil pollution, liability for damage caused out of necessity and liability for collisions with non-vessel structures.

5.1 Liability for Oil Pollution

Under Norwegian law, Chapter 10 of The Norwegian Maritime Code deals with liability for damage caused, and reasonable expenses concerned with preventing and containing such damages, where oil escapes from a ship. This chapter divides such liability into 2 categories: Part I for the liability for bunker oil,[104] and Part II for the liability for oil discharged from vessels designed to carry oil in bulk.[105] Each category is the Norwegian implementation of international conventions, with bunker liability coming from the Bunkers

[102] Thor (n39) 189.
[103] Ibid 192.
[104] Norwegian Maritime Code, §183.
[105] Ibid §191.

Convention,[106] and the liability for oil tankers coming from the Civil Liability Convention 1992 and the Fund Convention 1992.

With respect to bunker oil liability under Part I, §183 provides that a Shipowner "shall be liable regardless of fault for pollution damage caused by bunker oil". This clearly defines the Shipowner's strict liability for any damage cause by the "escape or discharge" of bunker oil from his vessel. This section also eliminates any confusion over whether a MASS operating at a high level of autonomy would be included under this provision, as it defines a ship as being "any seaborne vessel or other seaborne construction",[107] meaning any MASS vessels fall under the scope of this provision as they can still be considered "seaborne vessels", whatever level of manning or automation they are operating at, meaning that no alteration to §183 is required to ensure its applicability to MASS.

Part I also deals with other matters, such as the limitation and channeling of liability,[108] the duty to insure against such damage[109] and a Claimant's right to bring action against the insurer directly (Direct action), [110] and court competence and scope of the provisions.[111] These other provisions, however, do not warrant further discussion in the context of their applicability of MASS as the predominant difficulty is whether this Chapter is applicable to MASS in the first instance, which has been shown to be so under the provisions of §183, and the subsequent Sections deal with what action the Shipowner can take after liability has been established and the procedures and rules about such liability; these provisions do not require adaptation to MASS as they are equally applicable once it is established the Shipowner is liable for the vessel, irrespective of the ships level of autonomy.

Part II, dealing with oil pollution from tankers and other vessels designed to carry oil in bulk, is very similar to Part I in content and structure. The principle difference in content is that, under §191, the strict liability of the Shipowner is for oil pollution damage from oil

[106] International Convention on Civil Liability for Bunker Oil Pollution Damage 2001.
[107] NMC (n39), §183para 3.
[108] Ibid §185.
[109] Ibid §186.
[110] Ibid §188.
[111] Ibid §189-190.

that is “any persistent hydrocarbon mineral oil such as crude oil, fuel oil, heavy diesel oil and lubricating oil.” This covers oil being transported for sale, but also means that oils that were covered under Part I are instead covered under Part II for this type of ship. The type of vessels covered under Part II are “any seaborne vessel or other seaborne construction that is designed or adapted to carry oil in bulk”, and also vessels capable of carrying oil or other cargo, but in fact carrying oil or oil residue at the time of an incident.[112] This, more restrictive definition than that of §183, again poses no issue when translating this strict liability to MASS operations, as the definition of a ship being “any seaborne vessel…” is identical to that of §183, with the addition later in the section merely specifying the vessel’s cargo carrying capabilities and actuality.

As such, the Shipowner’s liability with respect to damage caused by oil pollution will remain unchanged: where oil escapes from his vessel and causes damage, whatever the vessel’s level of autonomy, he will be held liable without consideration as to whether he was at fault or negligent, and the current framework requires no alteration to ensure this intent is upheld. That being said, there is one area of the oil pollution rules that requires further evaluation: the exemptions.

In Part II there exist a list of exemptions the Shipowner may rely on as a complete defence to his liability for oil pollution damage in §192, which are also applicable to Part 1 via §184. §192(b) provides that a Shipowner is excepted from liability if it is proved that the damage was “wholly caused by an act… done with intent to cause damage by a third party”.

On reading the exemption, the Shipowner will not be held liable when the damage caused was the fault of a third party, however in order to satisfy this defence there are 2 important criteria to consider. One of these is that damage must be intended; this exemption does not allow it to be used where a cyber-attacker only intended to interfere or cause a nuisance, and oil pollution arose as a result. Where it is shown that the intent of the third party was to cause damage of any sort, be it from a collision, grounding or any other form and oil pollution arose as a result, this criterion is satisfied.

[112] Ibid §191.

The second criterion is that the damage was caused "wholly" by the third party. It can be considered that with respect to MASS, a third party successfully initiating a cyber-attack against a MASS with the intent to cause damage by oil pollution is "wholly" responsible for this act, thereby satisfying this criterion. However, consideration should be given to the responsibility of the Shipowner to protect his vessel against such acts.

MASS are particularly susceptible to cyberattacks as a result of their natural reliance on computer systems,[113] with their reliance, and consequently their susceptibility, increasing the higher the degree of autonomy the vessel is operating at. There already exist examples of where technology has been maliciously exploited, such as the GPS spoofing incident in 2017 where a number of vessels in the Black Sea had their GPS data altered, causing the GPS to display the vessels as being far away from their actual location.[114] Because MASS is inherently susceptible to such attacks, cyber resilience must increase as reliance on autonomy, and therefore systems, does.[115] To this end, in their Class Guidelines for Autonomous and remote-control vessels, with regard to cyber security DNV-GL have stipulated that such vessels have class notation *Cyber Secure (Advanced)*.[116]

If a Shipowner then allows the cyber protection level to fall below that of the above requirement, thereby exposing his MASS vessel to a greater level of threat from cyber-attacks, it must be considered whether such a failure on the Shipowner's part could amount to contributing to the cause of attack by facilitating the third party due to not having in place the proper protections. Should this failure be found to contribute to the cause, then the Shipowner would lose this defence in its entirety and be liable for the loss. In assessing whether such a failure should be considered as contributing to the cause, it is submitted that 2 factors are considered: (1) that there is causation between the failure to uphold the standard of class and the incident, and more generally (2) should the clause

[113] DNV-GL 'Class Guidelines' (n33) 22.
[114] HFW 'Autonomous Ships' (n13).
[115] Ibid.
[116] DNV-GL 'Class Guidelines' (n33) 93.

“wholly caused by..” be interpreted as being *actively caused by*, or also be interpreted as *indirectly caused by*?

For factor (1), in order for the Shipowner to lose this defence it should be shown that his failure to uphold the standard contributed to the damage, ie that if the vessel’s cyber-protection had been to the correct standard, the third party would not have been able to successfully launched his attack and cause the loss. This element of causation defines a clear causal link between the failure of the Shipowner and the cyber-attacker, however, may in practice be difficult to prove, which may lead to a presumption that the failure would have been prevented unless shown otherwise. Factor (2) can be seen as a policy consideration, as its consideration would decide which way the development of the law would flow: should *active causation* be the route followed by the courts, the focus would be on deliberate acts of the shipowner, meaning that the scope for considering the Shipowner’s behaviour as contributing to the cause of the damage is narrow. Should *indirect causation* be followed, then omissions will be more closely considered, and an omission to maintain Cyber-security standards is more likely to deny a Shipowner access to this defence.

It is submitted that the latter approach for factor (2), that of *indirect causation*, be preferred. This is because where a Shipowner knows that a function of his vessel will be controlled by a system, he should be bound to uphold the standard of class due to the potential danger if such a system is compromised, and this approach would encourage proper diligence in ensuring Shipowner’s satisfy their duty to keep their vessels safe and seaworthy. This will, however, increase the risk of the Shipowner, and so insurers of MASS vessels will need to adjust their approach with respect to cyber insurance, as they often expressly state that policies do not cover damage inflicted from cyber-attacks and/or virus’.[117]

All of the above considered, the rules related to oil pollution may be applied to MASS operations with little difficulty. The wide definitions used for what constitutes a ship allows MASS to be included with no alteration. The only potential issue is with the exception to

[117] Lloyd’s Market Association ‘*Marine Cyber Endorsement*’ LMA5403.

a Shipowner's liability under these rules, where greater clarity as to what constitutes damage being "wholly" caused by a third party should be implemented in order to establish to what degrees acts or omissions by a Shipowner may be considered as being a cause of the damage.

5.2 Necessity

Damage caused by necessity to avoid an even greater danger will not lead to criminal action against the defendant, however compensation must be paid to the injured party irrespective of fault or negligence being present.[118] This mechanism provides the master of a vessel with the knowledge and peace of mind to know that should the need arise, he can wilfully cause damage to other property if it is with the intent of avoiding other danger, without facing criminal ramifications, as it is essentially the lessor of 2 evils where the alternative may have more serious consequences. However, whilst the Shipowner will not face criminal liability, they will be required to compensate the injured party for the damage caused, irrespective of whether or not the vessel was at fault for being in the situation in the first place.

This requirement to pay compensation can be shown in T*he Consul Bratt*.[119] Here, the vessel lost steering control and so had to drop anchor in an area where dropping the anchor was prohibited to prevent the vessel colliding with a quay. In doing so the anchor struck and caused significant damage to subsea power cables, leaving a connected factory without power. In addition to the damaged power cables, it was held that the Shipowner had to pay compensation to this factory for damage suffered from their time without power, irrespective of any fault of the Shipowner.

It is submitted that this approach would lead to the same result in a MASS context. It is evident that the system would require risk analysis software in order to accurately decide

[118] Norwegian Tors Act, §1-4.
[119] ND 1955.181 NSC Consul Brutt.

that deliberately causing damage is the necessary and safest course of action instead of attempting to take a course of action to avoid any form of damage. Consequently, this principle could be applied to MASS in the same way it is applied to conventional ships, without the need for alteration provided that the systems are designed to properly assess the situation and consider this as a last resort, so that deliberately causing damage to prevent worse damage remains a last resort and not a decision taken too lightly. However, the logic behind making such decisions should be logged so that it can be analysed whether, with the information available to the systems, the decided course of action that led to damage was a reasonable decision to make, as if the decision was made too lightly based on the programming then in addition to civil liability, the criminal offence may still be considered, and logging the decision making logic will allow for clear identification of all the factors needed to asses whether the decision was reasonable by the standards of a conventional seaman.

5.3 Collisions With other Structures

Under Norwegian law, collisions with non-ship structures are treated differently to collisions with other vessels. The Brussels Collision Convention does not deal with collisions with non-ship structures, nor does the NMC. As such, normal Tort rules of Norwegian law apply,[120] basing liability on fault.

However, the Norwegian Supreme Court has imposed strict liability in 2 cases where a collision occurred between a bridge and dock respectively.[121] The linking factor between these 2 cases was mechanical failure with the reverse engines, and this factor has been shown to be key, as further cases where vessels have collided with a bridge or dock without mechanical failure have not been treated with strict liability.[122] Additionally, courts have not expanded the types of structures that this strict liability may apply to beyond

[120] Torts Act (n118).
[121] ND 1921.401 Neptun; ND 1052.320 Sokrates.
[122] ND 1958.587 NCA Leda.

bridges and docks. In *The Uthaug*[123] case, a submarine was not found strictly liable for damaging a trawler's trawl due a mechanical failure.

As such, it can be said that under the very specific circumstances of a vessel colliding with a bridge or dock due to a mechanical failure, the Shipowner will be held liable for the damage regardless of any fault. Taking this into the MASS context, there is no reason for there to be any change or exception made to MASS vessels. If the Shipowner is to be deemed responsible for paying compensation for such damage under Norwegian Law, it makes no difference whether the vessel was controlled by a human at the helm, a remote operator or a system.

5.4 Strict Liability Conclusions

The discussion in this chapter shows that strict liability is a useful mechanism to ensure that parties who have suffered loss are given adequate compensation when that loss is caused by a vessel, whether or not the vessel is at fault. The above discussion has outlined how the above circumstances where strict liability may arise do not require much, if any, adaptation to be equally applicable to MASS vessels. The focus on damage materialising as the basis of liability instead of a focus on damage as a result of fault allows strict liabilities to forego an assessment of whether it was a human or system that caused damage or loss, removing the complexities arising from increased reliance on systems as the most pertinent factor is that the specific damage has occurred and caused by the ship.

[123] ND 1973.348 NSC Uthaug.

6.0 Conclusions

The development of MASS vessels has the potential to decrease costs, increase safety and increase efficiency. However, MASS as a concept is often spoken about too generally, as shown by the inadequacy of the IMO 4-part definitions for the different levels of autonomy. By comparison with the Sheridan and NASA models of autonomy, and the DNV-GL model in their development guidelines, the IMO's definitions are far too vague to encapsulate the nuance and complexity of systems running at different levels of autonomy across the same function, or that may alter in their degree of autonomy and human reliance during a voyage. As such, a model such as the DNV-GL one, as the most suited for MASS purposes out of those examined within this thesis due to it's specific application to shipping and its greater degree of acknowledgment of the nuances in autonomy, should be considered the standard reference point when discussing any legal or technical issues regarding MASS accountability to understand whether a system or human was truly operating a vessel at the time of an incident.

With regard to collisions, it has been shown that the current liability framework does not need to be changed to a great extent when examining collisions with MASS vessels. 2 different types of causes have been identified: where collisions are caused by a physical or mechanical failure, and where collisions are caused by a system decision. Establishing fault for physical and mechanical failures will be reliant on proper maintenance and monitoring of all proper components in line with Classification Society requirements, which will develop as a better understanding of the available technology does. Faults from a decision-making system will be assessed with strong influences from comparisons with good seamanship from conventional vessels, as well as investigations into compliance with safe operating parameters, best practises and rules such as the ColRegs. Keeping the liability framework for all degrees of MASS operations as similar as possible to that of conventional vessels will provide the simplest and clearest route for establishing and defining fault, and to allow a clear route to compensation for the party who has suffered loss, however traditional rules may need to be interpreted more broadly to be applicable. Overall, there should be no need for great changes to establish liability for MASS vessels involved in Collisions under Norwegian Law, and the approach above, to assess fault based on compliance with best practises and comparisons to what would have been by a good seaman can be used more broadly to determine Shipowner liabilities for MASS vessels.

The mechanism in NMC §151 which establishes how a Shipowner is liable for the acts of his vessel's master and crew has been shown to need no modification to be applicable to MASS vessels operating remotely where the remote operator has ultimate responsibility for the decision which led to an incident causing another party loss. However, there has been an issue identified with respect to decisions made by the decision-making system, as a system cannot currently be held liable for its actions. 3 solutions have been proposed, with the most suitable being submitted as that of amending NMC §151 to expressly include decision-making systems under the list of entities that the Shipowner is responsible for, as this solution is both the simplest and will conflict the least with other areas of law, ie what can be considered a legal person.

Finally, how strict liability may be applicable to MASS vessels was examined. The analysis showed that changes will not be required, as the emphasis on factual materialised loss instead of fault in the causation means that, even for conventional vessels, who or what caused the loss does not necessarily need to be considered with respect to the Shipowner (3rd parties maliciously causing the loss notwithstanding). As such, whether the vessel was controlled by a human or a computer system will not have an impact on a finding of loss under these strict liability principles.

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